SYSTEM DYNAMICS APPROACH FOR WHOLE LIFE CYCLE COST MODELLING OF RESIDENTIAL BUILDING PROJECTS IN UNITED ARAB EMIRATES

نهج ديناميكيات النظام لنمذجة تكاليف دورة الحياة الكاملة لمشاريع البناء السكنية في دولة الإمارات العربية المتحدة

by

AHMED MOHSEN MOHAMED SADEK

A thesis submitted in fulfilment

of the requirements for the degree of

DOCTOR OF PHILOSOPHY IN PROJECT MANAGEMENT

at

The British University in Dubai

April 2020

SYSTEM DYNAMICS APPROACH FOR WHOLE LIFE CYCLE COST MODELLING OF RESIDENTIAL BUILDING PROJECTS IN UNITED ARAB EMIRATES

نهج ديناميكيات النظام لنمذجة تكاليف دورة الحياة الكاملة لمشاريع البناء السكنية في دولة الإمارات العربية المتحدة

by

AHMED MOHSEN MOHAMED SADEK

A thesis submitted in fulfilment of the requirements for the degree of

DOCTOR OF PHILOSOPHY IN PROJECT MANAGEMENT

at

The British University in Dubai

April 2020

Thesis Supervisor
Prof. Halim Boussabaine

Approved for award:

_____	_____
Name	Name
Designation	Designation
_____	_____
Name	Name
Designation	Designation

Date: 30th April 2020

DECLARATION

I warrant that the content of this research is the direct result of my own work and that any use made in it of published or unpublished copyright material falls within the limits permitted by international copyright conventions.

I understand that a copy of my research will be deposited in the University Library for permanent retention.

I hereby agree that the material mentioned above for which I am author and copyright holder may be copied and distributed by The British University in Dubai for the purposes of research, private study or education and that The British University in Dubai may recover from purchasers the costs incurred in such copying and distribution, where appropriate.

I understand that The British University in Dubai may make a digital copy available in the institutional repository.

I understand that I may apply to the University to retain the right to withhold or to restrict access to my thesis for a period which shall not normally exceed four calendar years from the congregation at which the degree is conferred, the length of the period to be specified in the application, together with the precise reasons for making that application.

AHMED MOHSEN MOHAMED SADEK

Signature of the student

COPYRIGHT AND INFORMATION TO USERS

The author whose copyright is declared on the title page of the work has granted to the British University in Dubai the right to lend his/her research work to users of its library and to make partial or single copies for educational and research use.

The author has also granted permission to the University to keep or make a digital copy for similar use and for the purpose of preservation of the work digitally.

Multiple copying of this work for scholarly purposes may be granted by either the author, the Registrar or the Dean only.

Copying for financial gain shall only be allowed with the author's express permission.

Any use of this work in whole or in part shall respect the moral rights of the author to be acknowledged and to reflect in good faith and without detriment the meaning of the content, and the original authorship.

Abstract

SYSTEM DYNAMICS APPROACH FOR WHOLE LIFE CYCLE COST MODELLING OF RESIDENTIAL BUILDING PROJECTS IN UNITED ARAB EMIRATES

Purpose – Project management field is experiencing many challenges to maintain its performance and delivery within planned time, budget, and quality. Latest research focused on cost modelling and estimation. There is a high demand to have many developments within a short period and acceptable quality. The significance of cost modelling comes from the forecasted information value. This research study aims to model project's whole life cycle costs of residential buildings in UAE at the preconstruction stage, choosing VENSIM system dynamics approach. The objective is to simulate dynamically cost over time for all outputs.

Design/methodology/approach – The approach of this research is pure quantitative. It requires mapping diagrams and mathematical computation systems. Research questions were answered as a gear unit to build the final cost model. Identifying cost risks values are the first required answer. These values are extracted from field experts. Data validity and reliability are conducted using mechanistic (hypotheses) mathematical models (correlation and regression). Adjusting cost risks are computed using Monte Carlo stochastic mathematical model. Finally, VENSIM system dynamics final cost model is developed approaching empirical, dynamic (stock and flow), and deterministic mathematics.

Findings – The result of system dynamics approach investigation revealed that it can model project's total expenditure (TOTEX) dynamically over time, including cash flow and NPV.

Limitations – The model's verification process could not verify OPEX estimation accuracy due to the absence of OPEX real data in UAE. This is because UAE age (≈ 50 year) is less than the model's lifecycle (60 years). The model is developed for residential buildings in UAE. This requires further investigation to check the ability of system dynamics approach to model costs for other project types and/or in other geographical regions. It is required to check the model's response against changing/adjusting the used mathematical system to ensure the maximum accuracy of system dynamics approach for cost modelling. It is compulsory to investigate system dynamics cost modelling response against adapting deferent demolition scenarios.

Theoretical implications – The final system dynamics cost model is incorporating TOTEX cash flow and net present value estimates for each time step across the project's whole life cycle at the preconstruction stage. This is achieved by applying adjusting risks on project's initial cost at the preconstruction stage with respect to cost and risk behaviours at each time step. Cost impact is following an increasing S-Curve behaviour during CAPEX time and risk impact is following a decreasing S-Curve behaviour during CAPEX lifetime. Both cost and risk impacts are linearly increasing during OPEX lifetime. And NPV is following a negative exponent behaviour over TOTEX lifetime. The applied adjusting risks are comprising three value levels. Minimum, mean, and maximum cost risks. Simulated costs under adjusting risks' levels can be presented in the same exported data sheet. All cash flow scenarios, under three cost risks levels, can be trended in the same chart, simultaneously, including all project's lifecycle time steps.

Practical implications – TOTEX and NPV accurate estimation outputs are the most important criteria for future investments decisions. In addition, modelling project's cash flow is the most helpful approach to apply stochastic area method (easy-to-apply) analysis. Multiple scenarios provide better understanding of future events.

Originality/value – This research significant contribution to the project management body of knowledge is accomplished by providing the first cost model, approaching system dynamics, for residential building projects' whole lifecycle.

الخلاصة

نهج ديناميكيات النظام لنمذجة تكاليف دورة الحياة الكاملة لمشاريع البناء السكنية في دولة الإمارات العربية المتحدة

الغرض – يواجه مجال إدارة المشاريع العديد من التحديات للحفاظ على أدائه وتسليمه ضمن الوقت المخطط له والميزانية والجودة. ركزت أحدث الأبحاث على نمذجة التكلفة وتقديرها. فهناك طلب كبير على العديد من التطويرات خلال فترة قصيرة وجودة مقبولة. تأتي أهمية نمذجة التكلفة من قيمة المعلومات المتوقعة. تهدف هذه الدراسة البحثية إلى نمذجة تكاليف دورة حياة المشروع بالكامل للمباني السكنية في دولة الإمارات العربية المتحدة في مرحلة ما قبل البناء ، وقد تم اختيار نهج ديناميكيات النظام لمحاكاة التكلفة الديناميكية مع مرور الوقت لجميع المخرجات.

التصميم/المنهجية/النهج – نهج هذا البحث هو كمّي بشكل أساسي، و يعتمد على الحسابات الرياضية و الكمية بشكل مطلق. و لكن، يتطلب التصميم الكمي للبحث رسم خرائط توضيحية لمتغيرات النموذج و علاقاتها مع بعضها البعض.. تمت الإجابة على أسئلة البحث كوحدة تروس لبناء نموذج التكلفة النهائية. فتم تحديد قيم مخاطر التكلفة من قِبَل الخبراء في المجال العلمي، و هي أول إجابة مطلوبة. تم التحقق من صحة البيانات باستخدام النماذج الرياضية الميكانيكية (الفرضيات = hypotheses) لنمذجة ارتباط البيانات (correlation and regression). تم حساب قيمة ضبط مخاطر التكلفة باستخدام نموذج مونتي كارلو الرياضي للعشوائية الكمية (Monte Carlo stochastic model). وأخيرا ، تم تطوير نموذج التكلفة النهائية الديناميكي باستخدام برنامج الحاسوب فينسيم (VENSIM) لنمذجة النظام الديناميكي بشكل كمي و دقة عالية. ويعتمد فينسيم على الرياضيات التجريبية والديناميكية والحتمية.

النتائج – كشفت نتيجة التحقيق في نهج ديناميكيات النظام أن بإمكانه نمذجة إجمالي نفقات المشروع (TOTEX) ديناميكياً مع مرور الوقت، شاملاً بما في ذلك التدفق النقدي (cash flow) و صافي القيمة الحالية (NPV).

القيود – لم يتمكن البحث من التحقق من دقة تقدير التكاليف التشغيلية (OPEX) بسبب عدم وجود بيانات حقيقية للتكاليف التشغيلية في دولة الإمارات العربية المتحدة. ويرجع ذلك إلى أن عمر دولة الإمارات العربية المتحدة (≈ 50 عاما) أقل من دورة حياة النموذج (60 عاما). أيضاً، طُوّر النموذج الديناميكي لتقدير التكلفة الكلية للمباني السكنية في الإمارات العربية المتحدة. وهذا يتطلب مزيدا من التحقيق للتأكد من قدرة نهج ديناميكيات النظام على نمذجة التكاليف الكلية لأنواع المشاريع الأخرى و/ أو في مناطق جغرافية أخرى. ينصح بالتحقق من استجابة النموذج ضد تغيير / تعديل النظام الرياضي المستخدم لضمان أعلى دقة لنهج ديناميكيات النظام لنمذجة التكلفة. أخيراً، يلزم التحقيق في استجابة و تكيف نهج ديناميكيات النظام لنمذجة التكاليف الكلية شاملاً سيناريوهات الهدم المختلفة.

الآثار النظرية – يتضمن نموذج ديناميكيات النظام النهائي على تقدير إجمالي نفقات المشروع (TOTEX) وتقدير صافي القيمة الحالية (NPV) لدورة حياة المشروع بأكملها في مرحلة ما قبل البناء. ويتحقق ذلك من خلال تطبيق قيمة تعديل المخاطر على التكلفة الأولية للمشروع في مرحلة ما قبل البناء متبعاً سلوكيات التكلفة و المخاطر في كل خطوة زمنية. يتبع تأثير التكلفة سلوكاً متزايداً للمنحنى S خلال فترة النفقات الرأسمالية، ويتبع تأثير المخاطر سلوكا متناقصاً للمنحنى S خلال فترة النفقات الرأسمالية. بالإضافة إلى ذلك، يتبع كل من تأثير التكلفة والمخاطر سلوكاً متزايداً خطيا خلال فترة النفقات التشغيلية ويتبع منحنى صافي القيمة الحالية (NPV) سلوك الأس السلبي على مدى عمر المشروع. أيضاً، وفر النموذج النهائي ثلاثة مستويات لقيمة التكلفة المقدرة. الحد الأدنى ، القيمة متوسط ، والحد الأقصى لتعديل لمخاطر التكلفة. يمكن عرض التكاليف المقدرة تحت تأثير مستويات ضبط المخاطر المختلفة في نفس ورقة البيانات المصدّرة. و يمكن عرض جميع سيناريوهات التدفق النقدي، شاملاً الثلاث مستويات، في نفس الرسم البياني و لنفس الخطوات الزمنية في حياة المشروع.

الآثار العملية – تقدير إجمالي نفقات المشروع (TOTEX) وصافي القيمة الحالية (NPV) هما أهم المعايير لقرارات الاستثمارات المستقبلية. بالإضافة إلى ذلك ، فإن نمذجة التدفق النقدي للمشروع هو النهج الأكثر فائدة لتطبيق تحليل تدفق النفقات بطريقة تحديد منطقة احتواء تغير التدفق عشوائياً، و هو الأسهل للتطبيق. و توفر النمذجة سيناريوهات متعددة لفهم أفضل للأحداث التكاليف المستقبلية.

الأصالة / القيمة – حقق هذا البحث مساهمة كبيرة في مجال علم إدارة المشاريع من خلال توفيرأول نموذج لتقدير التكلفة الكلية لدورة حياة المشاريع السكنية بأكملها باستخدام نهج ديناميكيات النظام.

ACKNOWLEDGMENTS

First of all, I would like to thank ***Allah*** for the countless blessings and bounties that I was given to successfully complete this work. Then, I would like to express my sincere gratitude, appreciation, and heartfelt thanks to my research supervisor (Director of Study), ***Dr Abdul-Halim Boussabaine,*** for his continuous support, encouragement, and guidance which I have benefited greatly from. His supervision has equipped me with the necessary academic skills to complete this research study. Besides, I would like to thank my Secondary Supervisor, ***Dr Khalid Al Marri,*** for his support as a modelling expert in the project management field.

After that, I would like to acknowledge my grateful feelings to my colleagues and friends at the University, British University in Dubai PhD Community group, with whom I have worked and shared ideas while being advised from them at various stages throughout my research study journey.

Finally, I am incredibly grateful for being a student and reaching the level of obtaining the highest academic degree (i.e., **Doctor of Philosophy**) from a great university like the British University in Dubai; nevertheless, it has been and still an excellent research institute for years which is providing the highest quality of education in the United Arab Emirates and the region. Therefore, being a graduate with a PhD from the British University in Dubai is a significant life experience that I am proud of for the remaining of my career and research journey.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS V

LIST OF TABLES XV

LIST OF DEFINITIONS AND ABBREVIATIONS XVIII

Chapter 1: INTRODUCTION 1

1.0 Inception 2
1.1 Cost Modelling and Estimating in Residential Project's Whole Lifecycle Industry 2
1.2 The Status of Buildings Projects and Investments Economy 5
1.3 Future Economic Developments in the United Arab Emirates 8
1.4 The Need for Cost Models Development in the UAE Projects industry 9
1.5 Research Problem Statement 12
1.6 The Research Aim, Objective, and Questions 13
1.7 The Research Significance 14
1.8 Research Methodology 16
1.9 Research Structure 17
1.9.1 Chapter 1 17
1.9.2 Chapter 2 17
1.9.3 Chapter 3 18
1.9.4 Chapter 4 19
1.9.5 Chapter 5 19
1.9.6 Chapter 6 20
1.9.7 Chapter 7 21
1.9.8 Chapter 8 21
1.9.9 Chapter 9 22
1.10 Summary 22

Chapter 2: LITERATURE REVIEW 23

2.0 Introduction 24
2.1 Project Cost Information Modelling Literature Review 26
2.2 Project Cost, Economics, & Profitability Modelling Literature Review 34
2.3 Project Cost and Risk Interaction Modelling Literature Review 45
2.4 Projects Cost Estimation Modelling Literature Review 65
2.5 Summary 93

Chapter 3: MAPPING PROJECT'S WHOLE LIFE CYCLE COST RISKS 96

3.0 Introduction 97
3.1 CAPEX Risks 101
A- Construction Activities' Risks 102
B- Political Risks 114
C- Legal Risks 118
D- Economic Change Risks 121
E- Natural Forces Risks 124
F- Market Risks 126
G- Project Selection Risks 129
H- Project Finance Risks 131
I- Building Functionality and Serviceability Risks 135
J- Stakeholders Relationship Risks 141
K- Knowledge Risks 145

3.2 OPEX Risks 148
3.3 Design, Equipment Replacement, and Demolition Variables 155
3.4 CAPEX-OPEX Risks Mapping 158
3.5 Summary 158

Chapter 4: RESEARCH METHODOLOGY 160

4.0 Introduction 161
4.1 Quantitative Research Approach 161
4.2 Qualitative Research Approach 164
4.3 Research Method 166
4.3.1 Writing a Literature Review 168
4.3.2 Mapping Cost's Risks 174
4.3.3 Data Collection Strategy 177
4.3.4 Design Data Collection 179
4.3.4.1 Interview Type 180
4.3.4.2 Interview Questionnaire Design 182
4.3.4.3 Questions Type 186
4.3.4.4 Sample Size 187
4.3.4.5 Pilot Study 195
4.3.5 Mathematical Modelling 199
4.3.5.1 Data Statistical Significance, Reliability and Validity 200
4.3.5.2 Cost Risks Minimum-Maximum Limits 204
4.3.5.3 Monte Carlo Simulation 206
4.3.5.4 Construction Cash Flow S-Curve 212
4.3.5.5 Construction Risk S-Curve 214
4.3.5.6 Capital Expenditure 216
4.3.5.7 Equipment Replacement 218
4.3.5.8 Operational Expenditure 219
4.3.5.9 Project's Whole Life Cycle Total Expenditure 222
4.3.5.10 Net Present Value 223
4.3.5.11 Project's Whole Lifecycle System Dynamics 225
4.3.5.12 Forecasting Accuracy Error 230
4.3.6 Final System Dynamics Model 231
4.3.7 Demolition 232
4.4 Summary 235

Chapter 5: DATA COLLECTION AND VALIDATION 239

5.0 Introduction 240
5.1 Experts' Competencies 240
5.2 Data Correlation Analysis 249
5.3 Data Regression Analysis 259
5.4 Summary 274

Chapter 6: MONTE-CARLO MODELLING 275

6.0 Introduction 276
6.1 Monte-Carlo Simulation Approach 276
6.2 Cost Risks Monte-Carlo Modelling 282
6.3 Summary 288

Chapter 7: SYSTEM DYNAMICS COST MODEL DEVELOPMENT 289

7.0 Introduction 290
7.1 Cost Cash Flow S-Curve Development 291
7.2 Risk S-Curve Development 294
A- Construction Activities' Risks 296
B- Political Risks 298
C- Legal Risks 299
D- Economic Change Risks 301
E- Natural Forces Risks 302
F- Market Risks 304
G- Project Selection Risks 305
H- Project Finance Risks 307
I- Building Functionality and Serviceability Risks 308
J- Stakeholders Relationship Risks 310
K- Knowledge Risks 311
7.3 OPEX System Dynamics Model Development 313
7.4 Project's Whole Life Cycle Cost Model Cost and Net Present Value 316
7.5 Summary 319

Chapter 8: SYSTEM DYNAMICS COST MODEL VALIDATION, VERIFICATION AND DISCUSSION .. 321

8.0 Introduction 322

8.1 System Dynamics Validation DEMO Model 322
8.1.1 CAPEX System Dynamics Model Validation 244
A- Construction Activities' Risks 328
B- Political Risks 329
C- Legal Risks 330
D- Economic Change Risks 331
E- Natural Forces Risks 332
F- Market Risks 333
G- Project Selection Risks 334
H- Project Finance Risks 335
I- Building Functionality and Serviceability Risks 336
J- Stakeholders Relationship Risks 337
K- Knowledge Risks 338
8.1.2 OPEX System Dynamics Model Validation 339
8.1.3 TOTEX System Dynamics Model Validation 340
8.1.4 Net Present Value System Dynamics Model Validation 342
8.1.5 Final Residential Project's Whole Lifecycle Cost Estimation Model 344
8.2 System Dynamics Model Verification 348
8.2.1 Project 1 351
8.2.2 Project 2 355
8.2.3 Project 3 359
8.3 Cash Flow Range and Final Model Accuracy 363
8.4 Discussion 370
8.4.1 Cash Flow Discussion 370
8.4.2 Final Cost Estimation and Error Discussion 371
8.5 Summary 374

Chapter 9: CONCLUSION 375

9.0 Introduction 376
9.1 Research Gaps, Aims, Objectives, and Questions 376
9.2 The Research Contribution 384
9.2.1 Theoretical Contribution 384
9.2.2 Practice Contribution 386
9.3 Limitations and Future Research 387
9.4 Summary 392

REFERENCES 394

APPENDIX: A 435

APPENDIX: B 447

LIST OF ILLUSTRATIONS

- Figure 1-1: Research Aim, Objective, and Questions. The aim is to develop a cost model. The objective is to achieve a dynamical cost model. The sub objectives are to ensure that answered research questions will satisfy this research aim and objective.
- Figure 2-1: Cost Estimation Mathematical equation used in cost information models (Hardcastle 1992).
- Figure 2-2: Cost Estimating Criteria which are affecting information quality of an accurate estimated cost (Hardcastle 1992).
- Figure 2-3: How information model is designed for modelling and estimating cost at the design stage (i.e., pre-construction stage) (Hardcastle 1992).
- Figure 2-4: Proposed Profitability System (Cui 2005).
- Figure 2-5: Profitability System Dynamical Model (Cui 2005).
- Figure 2-6: Complex Adaptive Bidding System with One Agent (Cui 2005).
- Figure 2-7: Feedback Loops in Construction Projects Cash Flow (Cui 2005).
- Figure 2-8: Cost Modelling Equations from Eq.2-5 to Eq.2-18 (Isaksson 2002).
- Figure 2-9: Cost Modelling Equations from Eq.2-19 to Eq.2-27 (Isaksson 2002).
- Figure 2-10: The relationship between the Meta Theory choices with the other methodology, strategy, and research design (Boateng 2014).
- Figure 2-11: The Proposed research Qualitative Framework for Building and developing the Risk Assessing Model (Boateng 2014).
- Figure 2-12: The ANP Model building and integrating process (Boateng 2014).
- Figure 2-13: Elements and components of how to build system dynamics model (Boateng 2014).
- Figure 2-14: The final simulated system dynamics model used for assessing risks in mega infrastructure construction projects (Boateng 2014).
- Figure 2-15: The conceptual model of how to understand construction cost variables and phases prior modelling its costs (Ahiaga-Dagbui 2014).
- Figure 2-16: showing the basic structure of Neural Network Architecture used for modelling cost in ANN final model (Ahiaga-Dagbui 2014).

- Figure 2-17: Showing how to reach the satisfactory targeted performance of the predicted construction project cost in ANN model (Ahiaga-Dagbui 2014).
- Figure 2-18: The summarizing chart of researchers focus area as per Steve's literature review to find researching gap (Jang 2011).
- Figure 2-19: The techniques of building NPV model to identify over costs or profits base on design-build-operate lifetime projects (Jang 2011).
- Figure 2-20: How risk events cause delay and cost overrun in NPV SD model (Jang 2011).
- Figure 2-21: The time behaviour patterns of the SD analysis in the NPV model (Jang 2011).
- Figure 2-22: Final NPV model showing the main 6 sub models including: Construction Cost, Operating Cost, Project Financing, Discount Rate, and Operating Revenue which are utilized in Final Project's Cash Flow model (Jang 2011).
- Figure 2-23: Risk Cost System Dynamics Constructs (Alzahrani 2015).
- Figure 2-24: Risks cost system dynamics model for KSA PPP projects showing risks groups and their interaction in each sub-model (Alzahrani 2015).
- Figure 2-25: The use of structured system dynamics as shown in the right side of the figure and causal loops shown in the lower left side of the figure to satisfy modelling fixable pavement resilience measurement under climate impact in UAE as shown in the left upper side of the figure (Al-Aryani 2019).
- Figure 3-1: Distribution of reviewed literature and governments/ RICS reports related to cost risk identification and allocation in buildings project's whole life cycle from 1976 to 2020.
- Figure 3-2: Construction Activities' Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.
- Figure 3-3: Political Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.
- Figure 3-4: Legal Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.
- Figure 3-5: Economic Change Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.
- Figure 3-6: Natural Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.

- Figure 3-7: Market Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.
- Figure 3-8: Project Selection Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.
- Figure 3-9: Finance Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.
- Figure 3-10: Building Functionality and Serviceability Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.
- Figure 3-11: Stakeholders Relationship Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.
- Figure 3-12: Knowledge Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.
- Figure 3-13: Operational Activities Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.
- Figure 3-14: project's whole life cycle NPV over 60 years showing that demolition costs will not impact the cost model based on long lifespan (Han, Srebric & Enache-Pommer 2014).
- Figure 3-15: Final cost estimation model mapping including both CAPEX and OPEX Risks from design to demolition, showing their interaction with each other in the proposed project whole life cycle cost estimation model.
- Figure 4-1: Association clarifying examples (Wild 2014).
- Figure 4-2: Correlation clarifying examples (Wild 2014).
- Figure 4-3: Literature review conceptual diagram for choosing reviewing type (Pautasso 2013).
- Figure 4-4: Literature review "Swiss Cheese" and "Inverted Pyramid" conceptual models (Maier 2013, p.4).
- Figure 4-5: Literature review structure in educational doctoral research from topic identification to conclusion (Maier 2013; Steward 2004; Pautasso 2013; Kucan 2001; Webster & Watson 2002; Rewhorn 2018; Asmussen & Moller 2019).
- Figure 4-6: VENSIM system dynamics stock-flow diagram (Kang et al. 2020).
- Figure 4-7: VENSIM system dynamics causal loop diagram (Boateng 2014).

- Figure 4-8: Project Management Institute (PMI) Risk Matrix: Probability X Threats/Opportunities impacts (PMBOK Guide 2004).
- Figure 4-9: Adjusted coloured Project Management Institute (PMI) Risk Matrix: Probability and Impact multiplication is showing risks values including low (green), medium (yellow) and high (red) risks.
- Figure 4-10: Final Adjusted Project Management Institute (PMI) Risk Matrix: Probability and Impact Matrix.
- Figure 4-11: Probability & Non-Probability Sampling methods (Omair 2014; Bhardwaj 2019).
- Figure 4-12: Probability and Non-Probability Sampling methods (McCombes 2019).
- Figure 4-13: mixed method sample size approach (Onwuegbuzie 2007).
- Figure 4-14: 95% confidence level chart (Szyk, Mah & Pal 2020).
- Figure 4-15: the difference between accuracy and precision (Heijungs 2020).
- Figure 4-16: Shifting data mean without discredit distribution reliability should be without changing the standard deviation.
- Figure 4-17: showing how shifting data mean while changing its standard deviation discredit the full data distribution and withdraw its reliability and validity.
- Figure 4-18: clarify the difference between survey risk mean and adjusted risk mean for the same data distribution of each variable.
- Figure 4-19: Experts data and Monte Carlo modelling impact on final outputs' accuracy and precision.
- Figure 4-20: The final S-Curve used in this research construction system dynamics cost modelling.
- Figure 4-21: Tending the construction Risk S-Curve which will be used in final system dynamics model.
- Figure 4-22: This figure is adapted by "Riley et al., 2005" for "Tao et al., 2001" table showing the percentage of MEP costs compared to the total building costs including residential building projects (Riley et al., 2005).
- Figure 4-23: This figure is adapted by Wu and Clements-Croome (2007) for Schaufelberger and Jacobson (2000) and Fuller (2005) table showing the percentage of operations and

maintenance costs compared to the total building costs including residential buildings projects (Riley et al. 2005).

- Figure 4-24: a screen shot of the official EIBOR rate value in the United Arab Emirates as of 23rd February 2020 which is used in calculating the net present value of the developed system dynamics model and its mathematical equation system.
- Figure 4-25: System Dynamics stock and flow diagram.
- Figure 4-26: problem solving approach based on open flow system (Sterman 2003).
- Figure 4-27: System Dynamics stock and flow conceptual framework (Sterman 2003).
- Figure 4-28: System Dynamics mathematics relationships graphical representation in VENSIM Software.
- Figure 4-29: System Dynamics Lookup Table Graph conceptual framework from VENSIM Software.
- Figure 4-30: The best practices of handling construction and demolition (C & D) waste management costs during design and construction stages based on data median (Me) assessment (Won & Cheng 2017).
- Figure 4-31: Construction and demolition waste management approach (Saez et al. 2013).
- Figure 5-1: Abu Dhabi Municipality License Sample to show official provided information to validate experts.
- Figure 5-2: Interviewees working sector.
- Figure 5-3: summarize how Schober, Boer and Schwarte (2018) classified data linear relationships based on Pearson's correlation coefficient r-value.
- Figure 5-4: weak, moderate, and strong relationship of each risk factor with its probability frequency.
- Figure 5-5: weak, moderate, and strong relationship of each risk factor with its impact weight.
- Figure 5-6: Show how much of the population is represented by the data analysis results in table 5-10.
- Figure 5-7: Show how many risks had outliers during validating the collected survey data in table 5-10.
- Figure 5-8: Valid sample size resulted from data analysis in table 5-10.
- Figure 6-1: Microsoft office official random equation used in excel (RAND function 2020).

- Figure 6-2: Computing $\Delta_{Minimum}$ and $\Delta_{Maximum}$ using Δ_{Mean} and equations 4-16 and 4-17 as detailed in chapter 4.
- Figure 6-3: Cost risks description and reference code (i.e., CA1) from table 6-1.
- Figure 6-4: CA1 Cost risks SPSS Mean and Standard Deviation from table 6-1.
- Figure 6-5: CA1 Cost risks Lower and Upper Limits from table 6-1.
- Figure 6-6: CA1 10,000 iterations average and cost risks adjusted Mean from table 6-1.
- Figure 6-7: CA1 $\Delta_{Minimum}$, Δ_{Mean}, and $\Delta_{Maximum}$ from table 6-1. Calculations are using equations 4-14 to 4-19 and figure 6-2.
- Figure 6-8: CA1 and CA2 Cost risks deference between the survey and the adjusted Means from table 6-1.
- Figure 6-9: Balancing table 6-1 Cost risks deference between the survey and the adjusted Means.
- Figure 7-1: adapted figure 4-20 showing fitting parameters: The final S-Curve used in this research construction system dynamics cost modelling based on literature guidance (Cristóbal 2017; Kucharavy & Guio 2014). However, K value represent construction cost of this research.
- Figure 7-2: Trending construction Risk decreasing S-Curve to be used in system dynamics final model.
- Figure 7-3: Developing the stock and flow system dynamics model of CAPEX Construction Activities' Risks and finalizing its mathematical equations system.
- Figure 7-4: Developing the stock and flow system dynamics model of CAPEX Political Risks and finalizing its mathematical equations system.
- Figure 7-5: Developing the stock and flow system dynamics model of CAPEX Legal Risks and finalizing its mathematical equations system.
- Figure 7-6: Developing the stock and flow system dynamics model of CAPEX Economic Change Risks and finalizing its mathematical equations system.
- Figure 7-7: Developing the stock and flow system dynamics model of CAPEX Natural Forces Risks and finalizing its mathematical equations system.
- Figure 7-8: Developing the stock and flow system dynamics model of CAPEX Market Risks and finalizing its mathematical equations system.

- Figure 7-9: Developing the stock and flow system dynamics model of CAPEX Project Selection Risks and finalizing its mathematical equations system.
- Figure 7-10: Developing the stock and flow system dynamics model of CAPEX Project Finance Risks and finalizing its mathematical equations system.
- Figure 7-11: Developing the stock and flow system dynamics model of CAPEX Building Functionality and Serviceability Risks and finalizing its mathematical equations system.
- Figure 7-12: Developing the stock and flow system dynamics model of CAPEX Stakeholders Relationship Risks and finalizing its mathematical equations system.
- Figure 7-13: Developing the stock and flow system dynamics model of CAPEX Knowledge Risks and finalizing its mathematical equations system.
- Figure 7-14: Developing the stock and flow system dynamics model of OPEX Risks and finalizing its mathematical equations system.
- Figure 7-15: Developing the system dynamics model of final cost estimation and its Net Present Value including CAPEX and OPEX Total costs and finalizing its mathematical equations system.
- Figure 7-16: Final developed system dynamics model of estimating and predicting residential projects whole lifecycle cost from the client perspective at the pre-construction stage.
- Figure 8-1: It is showing the Zero Risk CAPEX cost cash flow S-Curve of the DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.
- Figure 8-2: It is showing the minimum, mean and maximum CAPEX cost cash flow S-Curves using the validation demo project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.
- Figure 8-3: It is showing the adjusted CAPEX Cash Flow S-Curve including minimum, mean, and maximum adjusting risks using the validation demo project. DEMO cost is assigned equal to AED 400 million over 60 years projects whole lifecycle.
- 8-4: It is showing the Zero Risk CAPEX cost cash flow S-Curve of the DEMO project cost. DEMO cost is assigned equal to AED 400 million over 60 years projects whole lifecycle.
- Figure 8-5: It is showing the Risk Cost S-Curve of the **Construction Activities' Risks** using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

- Figure 8-6: It is showing the Risk Cost S-Curve of the **Political Risks** using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.
- Figure 8-7: It is showing the Risk Cost S-Curve of the **Legal Risks** using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.
- Figure 8-8: It is showing the Risk Cost S-Curve of the **Economic Change Risks** using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.
- Figure 8-9: It is showing the Risk Cost S-Curve of the **Natural Forces Risks** using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.
- Figure 8-10: It is showing the Risk Cost S-Curve of the **Market Risks** using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.
- Figure 8-11: It is showing the Risk Cost S-Curve of the **Project Selection Risks** using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.
- Figure 8-12: It is showing the Risk Cost S-Curve of the **Project Finance Risks** using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.
- Figure 8-13: It is showing the Risk Cost S-Curve of the **Building Functionality and Serviceability Risks** using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.
- Figure 8-14: It is showing the Risk Cost S-Curve of the **Stakeholders Relationship Risks** using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.
- Figure 8-15: It is showing the Risk Cost S-Curve of the **Knowledge Risks** using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

- Figure 8-16: It is showing OPEX cost flow at minimum, mean, and maximum adjusting risks using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 57 years operation time.
- Figure 8-17: It is showing TOTEX cost flow at minimum, mean, and maximum adjusting risks using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 60 years projects whole lifecycle.
- Figure 8-18: It is showing the comparison between adjusted OPEX and adjusted CAPEX Cash Flow S-Curve including equipment replacement cost, minimum adjusting risks, mean adjusting risks, and maximum adjusting risks using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 60 years projects whole lifecycle.
- Figure 8-19a: It is showing OPEX NPV cost curve at the minimum, mean, and maximum adjusting risks using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 57 years operation time.
- Figure 8-19b: It is showing the adjusted OPEX and CAPEX NPV Flow Curves including equipment replacement cost, minimum adjusting risks, mean adjusting risks, and maximum adjusting risks using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 60 years projects whole lifecycle.
- Figure 8-20: Final model validation simulation using the DEMO project cost. DEMO cost is assigned equal to AED 400 million over a simulation period equal to 3 years.
- Figure 8-21: It is showing a bigger snapshot of OPEX and final estimated cost besides their impact on the NPV when assigning in the contract value as AED 400 million and change the project period from 3 years to 60 years.
- Figure 8-22: Final model validation simulation using the DEMO project cost. DEMO cost is assigned equal to AED 400 million over 60 years projects whole lifecycle.
- Figure 8-23: VENSIM System dynamics modelling results for Project 1 costs including CAPEX, OPEX, Total Estimated Costs, OPEX NPV, and Projects Whole Life Cycle NPV.
- Figure 8-24: comparing project 1 model vs. actual cost cash flow in percentage during CAPEX stage.
- Figure 8-24a: Example of analysing progress vs. cost cash flow in percentage during construction stage (Wang, Wang et al. 2016).
- Figure 8-24b: adapted chart for progress vs. modelled and actual cost cash flow in percentage during CAPEX stage for project 1 (Wang, Wang et al. 2016).

- Figure 8-25: VENSIM System dynamics modelling results for Project 2 costs including CAPEX, OPEX, Total Estimated Costs, OPEX NPV, and Projects Whole Life Cycle NPV.
- Figure 8-26: comparing project 2 model vs. actual cost cash flow in percentage during CAPEX stage.
- Figure 8-26a: adapted chart for progress vs. modelled and actual cost cash flow in percentage during CAPEX stage for project 2 (Wang, Wang et al. 2016).
- Figure 8-27: VENSIM System dynamics modelling results for Project 3 costs including the CAPEX, OPEX, Total Estimated Costs, OPEX NPV, and Projects Whole Life Cycle NPV.
- Figure 8-28: comparing project 3 model vs. actual cost cash flow in percentage during CAPEX stage.
- Figure 8-28a: adapted chart for progress vs. modelled and actual cost cash flow in percentage during CAPEX stage for project 3 (Wang, Wang et al. 2016).
- Figure 8-29: Construction projects' cash flow area method approach for accurate estimation in each time step over project's duration (Konior & Szóstak 2020).
- Figure 8-30: Cash flow area method range of verification project 1 (i.e., within the highlighted area).
- Figure 8-31: Cash flow area method range of verification project 2 (i.e., within the highlighted area).
- Figure 8-32 Cash flow area method range of verification project 3 (i.e., within the highlighted area).
- Figure 8-33: Cash flow area method range of all verification projects 1,2, & 3 (i.e., within the highlighted area).
- Figure 8-34: Cash flow area range of total verification projects 1, 2 and 3 including maximum limits, minimum limits and estimated VENSIM cash flow mean risks S-Curve.
- Figure 8-35: Cost Estimation Accuracy Achievement over the last 50 years (i.e., from 1970 – 2020).
- Figure 8-36: Showing System dynamics (SD) Cost Estimation and Modelling Performance in PM Field.
- Figure 9-1: adapted figure 1-1 showing how research questions are answered to meet this research aim and objective.

LIST OF TABLES

- Table 3-1: Reviewed literatures and governments/ RICS reports for risk identification and allocation which impact cost in construction and project's whole life cycle from 1976 to 2020. This is an adapted table summary from literatures (Boussabaine & Kirkham 2004; Jang 2011; Forbatok 2014; Asal 2014; Osei-Fosu 2014; Andom 2015; Alzahrani 2015; Zhao et al. 2017; Al-Aryani, 2019).
- Table 4-1: Collected good literature review attributes from published articles and how it is adapted in this research study (Steward 2004, p.496; Kucan 2011; Rewhorn 2018).
- Table 4-2: Adapted Questionnaire Questions Analysis Criteria against this research study Questions Design (Makienko & Bernard 2012, p.143).
- Table 4-3: Regression Mandatory Error Assumptions Validation Requirements (Kadiyala 1970; Nazif et al. 2016; Jafarzadeh et al. 2015).
- Table 5-1: General information about interviewees who provided the required risk values based on its probability and impact weightage.
- Table 5-2: Interviewees years of experience within the current organization.
- Table 5-3: Interviewees total years of experience
- Table 5-4: Interviewees experienced size of projects.
- Table 5-5: experience size of projects criteria.
- Table 5-6: Show the detailed correlation analysis conducted for each variable including its Risk vs. Probability & its Risk vs. Impact. This is indicating whether the regression analysis will be successful or not. And will prove the linear relationship between each risk and its probability and impact including each value provided by survey interviewees.
- Table 5-7: summarize how Ratner (2009) classified data linear relationships based on "Pearson's correlation coefficient" r-value.

- Table 5-8: linear relationships classification with colour coding based on literatures "Pearson's correlation coefficient" r-value classifications (Ratner 2009; Schober, Boer & Schwarte 2018; Konior & Szóstak 2020).
- Table 5-9: Regression analysis colour coding criteria used in table 5-10 based on literatures.
- Table 5-10: Show how the detailed summary of each regression analysis conducted for each of the 117 risk factors.
- Table 6-1: Monte-Carlo Modelling table for all validated risks' value. This will be used in the Systems Dynamics Final Cost Estimation Model.
- Table 7-1: Final system dynamics model combining algorithms to satisfy chapter 4 mathematical modelling.
- Table 8-1: It is detailing the verification data percentages including the model adjusting risks (i.e., minimum, mean, and maximum) by presenting all three verification projects and highlight the differences in cash flow between the mean adjusting risks percentages and each project cash flow percentage.
- Table 8-2: it is showing model vs. actual cost summary including the percentages of costs at completion compared with contract value. (contract value is considered 100%).
- Table 8-3: It is detailing the verification data percentages including the model adjusting risks (i.e., minimum, mean, and maximum) while presenting verification project 1 and highlight the differences in cash flow between the mean adjusting risks percentages and project 1 cash flow percentage. Colour legend is shown below.
- Table 8-4: It is detailing the verification data percentages including the model adjusting risks (i.e., minimum, mean, and maximum) while presenting verification project 2 and highlight the differences in cash flow between the mean adjusting risks percentages and project 2 cash flow percentage. Colour legend is shown below.
- Table 8-5: It is detailing the verification data percentages including the model adjusting risks (i.e., minimum, mean, and maximum) while presenting verification project 3 and highlight the differences in cash flow between the mean adjusting risks percentages and project 3 cash flow percentage. Colour legend is shown below.

- Table 8-6: It is showing verification projects used for this research model and how much cost cash flow can fluctuate each time step including project 1, 2 and 3. The total possible fluctuation in percentage for the model is included based on verification S-Curves' maximum and minimum yield points.
- Table 8-7: Error calculation table including the System dynamics VENSIM model and all three verification projects 1, 2 and 3 to get the final estimation cost modelling accuracy which is equal to **96.728%.**

LIST OF DEFINITIONS AND ABBREVIATIONS

2D Modelling: two-dimension modelling.

3D Modelling: three-dimension modelling.

6 D Modelling: six-dimension modelling.

ANP: Analytical-Network-Process.

Auto CAD: Commercial Computer Aid Design for architect, project management, engineers, graphic designs, etc.

AI: Artificial Intelligence.

ANOVA: Analysis of Variance.

BIM: Building Information Modelling.

CAPEX: Capital Expenditures.

CCI: Construction Costs indices.

CPM: Critical Path Method.

CBT: Cost Benefit Analysis.

CCRAM: Correlated Cost Risk Analysis Model.

CEAC: Cost Effectiveness Acceptability Curve.

EXPO: a large international exhibition.

GDP: Gross Domestic Product.

HDM: Hypothetic- Deductive Model which is a mathematical approach.

IRR: Internal Rate of Return.

KSA: Kingdom of Saudi Arabia.

Microsoft Access: Database management system from Microsoft.

MS project: Project Management software product by Microsoft.

MAD: Mean Absolute Deviation.

MSE: Mean Squared Error.

MAPE: Mean Absolute Percentage Error.

NPV: Net Present Value.

NDM: Neural Dynamics Model.

OPEX: Operational Expenditures.

CEI Model: Cost Estimating Information Model.

PROMQACS: Project Management Quality Cost System.

Primavera: Project Management software product by ORACLE.

PBP: Pay Back Period.

PERT: Program Evaluation and Review Technique.

PPP: Public Private Partnership.

PWLC: Projects Whole Life Cycle.

SPSS: Statistical Package for the Social Science.

VENSIM: Time, agent, discrete event-based simulation software for system dynamics modelling.

SD: System Dynamics.

STEEP: Social, Technical, Economic, Ecological, and Political.

UAE: United Arab Emirates.

VAE Model: Vector Auto-regression Model.

WLC: Whole Life Cycle.

r = correlation coefficient

x_i = values of the x-variable in a sample

$\bar{x}$ = mean of the values of the x-variable

y_i = values of the y-variable in a sample

$\bar{y}$ = mean of the values of the y-variable

ν_t = nonzero eigenvalues

ρ = Durbin -Watson statistic hypothesis

e_t = the residual error

e_{t-1} = the previous residual error

d = Durbin -Watson statistic

t = Time

T = total number of observations

R^2 = ariance proportion in dependent variables explained by independent variables

$\mathbf{y_i}$ = actual Observation

$\hat{\mathbf{y}}_\mathbf{i}$ = predicted Observation

$\bar{\mathbf{y}}$ = mean of Actual value

Y_i = dependent variable

f = function

X_i = independent variable

β = unknown parameters

e_i = error terms

$\mathbf{Y_R}$ = the Risk dependent Variable of each factor.

$\mathbf{X_{prob}}$ and $\mathbf{X_{imp}}$ = the probability and impact independent Variable of each factor.

$\boldsymbol{\beta_{prob}}$ and $\boldsymbol{\beta_{imp}}$, = the Linear Regression Coefficients for X_{prob} and X_{imp}, respectively of each factor.

$\boldsymbol{\xi}$, = the Error (Considered Zero because this regression is not time-based).

$\boldsymbol{n_0}$ = Sample Size

$\boldsymbol{Z}$ = Standard score

$\boldsymbol{p}$ = the (estimated) proportion of the population (variability)

$\boldsymbol{q}$ = $1 - p$

$\boldsymbol{e}$ = Desired level of precision (i.e., 0.05 for 95% confidence level)

Min = the Minimum Survey Risk Value

Max = the Maximum Survey Risk Value

MC = Monte Carlo average of 10,000 random values (between 0 to 1).

$\boldsymbol{\sigma}$ is the risk standard deviation

$\bar{x}$ is the survey sample mean risk

Max Risk is the Normal Distribution Upper Limit

Min Risk is the Normal Distribution Lower Limit

δ = **Percent error**

v_A = **Believed actual value (i.e. Adjusted value)**

v_E = **Experts estimated value**

X = the time point on S-Curve chart

e = exponential constant

T_0 = the maximum slop adjusting parameter. The maximum slop increases as it increase.

t = the time step of f(x) cash flow point.

α = is the stepness of the curve

$\boldsymbol{P_T}$ = the probability of time danger

$\mathbf{T_E}$ = the total execution time

$\mathbf{T_S}$ = the risk time step value

$\mathbf{C_S}$ = the cost S curve value at each time step (from 0 to 1).

t = the time step of f(x) cash flow point.

$\boldsymbol{P_C}$ = the probability of cost danger

$\mathbf{C_{RGmean}}$ = the mean cost risks of each CAPEX risk group.

$\mathbf{C_{RGmin}}$ = the minimum cost risks of each CAPEX risk group.

$\mathbf{C_{RGmax}}$ = the maximum cost risks of each CAPEX risk group.

t = system dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 3).

i = the risk number in each group (i = 1, 2, 3, …, etc.).

C_D = initial construction contract cost at each time steps (t = 0, 0.125, 0.25, …, 3).

D_T = the initial construction contract cost at pre-construction design stage

C_{RCmean} = CAPEX Risks Cost (mean risk).

C_{RCmin} = CAPEX Risks Cost (min risk).

t (equipment) = system dynamics time of pulse impact (t = 28, 53). Every 25 years after CAPEX.

D_T = the initial construction contract cost at pre-construction design stage

E_C = equipment replacement cost as a ratio of total building cost ($E_C = 0.15$)

$\mathbf{O_{RGmean}}$ = the mean cost risks of OPEX risk group.

i = the risk number in OPEX group (i = 1, 2, 3, …, etc.).

$\mathbf{O_{RGmin}}$ = the minimum cost risks of OPEX risk group.

$\mathbf{C_{RGmax}}$ = the maximum cost risks of OPEX risk group.

$\mathbf{Y_{TS}}$ = the number of time steps per year (Y_{TS} = 8).

t = system dynamics time steps (t = 3, 3.125, 3.25, 3.375, 3.5, …, 60).

$\boldsymbol{O_M}$ = the ratio of operation and maintenance to initial capital investment ($\boldsymbol{O_M}$ = 0.09/25).

$\boldsymbol{E_C}$ = the equipment to initial capital investment ratio ($\boldsymbol{E_C}$ = 0.15).

O_{RCmean} = OPEX risks cost (mean risk).

O_{RCmin} = OPEX risks cost (min risk).

O_{RCmax} = OPEX risks cost (max risk).

$TOTEX_{mean}$ = Total expenditure under mean risk impact.

$TOTEX_{min}$ = Total expenditure under minimum risk impact.

$TOTEX_{max}$ = Total expenditure under maximum risk impact.

Chapter 1
INTRODUCTION

"*The introduction to the research is an essay that introduces readers to both the topic and the purpose of the research while providing an overview of the relevant literature.*"

(Galvan 2002, p. 14)

1.0 Inception

In this chapter, a brief introduction will be provided about cost modelling and estimating residential project's whole lifecycle industry, the United Arab Emirates needs and demands for the development of cost models in residential projects, including construction and operational industries, the status and overview of projects construction and operational economy, investments economy, and the planned economy of future developments in the United Arab Emirates. Then, the research questions, aims, objectives, and significance will be stated and identified clearly. After that, the research paper structure shall be introduced to summarise the thesis chapters and outcomes. Finally, the conclusion will be sum up the research introduction to introduce the following chapters starting with the literature review.

1.1 Cost Modelling and Estimating in Residential Project's Whole Lifecycle Industry

In business investments fields, it is essential to target having and making the maximum profit of invested money while overcoming all challenges and obstacles which might face the processes and operations of making and generating profits (Abdul-Rahman et al. 2013). However, this is due to knowing that the construction industry cost overrun became the most significant problem globally and due to the sustainability of investments, which had to be implemented in all kind of businesses, especially in an uncertain market after the economic crises in 2008 (Wu, Olson & Birge 2011; Abdul-Rahman et al. 2013). However, most developments in the developed and developing countries are focusing on the construction industry to provide the appropriate infrastructure and liveable cities; also, residential projects including, construction and operation, contribute to providing the required and necessary facilities and living requirements of sustainable waive of life for humanity (Forza 2002;

Nguyen, Ogunlana & Lan 2004; Cicmil et al. 2006; Winter et al. 2006; Leiringer 2006; Pantouvakis & Vandoros 2006; Santos & Ferreira 2011; Shi 2011; Memon & Abdul-Rahman 2014; Wang et al. 2016). Thus, that can be the reason why it is essential to have large, complex, expensive, and significant built environment projects developments such as housing projects (Price 2003; Oliver, Serovich & Mason 2005; Kazaz, Birgonul & Ulubeyli 2005; Yuan et al. 2011; Jin et al. 2012; Kuricheva & Popov 2016; Lindemann & Jahnke 2017; Cai et al. 2016; Canesi & Marella 2017; Abdul-Rahman et al. 2013; Koo, Hong & Hyun 2011; San & Heng 2011; Wu, Olson & Birge 2011; Sayed & Sawant 2015; Wibowo 2015; Fogsgaard et al. 2016; Yusof et al. 2016; Banihashemi et al. 2017). However, cost became the most critical issue due to the increase of demanding more quality of larger and more complex projects, like housing, in a shorter period (Wang & Mei 1998; Lewis 1998; Park et al. 2012; Horta et al. 2012; Sharma, Najafi & Qasim 2013; Shehu et al. 2014; Smith 2014; Hoffman et al. 2017). Thus, the modelling approaches of the future estimated costs of projects became essential for reaching business targets and achieve investments' purposes from all stakeholders' perspectives (Tang, Aoieong & Ahmed 2004; Kim, An & Kang 2004; Kim et al. 2004; Fleming & Bowden 2009; Mawdesley & Al-Jibouri 2009; Lehtonen & Kiiras 2010; Zhiliang, Zhenhua & Zhe 2011; Kim et al. 2012; Kim, Seo & Hyun 2012; Ma, Wei & Zhang 2013; Wang, Xia & Zhang 2014; Jafarzadeh et al. 2015; Ozcan-Deniz & Zhu 2016; Alshamrani 2016; Seo & Park 2017; Ballarini et al. 2017; Islam et al. 2015; Tam et al. 2017; Abanda, Kamsu-Foguem & Tah 2017; Zhao, Chen & Thomson 2017; Lee et al. 2013). Also, due to the long-time consumed in executing and operating projects (i.e., years), and because of the large number of changing project parameters while values of those variables can change several times during the execution and/or operation processes of one project, the estimating cost modelling methods and approaches became researchers' concern to add more value and improve the industry

outcomes throughout researching for more accurate and better cost estimation modelling in residential projects (Yu & Lo 2005; Agyapong-Kodua & Weston 2011; Torriti 2012; Hafez, Aziz & Eldars 2015; Doan & Chinda 2016; Enezy et al. 2017; Hasançebi 2017).

Cost modelling research investigated knowledge and information impacts and effects on the quality of residential projects estimated to cost at the pre-construction stage by analysing each criterion as per its significance (Hardcastle 1992). Furthermore, it is evaluated mathematically to design and build the knowledge and information model concerning its cost on projects (Hardcastle 1992). The research also covered project profitability studies based on modelling costs and their changing variables, affecting the actual final cost and deviating it from the estimated values (Cui 2005). However, economic inflation and tax are considered the most significant and vital factors that affect the investments' profitability, which must be considered in construction businesses (NikoliC 2003). Besides, estimating and studying risks impacting cost estimation values of residential projects was carried out in the early 2000s using a systematically related mathematical model (Isaksson 2002). Later, the risk analysis and its impact on cost prediction started to gain more advanced analysis techniques, and mechanisms in 2014 throughout the construction stage, including mathematical equations implementation such as system dynamics, analytical network process, and Monte Carlo approaches (Boateng 2014). The construction cost studies also investigated risk allocation identification and control using system dynamics and Monte Carlo modelling throughout the project's whole life cycle. These studies were carried out to have an appropriate and accurate cost estimation and prediction at the pre-construction stage compared with the actual cost at the end of projects. These studies were based on the relationships between projects' life cycle and risk events' impact on costs (Alzahrani 2015). This articulated that the risk impact on estimating the construction costs was a concern in most of the conducted studies during the last three decades.

Thus, regarding the cost modelling to estimate the projects' cost value at the pre-construction stage, artificial intelligence was used as a modelling tool. It claimed that accuracy was above 90%. These studies were based on building prediction value using the historical data of more than 1600 projects. However, it showed a weakness in estimating the cost of different construction projects type other than historical data (Ahiaga-Dagbui 2014). The researchers also investigated the whole cost life cycle's net present value to evaluate the project's actual value based on time, operation, and execution costs. Thus, NPV calculation results provide a better selection of contractors at the pre-construction stage (Jang 2011). However, the recent work on cost modelling estimated construction projects' duration based on 74 office and 113 residential buildings in the USA (Jarkas 2016). This study used Bromilow's time cost multifactor model to accurately determine the forecast results (Jarkas 2016). Thus, in UAE, no previous study included the required variables for this research, and it is mandatory to collect all common verified variables related to cost modelling and estimation from previous empirical studies and published literature. Then, verify its applicability on UAE projects. Integrating a new cost estimation model through this research for residential projects to include its construction and operations aims to create a simpler and more accurate model than all previous models.

1.2 The Status of Buildings Projects and Investments Economy

In this part, an overview of why more accurate cost models are required will be summarised. These models are now necessary to study the sensitivity of construction costs after the economic crisis. Therefore, projects cost modelling and analysis can analyse the significant impact of the economy and determine the most accurate decision concerning costs. Therefore, understanding the impact of a project's cost economy is essential to decide and find more

accurate financing methods (Betlejewska & Potkány 2015). Projects investments are based on the economics' status throughout the project's whole life cycle, starting from its execution and ending with the last operational processes. This is necessary to achieve sustainable development, which is the primary concern globally for years (Betlejewska & Potkány 2015). This threat to the economy is analysed financially, including inflation, uncertainty, and market investment competition to find out and predict project failure. Hence, it is mandatory to set an appropriate strategic management map of the economy during sustainable development in GCC countries (Ibn-Homaid & Tijani 2015). However, the studies showed that the whole life cycle of projects is affecting economy from the initiation of projects until its demolition (Kaiser & Snyder 2012; Han, Srebric & Enache-Pommer 2014; Smith 2014; Delmastro, Mutani & Corgnati 2016; Kirkwood, Shehab & Baguley 2016; Rodrigues & Freire, 2017; Mostavi, Asadi & Boussaa 2017). Thus, project performance sustainability is assessed financially from the design stage, via execution and operation stage, until reaching the demolishing stage (Shen et al. 2007). First, cost control is considered effective at the projects' design stage because variables and expected causes that impact costs are not yet executed and can be changed during design stages or excluded to eliminate a significant negative impact (Friedler & Pisanty 2006). Therefore, this research study shall include design costs based on UAE actual residential projects' design engineering fees contractual percentage and verify it with published residential buildings design fees percentages (Eckman, Cavaluzzi & Rabasca 2014; Hyari, Al-Daraiseh & El-Mashaleh 2016; Thompson 2020). Then, projects at the deconstruction stage have a salvage value coming from wastes materials recycling and reuse at the demolition stage, which should be considered in project whole life cycle cost estimation modelling (i.e., deconstruction: is representing demolition cost after considering the salvage value of wastes) (Marzouk & Azab 2014; Zahir 2015). Therefore, this study shall include the deconstruction stage in the

established cost model based on the literature of demolishing construction percentages and residential buildings depreciation percentage in the UAE (MICHIGAN RESIDENTIAL ASSESSOR'S MANUAL 2003; Zahir 2015; Bham 2016). Building depreciation percentage in UAE will cover costs such as waste quantities, disposal type, and recycling type (Zahir 2015; Bham 2016). However, those costs risks will require experiencing housing demolitions in the UAE through time and under deferent regulations and technologies that did not happen in any UAE housing projects. This study led this research to consider deconstruction percentage only.

The final estimation model will include the costs of environmental impact, energy consumption, quality of the end product, and the economic performance during the execution stage and the operation stage (Friedler & Pisanty 2006). Then, after interviewing 50 experts by researchers for extracting information related to construction funding, the main challenges regarding design, build and operate projects are the conflict of interest, financing entities, and alignment of interests, which are based on cost estimation value compared with actual cost (Levitt & Eriksson 2016). Furthermore, after modelling construction projects' investments in the United Kingdom, the ratio of benefit to cost decreased when the construction cost rose and cause many uncertainties at the economic decision-making stage (Thijssen 2015). Besides, research proved that the appropriate estimation of the construction cost is a significant factor of investment success; this is because of setting the project's budget based on predicted cost value, which is usually at the pre-construction stage (i.e., design stage) (Hong, Hyun & Moon 2011). The authors developed an algorithmic model for cost estimation showing errors and accuracy deviation between -4.25 % and 5.25% after using it on 4-four different projects (Hong, Hyun & Moon 2011). The model limitation is that it cannot be generalised because four projects are not good enough to capture challenges affected and affecting factors of projects cost estimation models (Hong, Hyun & Moon 2011). Moreover, the impact of construction on

the environment and its economic profit is considered the most crucial factor in construction cost modelling (Zhang & Chen 2016). This is due to the uncertainties of environmental needs, requirements, regulations, and legislation changing with time during the executing phase (Zhang & Chen 2016). On the other hand, the project cost analysis is essential for studying socio-economics factors and predict their impact on projects net present value (Florio, Forte & Sirtori 2016). This will help develop and model strategic management for the entire life cycle of sustainable economic development projects through a proper investment feasibility analysis and decision-making (Diskiene, Galiniene & Marčinskas 2008; Molinos-Senante, Hernández-Sancho & Sala-Garrido 2010). Thus, this research will solve these issues by developing integrated projects' whole life cycle cost estimation model to support residential buildings' decision-making processes in the United Arab Emirates.

1.3 Future Economic Developments in the United Arab Emirates

UAE's direction is to increase the accuracy of estimated cost values to improve investments and economic strength while successfully achieving future plans such as the Abu Dhabi 2030 vision plan. This is from the country's new directions concerning its five and ten-year plans, which started in 2015 for EXPO 2020 and Dubai Vision 2021. Nevertheless, achieving large size developments within the required timeframe, quality, and optimum cost will help in keeping up with the UAE government directions and strategies to "dazzle the world with our culture and our excellence, to be the first of its kind in the history of Expos in terms of the preparation, organisation, management and hospitality and respect for its guests" said by His Highness Sheikh Mohammed bin Rashid Al Maktoum, the United Arab Emirates Vice President, Prime Minister and Ruler of Dubai (Emirates 24|7 2016). "The UAE serves as a role model for coexistence among different cultures that are represented by the millions who live

in the UAE," said His Highness Sheikh Mohammed bin Zayed Al Nahyan, Crown Prince of Abu Dhabi and Deputy Supreme Commander of the UAE Armed Forces (Ministry of Culture and Youth 2017).

So, countries in the Middle East region started building and constructing sustainable developments. Furthermore, as a leading country in the region, UAE prepared for unique developments to dazzle the world, especially after EXPO 2020 in Dubai and established Abu Dhabi and Al Ain 2030 vision. Moreover, targeted developments started to demand more complicated and luxury projects with optimum cost (Assad et al. 2007; Dubai-Government 2016; KSA-Government 2016; Abu Dhabi-Government, 2016a, 2016b, 2016c, 2016d, 2016e, 2016f). Finally, it is published by UAE Fujairah local government that they need to increase residential projects besides expanding healthcare facilities and other projects due to the growing emirate's population according to their plan of 2040 (Fujairah Government 2018). Hence, this research's outcomes are expected to serve UAE building projects and developments for a long time, which will add value to existing cost modelling literature.

1.4 The Need for Cost Models Development in the UAE Projects industry

A country like the United Arab Emirates has been established since the seventies (i.e., 2nd December 1971) and experienced challenges through years up to date related to cash flow. For example, infrastructure had to be built and developed continuously besides buildings and structural developments that experienced significant enhancements and improvements countrywide. Nevertheless, nowadays, the country changed its visions and planned to provide a sustainable country by having sustainable developments forming sustainable cities; these changes happened due to the collapse of oil price and the demand of having a top developed

country in the world while covering oil price collapse to minimise and eliminate its negative impacts by national income diversification.

Due to GCC countries' economic growth besides the modernisation demand and burgeoning population, the building sector's sustainability increasing needs gained more experience and growth (Asif 2016). Thus, since GCC countries are taking a very high position globally and the United Arab Emirate reached to be from the top countries in construction industries, it is significantly essential to realise the demand of the new developments which are changing continually in order to keep up with new innovations and future plans (Asif 2016). The United Arab Emirates and the Kingdom of Saudi Arabia have taken around 80% of construction market investments in GCC countries (Asif 2016). This made the factors of policy and legislation roles regarding construction businesses increase and become more critical for achieving sustainable developments required for implementing future plans of the emirates (Asif 2016). Thus, cost modelling is essential because of the demanded expensive technologies and designs of modern buildings pushing development sustainability to reach higher than the existing minimum requirements (Radhi 2010). Also, studies that are including residential buildings showed that it is important to reduce construction and operations costs; however, the Urban Planning Council (i.e., UPC) in Abu Dhabi requires less impact on the environment during operational construction stages residential buildings (Radhi 2010). These requirements increased cost significantly while budgets are not increased at the same pace due to the economic issues (Radhi 2010). The new façade (i.e., external building cladding) design and execution in the United Arab Emirates had a big jump toward sustainability achievement by reducing the consumption of energy at operational stages; nevertheless, this is increasing costs because it demands more experts in the design stage, more resources/technologies in the

execution stage, and more demand for manufacturing suppliers of expensive special materials (Radhi, Sharples & Fikiry 2013).

Then, UAE has adopted the building information modelling (BIM) of construction in Dubai Municipality to reduce conflicts between stakeholders, reduce conflicts of coordinating between parties and activities, and increase the accuracy of cost estimating and modelling (Mehran 2016). Therefore, the 3D modelling approach helps set an appropriate plan and schedule while allocating appropriate resources at the pre-construction stage (Mehran 2016). This is the future direction in the construction industry's academic and professional fields, proving how cost modelling improvement demands in the United Arab Emirates are significant (Mehran 2016). Thus, it is important to follow up with countries' governance policies for complex construction projects, including risk emergent resulting from conflicts, extreme adjustments/ modification, and renegotiations (Naderpajouh & Hastak 2014).

In the United Arab Emirates, the construction industry started to be the main business as a series of activities that generate money. However, the price of residential units reached over 2200 AED/SQF in 2008, and it dropped down to below 1000 AED/SQF in 2012 due to the recession, which resulted from the economic crises (Asteco Property Management 2015). Nevertheless, it was expected to have prices increasing again, but it reached by the end of 2016 to about 1300 AED/SQF, which is approximately 60% of 2008 residential buildings prices (Deloitte 2018). On the other hand, inflation affects everything related to construction execution materials costs (Frimpong, Oluwoye & Crawford 2003). This made the contingency margin and weightage of having construction costs underestimating very high in a way that might break down and fail organisations and projects. However, due to reducing bidding prices to get the project at the tender stage, the most critical decisions and changes in the construction industry and investments are based on businesses' capital and costs (i.e., projects) (Donovan &

Corbishley 2016). Also, after the drop in the oil price and the new directions of shifting the country's income from being based on oil to be based on several investments like healthcare, education, transportation, tourism, and construction; on the other hand, United Arab Emirate GDP growth experienced a drop of 14.9% from 2014 to 2015 (Annual Economic Report 2016). As a result, this research significance comes from the need for residential project cost optimisation.

Finally, the cost of quality (i.e., cost of rectifying and reworking) in Dubai has reached 1.3% of total civil works in construction projects, while the failure cost has reached 0.7 % of the total project cost (Abdelsalam & Gad 2008). This is demanding cost estimates to predict an accurate value based on the project's complexity and size; however, cost estimation includes expected processes of reworks and quality costs in the construction industry (Abdelsalam & Gad 2008). In this industry, it is impossible to prevent defects and reworking comments at a certain execution stage. Nevertheless, including these considerations in cost modelling will significantly enhance cost estimates' accuracy to assign an appropriate budget for the project (Abdelsalam & Gad 2008). To sum up, this research will add value in understanding residential building development costs by using system dynamics, which considers risk and economic parameters.

1.5 Research Problem Statement

This research cost model will investigate the ability to utilise a system dynamics approach to develop a whole life cycle of the residential project cost estimation at the pre-construction stage. It is also investigating how mathematically cost risk change impacts the final cost estimation accuracy in the United Arab Emirates. Finally, the research investigates

how the delivered model can adjust cost change dynamically to generate sensitive analysis scenarios for decision-makers.

1.6 The Research Aim, Objective, and Questions

This research study aims to provide more accurate projects' whole life cycle cost estimation model. This model will support the decision-making process of residential buildings in the United Arab Emirates. This model is developed from the client and developer point of view at projects' pre- construction stage to support sustainable developments in the United Arab Emirates.

This study aims to approach system dynamics to model the project whole life cycle costs dynamically over time. This purpose is accomplished by satisfying 6 sub objectives. These sub objectives are used to ensure that all research questions have been answered successfully to meet the research aim and main objective. First, it is required to develop the model to identify all impacting risks. Second, it is required to simulate cash flow behaviour over time. The third and fourth sub objectives, respectively, are providing numerical values and graphical presentation for model's outputs over time. The fifth and sixth sub objectives are providing the net present value and the final cost value. The model is implemented through system dynamics VENSIM software, which can be flexible to adjust any possible necessary changes. Following research questions are set as guidance to satisfy this aim as explained in figure 1-1:

1- What are the risks' values of the UAE residential project's whole life cycle cost estimation?
2- How to model mathematically and graphically map all identified and verified risks?
3- How to approach modelling cost estimation dynamics through time, including cash flow, for UAE residential building projects' whole life cycle?

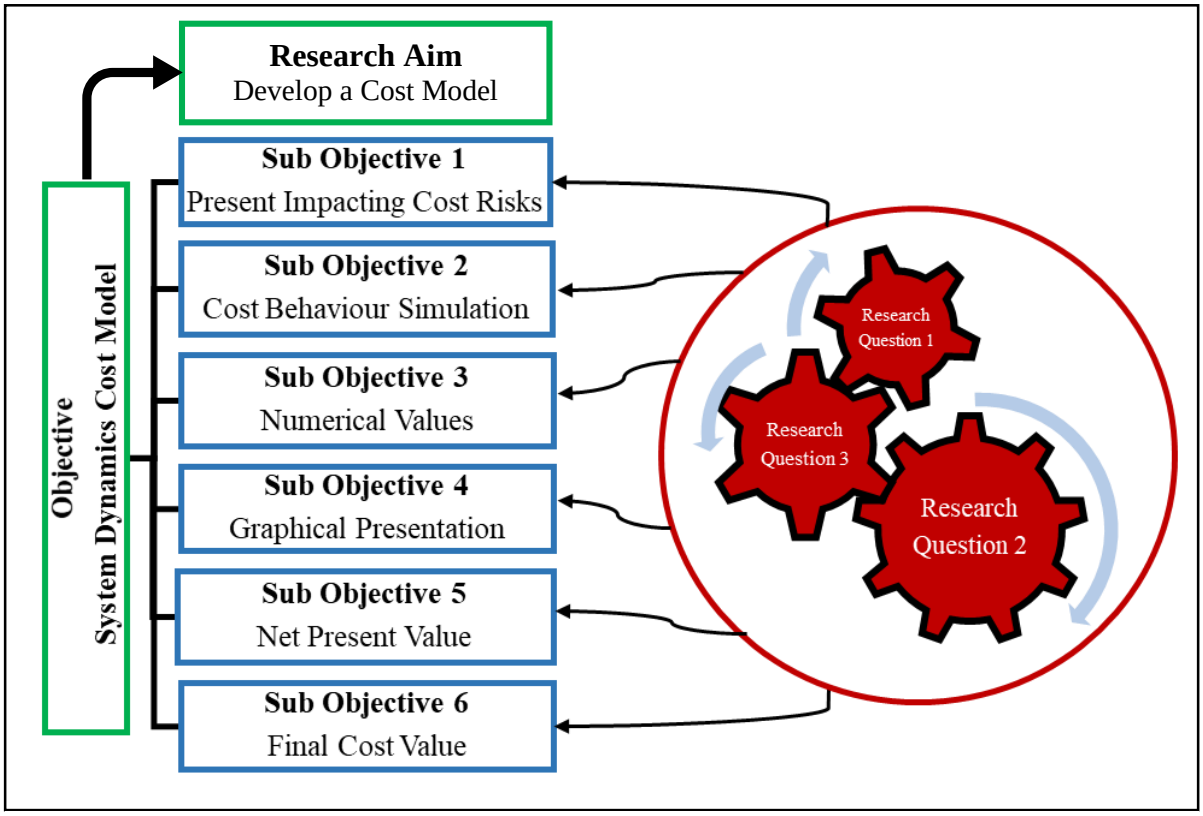


Figure 1-1: Research Aim, Objective, and Questions. The aim is to develop a cost model. The objective is to achieve a dynamical cost model. The sub objectives are to ensure that answered research questions will satisfy this research aim and objective.

1.7 The Research Significance

The research significance of this study is to contribute to achieving United Arab Emirates vision, plans, and pace regarding the targeted new sustainable developments for a better future (Cassell & Symon 2004; Schieg 2010; Turskis, 2008; Johnsen, Howard & Miemczyk 2009; Nasirzadeh, Khanzadi & Rezaie 2014; Lovering, Nordhaus & Yip 2016; Asif 2016; Akter, Mahmud & Oo 2017; Liu & Lin 2017). This is by developing a new cost estimation model using system dynamics for residential projects' whole life cycle while utilising probability and quantitative mathematical approaches to enhance model accuracy. This model will introduce the results of investigating system dynamics in utilising mathematical equations, Monte-Carlo simulation, risk, and historical data in estimating project

costs at the pre-construction stage. Therefore, clients will have the following advantages at the pre-construction stage if they choose to use this research system dynamics cost estimation model:

1- Full cash flow estimation from start to end of residential project's WLC in UAE.

2- Present three curves of residential project's WLC costs cash flow at any selected time step.

3- Compare three curves of the adjusted project's WLC contract value cash flows, including minimum risks, mean risks, and maximum risks, in the same model simulation simultaneously.

4- Adapt the change of risks whenever required to simulate cash flows after any adjustment using the same model.

5- Present the net present value of residential project's whole lifecycle cash flows from start to end, including each time step value in each simulation.

6- Provide separate curves of CAPEX cash flows individually, including its risk implementation curves and its net present value (NPV).

7- Provide separate curves of OPEX cash flows individually, including its risk implementation curves and net present value (NPV).

8- Provide estimation curves of TOTEX (i.e., CAPEX, OPEX, and Equipment Replacement), including its risk implementation curves and net present value (NPV).

9- Compare CAPEX and OPEX actual against estimated cash flow curves.

10- Provide modelling and simulating outputs with an accuracy of **96.728%.**

1.8 Research Methodology

The approach of this research methodology is going to be a quantitative approach to enhance the results of the mathematical research model and outputs through System dynamics VENSIM, SPSS, and Monte-Carlo Analysis based on the following steps:

1- First, conduct a detailed literature review and validate the topic,

2- Identify and verify the model's variables and map them in classification groups.

3- Define the required data for satisfying the research goals and objectives.

4- Design data collection technique and mechanism (i.e., 55 completed face to face quantitative structured experts' surveys for each variable).

5- Design the questioner and make a pilot sample to optimise it.

6- Invite experts for interviews and await their response to conduct the interview.

7- Collect the data and validate it using SPSS (i.e., find out the relationship, outliers, and descriptive statistics).

8- Conduct a regression analysis to find out the limits, minimum, and maximum values of influencing strengths.

9- Conduct a Monte-Carlo Simulation for each variable to increase the accuracy of random points picked up between the defined minimum and maximum points and determine the final influence coefficient of each variable.

10- Find out the time relationship between variables related to CAPEX and OPEX of the project whole life cycle.

11- Build the final system dynamics model and validate it.

12- Discuss the results and draw a conclusion clarifying the limitations and challenges of this research besides further research.

1.9 Research Structure

In this part, a summary of the research thesis will be provided for each chapter, including its aim, content, and outputs; however, this is to facilitate readers and researchers to understand this empirical study and its contribution to the project management body of knowledge. Therefore, the following summary of each chapter included in this research thesis will make it easier and simpler to navigate through this research from its start to end.

1.9.1 Chapter 1

Chapter 1 introduces this empirical research study to familiarise the reader with the conducted research, including its aims, objectives, significance, and contribution to the body of project management knowledge. However, it also includes the thesis structure and a summary of each of its 9 chapters.

1.9.2 Chapter 2

Chapter 2 is the literature review of this research, covering all conducted empirical and published research related to the chosen topic. However, in this study, the research area is including several fields' keywords such as cost estimation, modelling, construction, residential projects, United Arab Emirates projects, risks, and system dynamics. Therefore, each field key world includes a magnificent amount of existing research contributions over tens of years before this study take place in the body of knowledge. Each field key word also includes deferent areas such as cost estimation, including deferent areas like construction, information technology, deferent engineering disciplines, and even medical studies. In chapter 2, the researcher considers all contribution of areas related to the proposed studying topic when

literature review covers each keyword. For instance, cost estimation research started to take researchers' attention and concentration from the early 90s who covered the research done since the 70s onward. However, the cost estimation considered knowledge modelling, mathematical modelling, artificial intelligence, and many other approaches using system dynamics for cost estimation. The construction project management research included risk modelling, infrastructure net present value, infrastructure project whole lifecycle modelling, and historical data modelling of infrastructure modelling; however, they didn't complete residential project whole lifecycle stages cost modelling. Finally, system dynamics included modelling many systems like infrastructure PPP projects risks, technical lifetime expected due to roads usage, and infrastructure net present value modelling; however, no one up to date used system dynamics VENSIM modelling to estimate costs and provide predicted cash flows over time steps through the whole lifecycle.

Finally, chapter 2, will end with what has been accomplished concerning this study research field; and what is missed and will be covered to form this research contributes to the project management body of knowledge.

1.9.3 Chapter 3

In chapter 3, the literature review journey is not finished yet. After identifying research gaps and justify the research topic, it is mandatory to dive in the published research and empirical studies to identify risks that impact cost modelling and/or estimation. However, it is important to group all identified risks and map their relationship connection before any further analysis.Nevertheless, the identified risk groups were 11 groups, impacting CAPEX cost estimation modelling and one group for OPEX cost estimation modelling. Therefore, each group's figure will be presented to show graphically how each risk is interacting with other

risks and with CAPEX / OPEX final outputs. Finally, the conceptual mapping model will show how all the 117 risks interact with each other from start to end of cost estimation time steps values.

1.9.4 Chapter 4

Chapter 4 presents the detailed research methodology from start to end, describing how this empirical study starts and systematically progresses to provide validly and verified outputs; however, this research's primary approach is modelling using system dynamics software. This modelling process requires pre-arrangements and research approaches such as collecting data from experts through a well-designed survey questioner. Then, validate the collected data statistically using SPSS software through correlation and regression modelling. Then, simulating the validated data resulting from SPSS for each risk factor in Monte-Carlo Simulations to adjust risk values. Use the resulted adjusting risks from Monte-Carlo modelling in a mathematical relationship system to prepare the inputs of the VENSIM system dynamics model. After that, simulate the completed built system dynamics model and validate its functionality. Finally, verify its accuracy using actual cost flow data from residential projects in the United Arab Emirates. However, the designed survey used in collecting the data from experts will be attached as Appendix A.

1.9.5 Chapter 5

Chapter 5 is the stage of analysing collected data from experts from 55 experts through face-to-face surveys to ensure that the interviewee understands the aim and required answer. However, this will optimise the accuracy of collected data and ensure that it is related to the

research objectives. Then, general information about experts such as how many years of experience they have, what sector they are working in currently (i.e., private or public), what position they are rolling at present, and the size of projects (i.e., cost), which they are handling at present during their job activities. The detailed correlation analysis will then take place for each risk factor and summarise the main outputs in a table to discuss its results and ensure that linear relationship exists between data sets (i.e., Risk vs Probability and Risk vs Impact) for each risk factor. However, after ensuring linear relationships between each risk data set, linear regression modelling will be conducted to create a linear equation for each risk using its probability and impact and their beta coefficients that show negative or positive relationships as applicable. Finally, the detailed SPSS outputs and charts/figures will be attached to this research thesis as Appendix B.

1.9.6 Chapter 6

In chapter 6, after validating the data collected from experts through utilising SPSS analysis and modelling, a Monte-Carlo model is created to conduct 10,000 random values between the minimum and maximum values of each risk. In other words, the Monte-Carlo simulation is made for each of the 117 risks to fill the random samples gap with 10,000 random values between the minimum and the maximum values. However, this is done by adding the average of 10,000 random values to the minimum value for each risk to get adjusted risk values. Thus, the error between mean risk values provided by experts and adjusted risk values is adjusting risks; nevertheless, these adjusting risks will be the inputs of the final system dynamics model. This is because experts already considered the risk cost in contracts value and have their management plan to minimise or avoid the risk while the actual risks can vary accordingly. Therefore, the unknown variation of risks will require adjustment in the clients

cost prediction model. Finally, the calculated adjusting risks will be applied to the project's construction contract value through the mathematical relationship in VENSIM's system dynamics model as shown in chapter 7 to end up with estimated actual costs of the project's whole life cycle.

1.9.7 Chapter 7

In chapter 7, the system dynamics stock and flow model of each risk group is developed systematically; however, those groups will be connected to develop CAPEX and OPEX stock and flow system, dynamics models. Then, CAPEX and OPEX models are connected mathematically to provide the final project estimated cost for the whole life cycle from design to demolition. After that, the stock and flow of equipment change in the OPEX stage are built and connected to the final model. Finally, each OPEX and CAPEX's net present value is developed and connected to the model based on the estimated costs cash flow and considering each time step in the simulation.

1.9.8 Chapter 8

In chapter 8, model validation using assumed contract value (i.e., let it be 400,000,000 AED) to check the final developed model's functionality for each element is completed. However, this process will ensure that the model provides appropriate and accurate cost estimation and cash flow predictions before applying real data verification in the system.

Three completed CAPEX real project values are used to verify the final developed project's whole lifecycle cost estimation system dynamics model. The verified outputs will be including final estimated costs and predicted cash flows S-Curve during construction execution. Finally, OPEX is validated through assumed value, and it cannot be verified with

real data because the model is over 60 years while the United Arab Emirates is 49 years old as of 2020; therefore, the required OPEX verification data is absent at present.

1.9.9 Chapter 9

Chapter 9 is the conclusion of this research study. It is taking place to summarise what the latest related research has accomplished, the contribution of this research thesis to the project management body of knowledge, the approach to complete this research study, and its outputs. However, this study's limitations have been summarized, including the most critical limitations. Although the final model has been validated, opportunities for conducting further researches start from these research outcomes.

1.10 Summary

From chapter 1, this research study has been introduced for further investigation into cost estimation modelling at the preconstruction stage. The inception has briefed this chapter components. Then, a comprehensible critique from subject's relevant literatures (i.e., cost estimation and modelling) is developed to explain the need for additional research works under the chosen topic. This included a review for the residential project's cost modelling and estimation literature, the status of investments economy and buildings projects, the future economics of the United Arab Emirates, and the need for cost estimation models in the United Arab Emirates. Thus, the identified research problem has been clearly stated. And the research aim, objective, and questions are set to contribute in solving the identified problem. Finally, the research significance, methodology, and structure have been introduced to articulate a rational justification for the chosen topic.

Chapter 2
LITERATURE REVIEW

"*Where should I begin?*"

(Galvan 2002, p. 17)

2.0 Introduction

Financial management in the construction industry has many paths and ways, elements and factors, and concerns and issues regarding the process designing and engineering (Yana, Rusdhi & Wibowo 2015; Rodrigues & Bowers 1996; Khang & Myint 1999). For example, high pressure of clients on contractors, subcontractors, and even the consultant to achieve the required quality and time increases costs rise significantly (Yana, Rusdhi & Wibowo 2015; Rodrigues & Bowers 1996; Khang & Myint 1999). The design stage needs to identify complexity in each of its parts to achieve a successful execution and deliver the designed product with the lowest tolerance and using rare and/or expensive equipment, materials, and other resources optimally (Yana, Rusdhi & Wibowo 2015; Rodrigues & Bowers 1996; Khang & Myint 1999). On the other hand, some researchers such as James (2014) found that managing team members and their competencies contain most financial management factors in the construction industry, including managing human resources as a primary core subject (James 2014). For instance, the subject assigned to employees' wedges should be carefully designed (James 2014). Also, experience, capabilities, and competencies have to match each employee's offered packages (James 2014). Therefore, it is crucial to consider updated critical success factors and risks to improve the final modelling outputs in this research study.

Besides, the economic structure of the United Arab Emirates has been changed. It is changing to reduce construction cost for all executers in the private sector as a government financial initiative to minimize risk and enhance economic performance (Radhi 2009). Furthermore, construction financial management had to include risk assessment plans regarding value engineering of resulted products compared to the consumed amount of money and resources (Ibn-Homaid & Tijani 2015). This is a significant issue, especially when the contractor

fails the project execution stage and hand over the work to another contractor or holds it for some time; hence, it can affect banks' capability to finance construction projects and bankrupt companies (Ibn-Homaid & Tijani 2015). Thus, the value engineering assessment should consider that uncertainty, risks, inflation, profit, and industry costs should be included (Ibn-Homaid & Tijani 2015). Value engineering assesses critical success factors of construction procurement effectiveness, project implementation, economic conditions, and government guarantees for optimum results of invested money and resource (Winter et al. 2006; Bari et al. 2011; Takim & Akintoye 2002). Cost modelling became the most important priority to assess money invested in projects at pre-construction stages for reaching more value of the resulted executed project. This is an added value to this research study because cost modelling and estimation can solve financial management and value engineering challenges.

Cost modelling issues have been raised in the construction industry from the early eighties because of the demand for complicated fast large-scale developments in cities (Hardcastle 1992). This research reviewed Hardcastle's (1992) information modelling approaches for estimating construction industry costs to cover the 1980s and early 1990s (Isaksson 2002). This research reviewed time and cost modelling in the 1990s and early 2000s in more detail to identify significant gaps in construction industry cost modelling research (Isaksson 2002). Finally, since 2002, system dynamics and cost modelling research is reviewed to conclude this chapter with research contributions and existing gaps (Nikolic 2003; Cui 2005; Jang 2011; Boateng 2014; Ahiaga-Daghui-2014; Alzahrani-2015).

2.1 Project Cost Information Modelling Literature Review

In this part, knowledge and information importance and interactions within cost estimating and modelling will be reviewed and analysed to determine the gap of its contribution to the construction industry. However, this will be through having a detailed literature review of previous research and related publications. Knowledge and information have several means and methodologies to be identified and managed using different construction industry software programs. However, it is contributing to mathematical and cost modelling significantly because it is impacting data accuracy and validity used in models with different weights (Schell, Claro & Guikema 2017; Zhang, Gong, et al., 2017; Pérez & Pericchi 2014; Cho, Hong & Hyun 2010; Zeng, An & Smith 2007; Chapman 1998; Hardcastle 1992). As a result, it is essential to include knowledge management and information source as a part of this research model to ensure more accurate results from generated simulations (Teerajetgul, Chareonngam & Wethyavivorn 2009; Seijts & Latham 2005; Bertrand & Fransoo Department 2002). Knowing how it is possible to estimate error based on accuracy weightage of information is used to predict construction costs (Zhang, Gong, et al. 2017; Abanda, Kamsu-Foguem & Tah 2017; Seijts & Latham 2005). This knowledge also includes data and information supporting the cost decision-making process in the construction engineering industry and project management (Toor & Ogunlana 2007; Seijts & Latham 2005). Knowledge can be used as quantitative and qualitative models to deal with unknowns and uncertainties (Seijts & Latham 2005; Flyvbjerg 2004; Koul & Falebita et al. 2016). Thus, it is crucial to consider its impact weightage in cost modelling and estimate.

After reviewing researches and literature, it is found that the most critical sources of collecting cost information in the building projects industry are historical data from previous similar projects activities and information provided by experts who experienced similar projects, problems, risks, and lessons learned (WEICK 1989; Jack & Raturi 2006; Klein &

Myers 1999; Cho, Hong & Hyun 2010). However, this increases the accuracy of cost models and estimated results (Cho, Hong & Hyun 2010). Because of this importance of information regarding the cost estimation process, researchers have developed the Building Information Modelling-BIM system to provide accurate and précised projects before projects 3D visualization ability (Abanda, Kamsu-Foguem & Tah 2017; Cheung et al. 2012). However, the BIM system provides calculation and specification analysis to accurately manage costs and allocate resources to execute project activity (Abanda, Kamsu-Foguem & Tah 2017; Cheung et al. 2012). Also, to have proper project management cost control during the execution stage, it must have a historical database of costs, economics, and estimation results to benchmark actual progress and performance for taking appropriate decisions financially and non-financially (Abudayyeh et al. 2001). Thus, the control of information database is essential to success in taking or making cost-related decisions (Abudayyeh et al. 2001). Then, ontological approaches have been used to enhance BIM systems in an automated process by establishing ontology of work conditions and its determinants; and, establishing ontology of the works items and its factors; and, establishing the rules of semantic and logical reasoning of work activities (Poole & Ven 1989; Lee, Kim & Yu 2014; Niknam & Karshenas 2015). Nevertheless, dealing and working with unknown variables are considered big risks that require elimination or minimization, especially in a complex industry. For example, in the construction field and a sensitive topic such as cost prediction and estimation, it is essential to eliminate unknown variables (Kubba 2017; Odeyinka, Lowe & Kaka 2013; Ramasesh & Browning, 2014). Moreover, researchers showed that information and knowledge about the risk and uncertainty could be classified as known unknowns and unknown unknowns proving the importance of the utilised accurate information to deal with risks and cost estimation (Ramasesh & Browning, 2014). Therefore, the process of getting the required valuable information for modelling

construction costs has to be through modelling data using intensive experienced human resources with the respect of each specialisation (Niknam & Karshenas 2015). Hence, the experts significantly impacted gathering proper information and knowledge collection of cost estimation models (Iyer & Jha 2005). This can affect factors and variables used in this research model; and, it will have a big role in cost estimate results' efficiency and effectiveness (Iyer & Jha 2005). The approaches of analysing and calculating variables input are affected by information and knowledge of how to deal with each variable, such as socio-economics variables (Todorov 2014). On the other hand, it is proved that critical success factors are connected mainly with appropriate knowledge management in the buildings project management field (Toor & Ogunlana, 2009). Hence, cost estimation modelling can be successfully launched when knowledge and information factors and criteria are respected and handled accurately to contribute strongly to project cost decisions. However, cost optimisation and research are done to enhance socioeconomics, develop public benefits, and improve countries' economies; they are also used to better decisions in projects to maximise profit (Florio & Sirtori, 2016).

First, cost estimating and predicting research in the 1980s and 1990s was based on hypotheses and paradigm approaches to improve performance results in design and pre-construction stages (Ray, Muhanna & Barney 2005; Hardcastle 1992). The approaches were similar to each other, but researchers have adopted them over the years for achieving the best cost modelling of construction projects (Meredith et al. 1989; Hardcastle 1992; Malhotra et al. 2014). However, these approaches' primary adoption is essential to build the cost information model before cost estimation processes at design and pre-construction stages (ElSawy, Hosny & Abdel-Razek 2011; Dowlatshahi 2010; Hardcastle 1992). Thus, in the design stage, it is easier to identify and extract the required information of what is needed to be done in projects

execution and how these activities can be done (i.e., resources and other requirements) (ElSawy, Hosny & Abdel-Razek 2011; Dowlatshahi 2010; Hardcastle 1992). This is why information modelling is vital for creating a new cost estimation model. For example, it has a pre-model for cost called Cost Estimating Information Model which is a major output of research done during the 1990s in the field of building construction economy and financial management due to its impact on the accuracy of predicted cost (Hardcastle 1992). In the first adapted approach, "Paradigmatic Model," it is based on that theory is made to solve a puzzle before being able to take a proper decision through reaching a true or false answer for puzzle statement using analysing successful examples and conclude the required results (Dyer & Wilkins 1991; Hardcastle 1992, p. 11; Filippini 1997; Barnes 2001; Benjaoran 2009). Besides, the cost information model used "hypothetico-deductive" model to approach mathematically several hypotheses of the several assumptions made regarding the cost factors, decisions, and management analysis. Then, verify which hypothesis is correct and which one is wrong mathematically using numbers (Hardcastle 1992, p. 24; Kvale 1992; Ketokivi & Choi 2014).

The equations in Figure 2-1 are based on information provided for construction cost estimating process in the design stage and used by previous researchers (Hardcastle 1992). However, in Eq. 2-1, "E_{acc}" is representing the estimation accuracy while "f" is the function of "F" (i.e., future), and "I" is representing the provided information (Hardcastle 1992, pp. 26-37).

$$E_{acc} = f(I + F) \quad \text{(Eq. 2-1)}$$

$$E_{acc} = f(I_q) \quad \text{(Eq. 2-2)}$$

$$I = S(Q/X) - S(Q/X^1) \quad \text{(Eq. 2-3)}$$

$$E_{acc1}\ E_{acc2} = f(I_1^2) \quad \text{(Eq. 2-4)}$$

Figure 2-1: Cost Estimation Mathematical equation used in cost information models (Hardcastle 1992).

Then, in Eq. 2-2, "Iq" represents the quality of provided information, while in Eq. 2-3 "S" is the function of "Q" (i.e., the accuracy of asked questions to gather information), and "X" is knowledge in providing the required information (Hardcastle 1992, pp. 26-37). Finally, in

Eq. 2-4, "E_{acc1}" and "E_{acc2}" represent the estimation accuracy of different people and equal to the square of first observer and provider information quality (Hardcastle 1992, pp. 26-37). Thus, by having differences between the sides of an equation, it will be easy to catch low-quality information of each step's cost estimation process (Hardcastle 1992; Maiwenn 2013; Sturges & Hanrahan 2004; Trier-Bieniek 2012; Boyer et al. 2002). Also, from this set of equations, it is clear that the risk and uncertainty of having accurate information are high and need appropriate models for further improvement and development to achieve the demanded efficiency as proposed in Figures 2-2 and 2-3 (Hardcastle 1992).

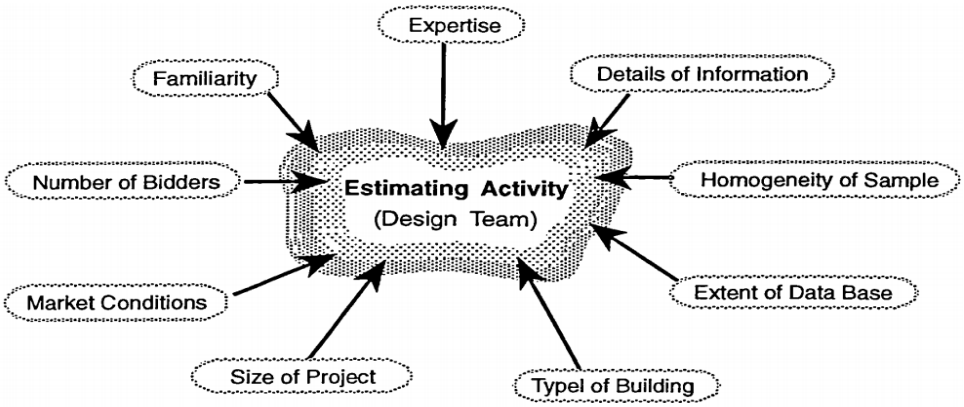


Figure 2-2: Cost Estimating Criteria which are affecting information quality of an accurate estimated cost (Hardcastle 1992).

In Figure 2-2, the criteria of activity estimation are made of several factors: project size, expertise, building type, familiarity, market conditions, details of information, number of bidders, sample homogeneity, and extent of the available database (Hardcastle 1992). This can be done at the design stage to optimize the estimated cost subject to accuracy (Hardcastle 1992). On the other hand, Figure 2-3 shows the process of designing a cost information model for accurate cost estimation of the construction project at the pre-construction stage; however, as much the demand for information increases, the feedback of information will increase (Hardcastle 1992). So, this can be done and conducted in the following stages: 1) pre-tender

planning, 2) master program, 3) stage program, 4) short term program, 5) allocation of labours and plants, 6) material pricing and ordering stage, 7) bonus progress, 8) and progress monitoring (Hardcastle 1992).

In the end, the cost estimation information model's investigation proved that it is crucial to have appropriate knowledge through studying information rather than directly studying cost itself to get accurate and effective values (Shen, Nguyen & Ojiako 2013; Xu & Moon 2013; Tummala & Schoenherr 2011; Hardcastle 1992). Hence, projects' budgets and prices can be set accurately to provide more profit and efficiency of investment financial decisions (Hardcastle 1992). This will vary based on geographical location, time, and extracted information source (Ju, Li et al. 2017; Binder & Edwards 2009; Venkatesh, Brown & Bala 2013; Hardcastle 1992). Nevertheless, the variation of costs after gathering information has a significant impact on estimated cost results; so, it has to be covered according to information flow and criteria of construction project development (Abanda, Tah & Cheung 2013; Baloi & Price 2003; Hardcastle 1992).

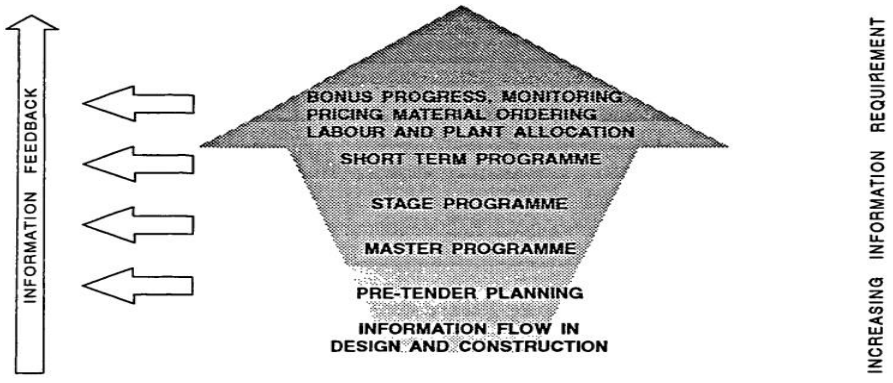


Figure 2-3: How information model is designed for modelling and estimating cost at the design stage (i.e., pre-construction stage) (Hardcastle 1992).

On the other hand, the latest research and journal articles explained the relationship between constructions cost prediction, knowledge, and information modelling from 1992 until the present time (Hardcastle 1992). These researches have been proving and showing new

important factors and points that impact modelling costs (Kambanou & Lindahl 2016; Stockton, Khalil & Mukhongo 2013; Hardcastle 1992). First, information modelling could check the adequacy of factors using Building Information Modelling-BIM, which is the primary tool of modelling construction information before any estimation related to quantities, resources, or costs (Wang, Wang, et al. 2016; James 2014; Belay, Torp, et al. 2016; Jrade & Lessard 2015). However, it is essential to update factors and information used for modelling construction at the pre-construction stage (Ibanez-Lopez, Martinez-Val & Moratilla-Soria 2017; Yasin, Czuchry, et al. 1999). For example, developing and shaping manufacturing information, criteria, and factors is done to integrate more accurate construction models (Zhiliang et al. 2011). Also, the latest research showed that the client's specifications compliance could be only achieved by translating it successfully into an estimating information model; so, at tendering stage of constructions, it is necessary to get appropriate budget approval to satisfy the client's engineering, architectural and technological requirements (Ma, Wei & Zhang 2013). Besides, information modelling characteristics had to be enhanced to cover time change and its impact on each factor included in cost estimation information; nevertheless, this is going to improve the planning and execution processes to be within the approved budget as much as possible while making overrun and underestimating processes as low as possible at the design and pre-construction stages (Jrade & Lessard 2015). Moreover, it is proved that applying building information management systems (3D) for scheduling and predicting budget has a strong impact on the results of execution pricing. However, 3D BIM is being developed to include more dimensions and is more efficient with PROMQACS "Project Management Quality Cost System" (Wang, Wang, et al. 2016; Love & Irani 2003, p. 653). Finally, the latest essential and significant dimensions of building information modelling (BIM) in the construction industry added time, cost, and as-built operations to end up with a 6D model in

the pre-construction stage. 6D BIM model estimate accurately costs and risks of the execution stage; however, in the last three years, researchers have tried to estimate construction cost using information modelling instead of modelling cost information at the pre-construction stage. For example, several software programs help estimate and model costs, such as BIM, Microsoft Access, Primavera, and MS project (Hafez, Aziz & Eldars 2015; Smith 2014; Wu, Olson & Birge 2011; Perera & Imriyas, 2004).

In summary, it was discussed how the knowledge and information management systems could affect and impact cost estimation modelling and its results. Therefore, the first part of this chapter took into consideration information, including its types and approaches. First, knowledge collection methods and systems are concerned with gathering required data for pricing and budgeting projects. Data collection had several criteria, such as the details, size, complexity, and other mentioned points included in reviewed research. Also, cost information mathematical modelling determines its adequacy, accuracy, and class weighting based on cost results. Second, information management results can impact the validity and quality of the cost prediction model. After that, this chapter discussed the types of information presentation and modelling, including charts and figures such as Primavera and MS project software programs; and statistical tables and mathematical analysis such as the MS Access; and data visualization, including Auto CAD Revit programs. However, information models are developed to include 3, 4, 5, and 6-dimensional models. Finally, this part of chapter 2 is going to be used in collecting factors of cost prediction modelling and how they should be connected in order to have more accurate and efficient results from this study; nevertheless, this will develop an approach to connect variables and set out their equations and weights as per their significance for this thesis integrated model.

2.2 Project Cost, Economics, & Profitability Modelling Literature Review

In many countries around the world, projects have played a big role in the countries' economy over the years; however, this economy has been changed according to people interactions for reducing uncertainties of upcoming events and projects to ensure sustainability through developments and time (Gagliardi 2016; Nguyen, Ogunlana & Lan 2004; Abd-El-Razek, Bassioni & Mobarak 2009; Boyer & Pagell 2000; Ashrafia et al. 2016; Ali & Kamaruzzaman 2010; Chou 2011; Handfield & Melnyk 1998). Nevertheless, the economy and policies have impacted and shaped industrial business, including construction and manufacturing business; so, it is essential to estimate profitability and loss based on cost prediction to realize the non-conformity of production (Pasandideh et al. 2015). Therefore, waste of resources or materials that might affect the profitability of construction projects' execution should be added to this research study (Pasandideh et al. 2015). The economic factors and variables are crucial to set project profitability criteria at the pre-construction stage (Tang, Aoieong & Ahmed 2004). For example, the quality costs and variables are not included in the information modelling systems such as Primavera and BIM software; however, the cost modelling of processes is important because it tests the project's feasibility and applicability (Tang, Aoieong & Ahmed 2004). As a result, it is concluded from previous researches that cost modelling improvement is still required for more accurate estimations. This depends on how variables and factors are connected to form an estimating network of project costs (Lehtonen & Kiiras 2010). In other words, variables and factors had to be customized and integrated to fulfil project criteria and requirements to achieve profitability and avoid any delay or non-compliance (Lehtonen & Kiiras 2010). It is also necessary to optimize the allocation of the calculated budget, which is done by having appropriate cost identification for each process (Golenko-Ginzburg et al. 2006). This will help in monitoring and controlling the project's

activities accurately (Golenko-Ginzburg et al. 2006). Finally, it is essential to determine contracting feasibility solutions to optimize costs while choosing the best contractor for the assigned job and minimize risks (Turskis 2008).

The following review will detail researchers' outcomes regarding project cost estimation feasibility, profitability, and economics. It will then detail cost and profitability updates from scientific journals required to determine this research modelling. In order to develop the economy in cities or other geographical areas, it is important to have optimum buildings and infrastructures and set appropriate economic development plans (Bigsten 2016). This can be done by improving processes resulting from project management cost modelling optimization research and practices; besides, this will achieve higher profitability from delivering end-user products (Agyapong-Kodua et al. 2012; Wudhikarn 2011; Bigsten 2016; Love et al. 2002). On the other hand, cities are based on the market investments' environment besides individuals and organizations involved in the economic circulation of investment loops (Enezy et al. 2017; Doloi 2012). However, the United Arab Emirate economy is changing to adapt sustainable building projects to enhance and benefit its national economy (Asif 2016; Clifton 2016). These opportunities are demanding huge construction developments in the building and infrastructures, which require to have sustainable materials and energy consumption to the EXPO 2020 and 2030 development plan in Dubai and Abu Dhabi emirates (Asif 2016; Clifton 2016; Dubai-Government 2016; KSA-Government 2016; Abu Dhabi-Government, 2016a, 2016b, 2016c, 2016d, 2016e, 2016f). Abu Dhabi and Dubai required having negative inflation for construction after 2008 economic cries due to the high need for more developments (Clifton 2016). Therefore, it requires more cost optimization due to the change in available budgets of megaprojects and other complex construction (Clifton 2016; Asif 2016). This represents the main challenge at present and for 20 years because of economic

GDP drop in the United Arab Emirates from 399 US$ BN to 385 US$ BN from 2014 to 2016 and the because of UAE economic re-structure to replace oil income (Clifton 2016; Asif 2016). Researchers found that system dynamics is the most effective method and approach to analysing changeable variables showing results before and after changes. This made system dynamics more realistic and accurate in critical cost and risk forecasting, such as engineering processes and construction activities (Chapman 1998). Then, because this research study focuses on the critical variable of cost, using system dynamics can be considered the most effective and accurate approach (Cassettari & et al. 2016; Lee, Pena-Mora & Park 2006; Reichelt & Lyneis 1999; Williams 2001; Chapman 1998). After researching large projects and construction of building and infrastructure industry, it is also proved that dynamical modelling is the most efficient method to solve disputes and conflicts between parties (Bates & Holt, 2011). However, research proved that cost is the most critical reason for conflicts and dispute resolution generation within projects (Bates & Holt, 2011). These conflicts affect the cost, quality, and time of projects and can even drive to failure of complex and large projects in the construction industry (Bates & Holt, 2011). As a result, it is required to all the conflict by using appropriate tools and approaches such as system dynamics techniques (Bates & Holt, 2011). Researchers showed that to have the best efficiency of costs and benefits requires optimizing economics and managerial processes of scientific-technical developments at the design stage to handle the building constructions' costs and performance under challenges and changes (Abdallah 2007). Project challenges can result from the political, economic, and working environment at different construction stages (Abdallah 2007). Also, modelling other variables than costs, such as 3D modelling of construction buildings, can be very useful in estimating costs (Abdallah 2007). After that, cost of quality is a critical issue in United Arab Emirates cities such as Dubai; however, it is due to cost overrun when an undesirable product’s quality

reaches the rework level (Abdelsalam & Gad 2009). This cost of quality is around 7% of the project construction costs while usually not budgeted or estimated in cost models (Abdelsalam & Gad 2009). Thus, controlling cash flow overrun in the construction industry in the United Arab Emirates will help in faster economic growth since it is the main industry (Abdelsalam & Gad 2009). Moreover, the profitability of construction projects is generally calculated at pre-construction stages (Al-Jibouri 2003). On the other hand, profitability is reduced when budgeted costs start to be broken, and the project's performance takes more than what it should, according to estimated costs (Al-Jibouri 2003). So, appropriate monitoring of performance will enhance cost control effectiveness in construction projects (Al-Jibouri 2003). Nevertheless, to have appropriate monitoring of the project's activities, it is necessary to apply and simulate dynamical planning to keep up with dynamical construction variables that keep changing (Alzraiee, Zayed & Moselhi 2015). After that, it is important to know that cost x modelling has many controllers, affecting its accuracy and efficiency; however, one of these significant factors is price inflation, especially in a country like the United Arab Emirates (Abdallah 2007; Clifton 2016; Asif 2016). For example, the main reason for the significant problem is business economy and costs; therefore, it is important to review economic research that includes inflation and money supply relationships (NikoliC 2003; Abdallah 2007; Clifton 2016; Asif 2016). This is resulting in either changing interest rates or changing tax rates (NikoliC 2003). The research studies showed that inflation based on tax changes is causing inflation of the interest rates (NikoliC 2003). This is very important to model cost after knowing that United Arab Emirate will apply taxes starting 1st January 2018, leading to inflation (Al-Hamadi 2020). Also, researchers studied profitability in construction industry firms to understand and analyze its uncertainty and complexity using the dynamical model (Cui 2005; Salling & Leleur 2015; Cheng 2014; Kujawski 2007). This will show the best possible way of managing profitability

in construction industry firms (Cui 2005; Shahandashti & Ashuri 2013; Williams 2003; Ayangade, Wahab & Alake 2009). This uncertainty and complexity are resulting because contractor have to underestimate costs to bid and award projects then deal with inflation, government regulations, fluctuation of interest rates, and changing orders at a later stage (Cui 2005; Mizell & Malone 2007; Doloi 2011; Elhag, Boussabaine & Ballal 2005). Therefore, profitability system dynamics will support achieving projects' acceptable quality within the planned budget and time frame (Cui 2005; Bovsunovskaya 2016; Atkinson 1999; Poucke, Matthyssens & Weeren 2016). In other words, competition on construction project bids requires a meagre budget while actual cost increases due to deferent variables change, making profitability almost impossible to be achieved or be satisfactory (Cui 2005; Siciliano et al. 2016; Koomey, Hultman & Grubler 2017; Willis & Willis 1995). However, this is not the first time that contractors suffer from profitability issues since more than 11% of business failures in 1987 and an average of 60 construction business failures per year until 1998 (Kamaruzzaman 2010; Peña-Mora et al. 2008; Cui 2005). It was then found that the profitability issue contributed to about 26.72% to construction failure, which has been increased in early 2000 (Cui 2005). Researchers studied cost from the perspective of profitability because it is the way to maintain project base businesses and measure their performance since 1972 (Cui 2005). Thus, profitability was considered a research topic based on comparing projects cost with bidding budget over time, including changing variables in dynamic systems and influence networks (Poh & Tah 2006; Cui 2005). However, profitability research created a dynamical management model system to analyse profit quality, profit sustainability, profit possibility, and profit potentials, as shown in Figure 2-4 (Cui 2005).

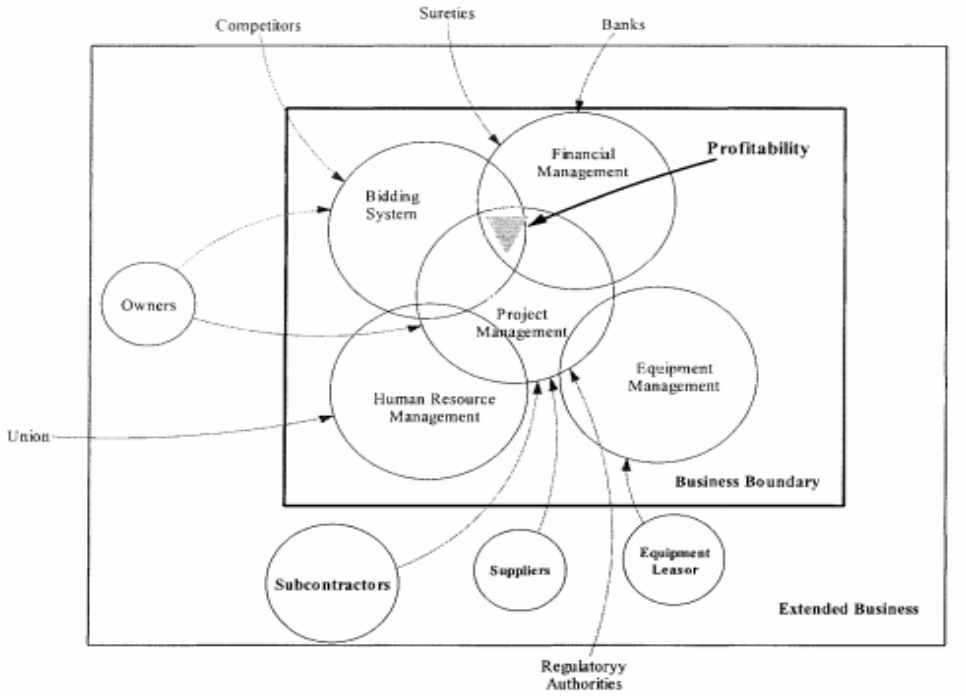


Figure 2-4: Proposed Profitability System (Cui 2005).

The proposed system of modelling profitability as in Figure 2-4 shows multiple players like equipment leaser, subcontractors, suppliers, banks, competitors, and owners; however, these layers contribute to several management systems that interact directly with the construction project management field industry (Cui 2005). For instance, the equipment management system, human resources management system, bidding management system, and financial management system are directly interacting with the construction project management field (Cui 2005). In other words, profitability research from 2000 to 2005 took the intersection point between project management, financial management, and bidding management system as the primary research gap to build profitability management model using system dynamics to contribute to the body of knowledge (Cui 2005). Therefore, profitability modelling outputs did not include cost estimation cash flow for residential buildings whole life cycle, covered in this research thesis (Modell 2005; Cui 2005; Dikmen, Birgonul & Han 2007; Resende et al. 2017; Moghaddam & Michelot 2009). On the other hand, researchers used

system dynamics modelling and other modelling approaches to support building this final thesis model; nevertheless, the following part will include how researchers contribute to this study.

For instance, the development of profitability modelling system started from the four main bases of profitability management; first, profitability quality, this is the part where stakeholders need to be satisfied with profit margin, rate of return, and quantity after investing their money (Cui 2005; Hurt & Schrock 2016). Second, profitability management includes affording cost and taking the risk of losing what is invested (Cui 2005; Lowe 2015; Mils 2001). Third, profit potentiality is where the contractor needs to check all possible ways to optimize and maximize project profit while satisfying surrounded constraints, including all contributing variables (Cui 2005). Finally, profit sustainability maintains the sustainable value of profit for stakeholders, including value to economic changes and inflation such as interest rates and inflation (Cui 2005; Murillo-Hoyos, Volovski & Labi 2016; Feuillette et al. 2016; Moore & Loredo 2013). And, value to the legislation governmental roles and regulation costs like taxis and fees (Cui 2005; Matto & Sippola 2016). Also, it includes the value of the profit percentage to net income quantity such as money and assets (Cui 2005; Wu, Olson & Birge 2011). As a result, the model has reached a more complex level based on adding other related variables to the bidding and profitability dynamical modelling system, as shown in Figure 2-5 (Cui 2005). Therefore, this research should include profitability management variables for better cost estimation modelling.

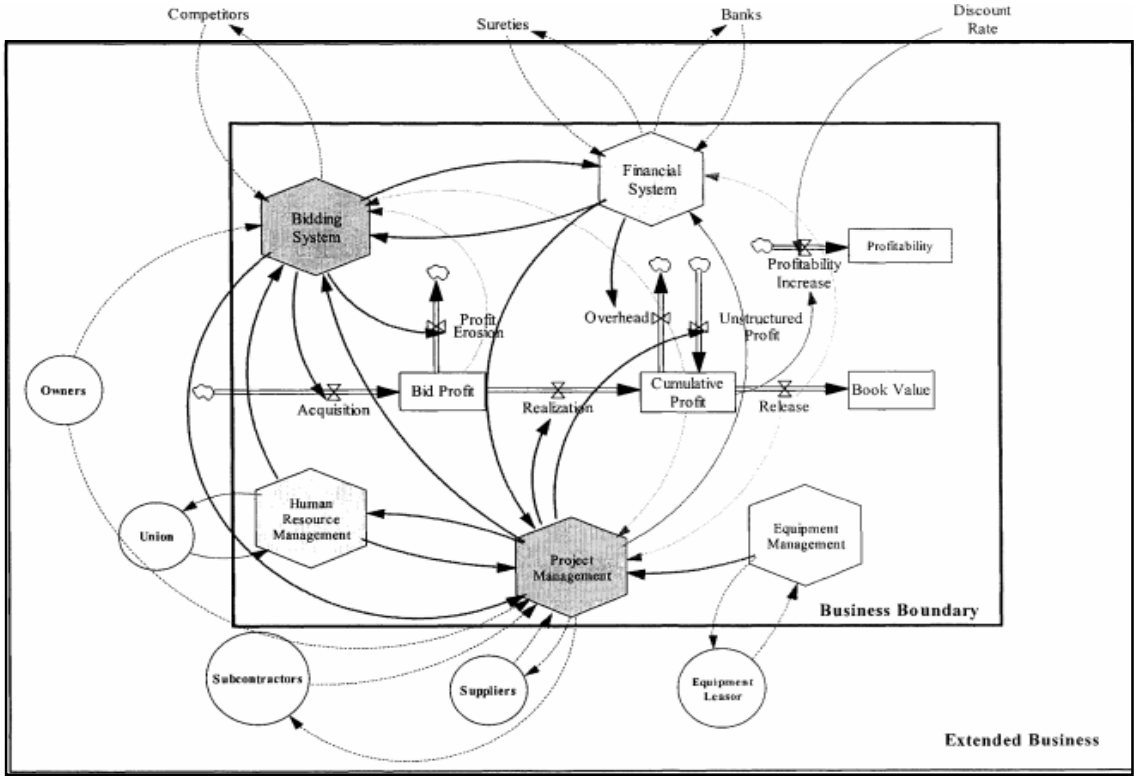


Figure 2-5: Profitability System Dynamical Model (Cui 2005).

Next, to study profitability using the dynamical model in Figure 2-5, researchers involved uncertainties and agents in representing individuals, organisations, or teams interacting and getting involved in the explained game theory structure (Cui 2005; Walker et al. 2014; Cohen & Kunreuther 2007). First, uncertainty appears in decisions of a contractor, which is translated to money on a later stage to cover different bad scenarios that might happen; also, the proposed agent supposed to be able to predict the consequences of its actions (Cui 2005; Walker et al. 2014; Cohen & Kunreuther 2007). Other agents then have actions and can predict their consequences (Cui 2005; Walker et al. 2014; Cohen & Kunreuther 2007). However, they are used to direct model behaviour when employed (Cui 2005; Walker et al. 2014; Cohen & Kunreuther 2007). In this way, the model will represent the required information for proper analysis and better understand how costs and budgets can interact with

other influencing and influenced variables, as shown in Figure 2-6 (Cui 2005). Therefore, this research should test variables against several scenarios in its validation stage to ensure accurate project cost prediction.

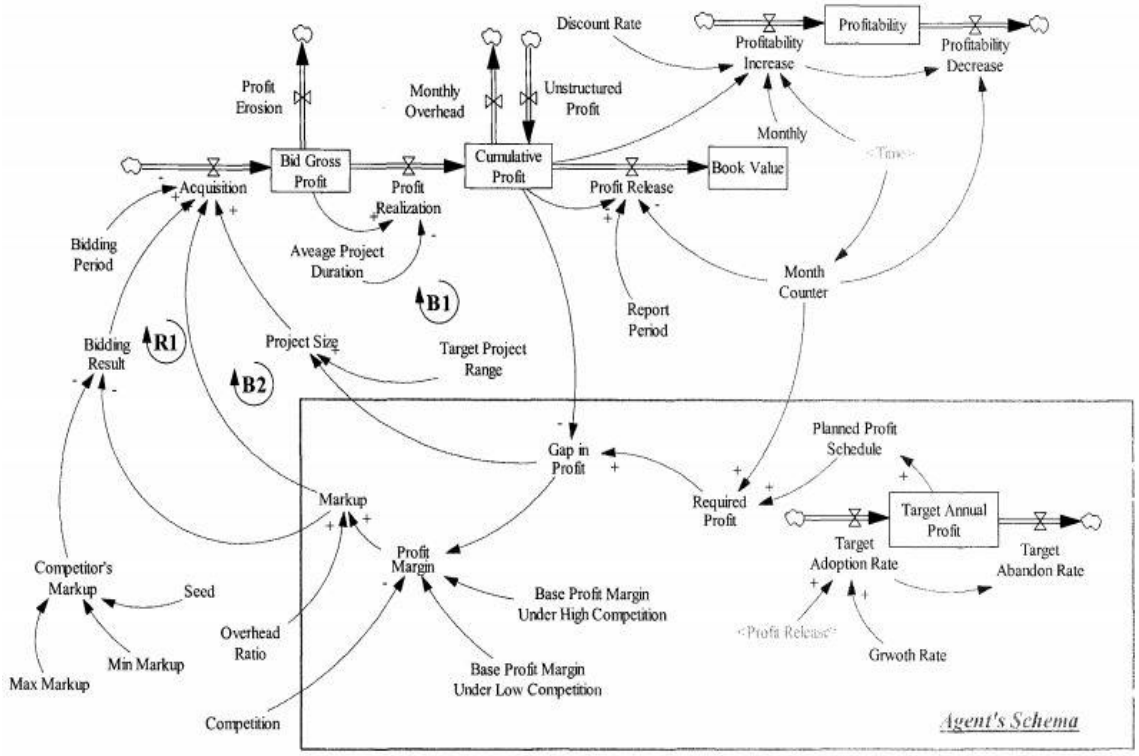


Figure 2-6: Complex Adaptive Bidding System with One Agent (Cui 2005).

As a result of this developed modelling analysis, the primary and most significant problem of profitability issue is the cash flow balancing process; so, cash flow loops model has been developed to study its efficiency within the bidding system model as shown in Figure 2-7 (Cui 2005; Hwang 2011; Hwang 2005; Chang & Ko 2016; Spickova & Myskova 2015). This is describing and involving related variables of in and out cash flow processes of projects at construction stages (Cui 2005; Hwang 2011; Hwang 2005; Chang & Ko 2016; Spickova & Myskova 2015). Therefore, during the construction stage, cash flow is significant and requires, including it in this research study.

Besides, cost-sharing within the project can generate more and different cash-based cash farming concepts through building operation when having multiple projects (Cui 2005; Aziz & Abdel-Hakam 2016; Marzouk & Azab 2014). For example, the cost of equipment leasing for a project can be less if the leasing period is longer to cover two or more projects instead of leasing it separately for each project; in this case, each project will cost less for using the same equipment, which will increase the profitability significantly (Cui 2005; Aziz & Abdel-Hakam 2016; Marzouk & Azab 2014). It also applies to used equipment instead of new ones (Marzouk & Azab 2014).

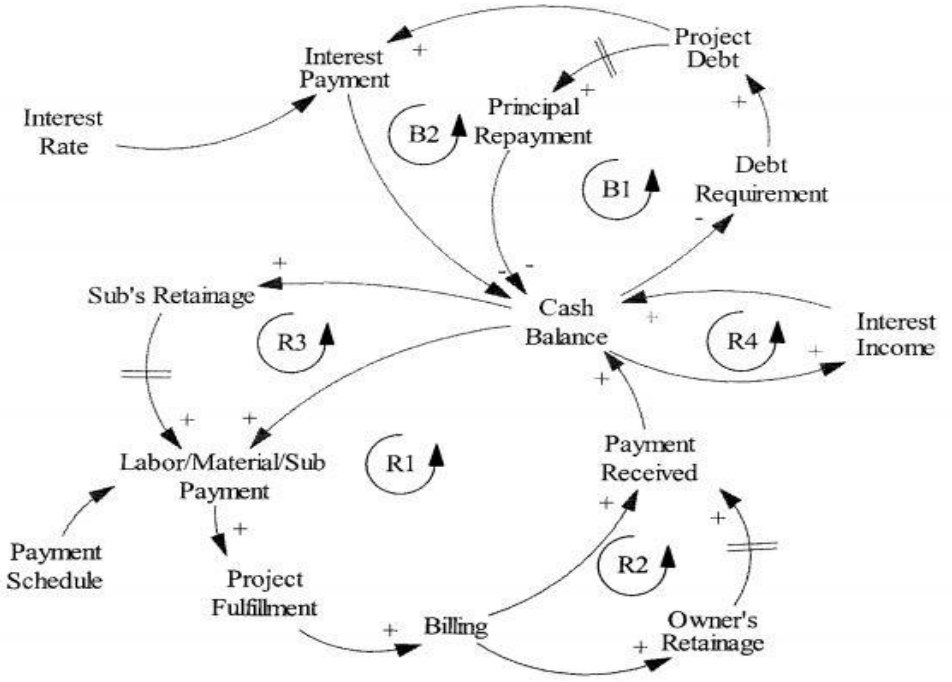


Figure 2-7: Feedback Loops in Construction Projects Cash Flow (Cui 2005).

In the cash flow feedback loop of Figure 2-7, costs, and cash outflow liabilities interact with income to reach profitability cash balance in the construction projects in the used dynamical model (Cui 2005).

However, studies from 1989 showed that construction management uncertainties and problems appeared from low précised estimation and costs budgeting (Winch 1989). Research proved that most risk factors fall under the cost uncertainty umbrella (Ökmen & Öztas 2010). Besides, "Correlated Cost Risk Analysis Model" (i.e., "CCRAM") is created after the economic crises using a hypotheses approach to simulate the risks and costs of construction projects besides the Monte Carlo Modelling and analysis to provide an accurate prediction of costs and profitability in related with known risks (Ökmen & Öztas 2010, p. 203). Finally, profitability maximization demands cost modelling innovation in processes and activities based on available opportunities to improve the performance and results (i.e., outcomes and products). Therefore, researchers started to check construction costs based on time and internal dimensions of construction cost models to contribute in project management improvement (Xiong, Xiong & Xia 2015; Leiringer 2006; Yu & Lo 2005).

In summary, factors analysis and integrating cost estimating models in economics and profitability disciplines are significantly important. Its importance comes from the required and desired results, maximizing the project's profit from contractors' perspectives. Also, integrating cost estimating models reduces cost overrun and loss of money from clients' perspectives by staying within an acceptable tolerance of planned budgets. For example, the analysis of multiple projects' cost-benefit discount rate is an essential tool for minimizing risk cost (Torriti 2012). An artificial cost flow network is another example of modelling risks and costs within construction businesses (Odeyinka, Lowe & Kaka 2013). However, capital analysis in most of published reviewed articles included cash cycle, current assets, liquidity ratio, and short term liabilities, which are required to maximize profit while optimizing operational costs of complex processes (Meszek & Polewski 2006; Winter 2016; Chowdhury, Sharma & Platz 2016; Geissmann 2017; Cople & Brick 2010; Yusoff et al. 2016; Ibn-Homaid

& Tijani 2015; Sydor et al. 2014; McLean & McGovern 2017;). On the other hand, forecasting models of cost in Taiwan showed that errors, mean values, weightings and indices of costs play a significant role in determining whether projects are profitable or not (Wang & Mei, 1998). In other words, it will ensure cost variation (i.e., cost overrun tolerance) to be within the expected tolerance of the planned budgets (Wang & Mei, 1998). According to more than a hundred construction experts, construction profitability is based on its critical success factors; nevertheless, it affects and affects economics' situation, commitment, comfort, communication, and competence categories (Nguyen, Ogunlana & Lan 2004). In summary, previous research reviews showed how profitability analysis, factors, and variables are essential concerning the economy, projects costs, and risks, which can be done using several tools and approaches. However, the best and most accurate approach up to date as per reviewed literature is to use system dynamics tools and techniques to analyse all possible dimensions that can impact final estimated cost results. Also, the analysis of profitability factors and variables from the contractor's perspective will give a more appropriate understanding of how to cover what they miss as a client. In other words, studying contractors' ways of understanding and dealing with cash flows considering risks variables and factors while connecting them with economic factors' network of the construction project at the pre-construction stage will give more accurate cost prediction model and value.

2.3 Project Cost and Risk Interaction Modelling Literature Review

Although risk quantitative management and analysis are ignored, they are essential to predict its costs and impact on planned time, performance, and budget of construction projects (Poh & Tah 2006). So, it is imperative and valuable to identify and assess possible known risks and predict the unknown risks in projects at the pre-construction stage (Schieg 2010). This will

avoid cost overrun due to waste of time or resources; however, researches proved that risk factors and variables are major and required to be considered while integrating and analyzing construction cost models (Schieg 2010). For more than 40 years, these factors and variables of industrial businesses' risks are projects' concerns for project managers and operations managers (Seshadri & Subrahmanyam 2005). However, the risks and cost statistical and mathematical equations are the best way to measure and evaluate the financial and non-financial assets' risks impact on predicting costs (Hernandez-Sancho, Molinos-Senante & Sala-Garrido 2011). In other words, the relationship between costs and risks has been proved by researchers that costs and time impact risks; however, vice versa connection of variables' sets did research in cost estimating and modelling take into consideration risks from identification stage to assessment stage using integrated models (Doloi 2012). In 2010, researchers started to develop and compare cost modelling of constructions to reach more accurate solutions using mathematical equations for a précised value before executing projects (Petroutsatou & Lambropoulos 2010). It is done on infrastructure roads and tunnels projects while not including residential projects covered in this research (Petroutsatou & Lambropoulos 2010). Researchers' models covered fuzzy techniques for reasoning and analysing construction risks to take and implement appropriate decisions (Zeng, An & Smith 2007). These fuzzy modelling of risks opened the door for more appropriate methods and approaches to analyse risks with the other factors and categories such as system dynamics (Nasirzadeh, Khanzadi & Rezaie 2013). Therefore, in chapter 2 of this thesis, cost modelling and its interaction with risks using system dynamics will be reviewed and considered based on the latest empirical research. The latest tools and results of modelling costs and risks in the construction industry, according to scientific journal publications will be reviewed to reach the highest possible inputs accuracy of the proposed cost model.

After that, risks lead to extra costs in the construction industry due to improper assessment processes or misidentifying some of the critical risks; so, variables of risks are impacting estimated budget accuracy significantly when they cause changes in costs of construction execution (Ali & Kamaruzzaman 2010). Also, most of the time, risks are identified and assessed to provide the proper performance of the project delivery process; thus, performance variables are considered critical projects cost modelling (Ali & Kamaruzzaman 2010). However, according to some researchers, costs mathematical modelling in building construction projects, optimises estimated results when related to risky components such as time, waste, and energy (Abanda, Tah & Cheung 2013). It was also proposed to model costs against an important criterion such as the cost impact of risky variables over time (Abanda, Tah & Cheung 2013). This was done by integrating and designing a set of equations required to get better results (Abanda, Tah & Cheung 2013). Cost modelling in public-private partnership construction projects is considered a big challenge that has to be eliminated or minimized for more accurate financing and funding without facing challengeable obstacles. However, these obstacles may lead to delay or fail projects at the execution stage (Akinyemi et al., 2009). In order to solve risky cost decisions, it was found in research that most construction practitioners and professionals such as project managers use "Cost-Effectiveness Acceptability Curve" (CEAC) for appropriate and optimum decisions. For instance, the percentage of using the (CEAC) has increased from 2.1% to 32.6% between 2001 and 2006, proving its efficiency and deep connection between risk and cost in projects (Maiwenn 2013, p. 93). Moreover, regarding construction risks and cost overrun, it is popular that structural elements and other components make people over-design the engineering component for reducing risk while increasing cost significantly; however, cost-design optimization methods have been developed by researchers to solve risk-cost conflicts between management and

technical professionals (Aldwaik & Adeli 2016). Therefore, it can be considered one construction project management cost modelling factors and variable (Aldwaik & Adeli 2016). Next, researchers developed controlling charts of checking, monitoring, and controlling quality; however, the quality will be considered a factor of cost-risk variables due to the conflict between management and technical requirements for end-users (Aliverdi, Naeni & Salehipour 2013). Form investigation conducted by researchers in the private and the public sectors, it was found that estimating and predicting cost modelling must cover construction industry risks when it comes to the financial decision starting from choosing contractors until delivering the project to the end-users by the client; however, this is because of the following: 1) the underestimate at projects pre-construction stage (i.e., tendering stage), 2) the overrun of costs during projects' execution, 3) the financial and funding constraints of appearing risks and claims made by projects parties (Ayangade, Wahab, & Alake 2009). This makes cost modelling accuracy extremely significant in the construction industry from the client's point of view (Ayangade, Wahab, & Alake 2009). Therefore, it is essential to cover construction risks in this research modelling study.

One of the effective methods of analysing construction costs under the risks and uncertainty in developing a fuzzy approach and framework (Dikmen, Birgonul & Han 2007; Baloi & Price, 2003). This will help make an appropriate financial decision and estimation (Dikmen, Birgonul & Han 2007; Baloi & Price, 2003). The fuzzy framework has been discussed in several cost research papers and thesis as per the following parts of this chapter. It can also be based on case-based approaches for cost estimate modelling scenarios through experience and hierarchy process combination methodology (An, Kim & Kaug 2007). It can be achieved by developing project costs predicting reasoning efficiency analysis (An, Kim & Kaug 2007). So, the dynamical modelling of risks in construction projects using fuzzy logic

showed that system dynamics could identify and allocate risks at the early stages of executions while it can also help in eliminating unnecessary risks before experiencing its impact on costs, time, or performance (Wang, Ding, et al. 2016; Nasirzadeh, Khanzadi & Rezaie 2014). After that, risk modelling identified different reasons behind different pricing results for the same construction project processes and activities in different times and positions; for example, political, law, and international procedures risks as significant in modelling costs accurately (Cohen & Kunreuther 2007). However, it is essential to consider it in this research system dynamics modelling as the best approach to identify the most accurate costs of resources and activities during the project's stages (Eden, Williams & Ackermann 2005; Liu, Xu et al. 2012). For example, the "Vector Autoregression" Model (i.e., VAR) proved that budgeting processes for long and short-term project operations have significant impacts on CCI "Construction Cost Index" stochastic forecasting (Xu & Moon 2013, p.10). So, the risks of changing the project schedule will significantly change its pricing, and the estimated costs and budget accuracy will change accordingly (Pajares & López-Paredes 2011; Mizell & Malone 2007). This is because of economics and policy conditions, which may change resource prices variations (Pajares & López-Paredes 2011; Mizell & Malone 2007). Therefore, the "earned value management," besides monitoring and controlling techniques, needs to be considered when scheduling processes to fix estimated budget as much as possible (Pajares & López-Paredes 2011, p.615; Mizell & Malone 2007).

Besides, researchers found out that it is crucial to model cost and time in mega construction projects such as tunnels (Isaksson 2002). However, the tremendous adverse effects of high risks and uncertainty of construction projects, such as infrastructure and tunnelling projects, are caused by over costs and delays resulting from an improper assessment of cost and time risks at pre-construction stages (Torp et al. 2016; Memon et al. 2010; Thijssen 2015;

Isaksson 2002). These researches declared that cost estimation modelling is essential for megaprojects and investigated this importance validity using infrastructure projects without covering residential buildings; therefore, this research study will continue after investigating cost estimation modelling for residential projects using system dynamics. Also, it is agreed that over costs in construction projects are happening because of several factors, including unfixed costs after fixing the budgets, finalizing tender documents, starting project's activities under inflation, which are changing actual costs from the expected budget (Isaksson 2002; Ong & Ong 1986; Toh, Ali, et al. 2012; Peng & Lai 2012; Zakis, Zakis & Arfridsson 2017). So, time and cost modelling of projects is significant because of its power to shape clients and contractors' decision-makers who are the most powerful and essential stakeholders in mega projects such as infrastructure and tunnels (Isaksson 2002; Acebes et al. 2013; Signor et al. 2016; Karim & Adeli 1999). As a result, this research study will investigate cost estimation accuracy in housing mega residential projects in the UAE. Besides, researchers concluded that research mathematical modelling and approaches, including probability and Monte Carlo simulating technique, is to maximize forecasting decisions accuracy (Isaksson 2002; Meyer et al. 2013; Matto & Sippola 2016; Kleyner & Sandborn 2008; Hamaker & Componation 2005; Sher & Punglia 2014; Shah & Goldstein 2006; Lee, Lee, et al. 2011).

In other words, the advantage of including cost overrun estimate calculations and time modelling mathematically from client and contractor perspectives is to help in making better decisions regarding tender budget and pricing; however, studies found that the "construction-contracting" method can consume and waste too much time and money during project execution stage (Isaksson 2002, p.9; Hu & He 2014; Jrade & Lessard University 2015; Wilke 2005). Overrun and over budget uncertainties are high costs risks on contractors and clients; however, it will be included in this research variables and factors (Isaksson 2002). Cost-time

modelling has been proposed based on estimation and the practical modelling of projects' cost dynamics (Isaksson 2002; Zhu et al. 2007; Adey et al. 2012; Howell & Koskela 2000). It is also imperative to determine the condition of geological and hydrological aspects (i.e., soil and ground conditions) of the mega-project execution (Isaksson 2002; Ong & Ong 2016; Jafarzadeh et al. 2015). Second, it is necessary to select the executing method for each project part of the tunnel by dividing it into zones or segments based on the geological classification's characteristics and then grouping the similar zones based on the homogeneity characteristic. However, this will help choose the method of executing the project which is critical and necessary to determine the time and cost estimation and modelling (Isaksson 2002; Koo et al. 2010; Battistoni et al. 2016). That is why the execution method, geographical location and soil type must be included in this research study.

Third, the following step estimates the needed normal cost to execute each zone (Isaksson 2002). In other words, it aims to estimate and expect costs during the execution time required to finish the project under normal circumstances and conditions (Isaksson 2002; Battistoni et al. 2016). This will be done by having several formulas as shown in equation 2-5 for measuring the normal cost of tunnel construction where "C_{Ni}" is the normal cost, "Z" is the cost variable, and "g(x(l))" is the effort production function. The normal production time "Q" can be calculated from efforts production function "g(x(l))" based on time-dependent cost (Isaksson 2002). After estimating and calculating all zones' normal cost and time, it is mandatory to measure and estimate the probability of the normal time frame and normal cost budget for each executed and constructed production class (Isaksson 2002, p.107). This can be done by having Monte Carlo modelling to measure probability while "g(x(l))" can be calculated by using the following steps (Isaksson 2002, p.107):

1- Using equation 2-6 and 2-7, where "m_i" is the mean value for each class or group, "a" is the lowest expected value of production effort. "b" is the production effort probability value, and "c" is the highest expected value of production effort.

2- Calculate the standard deviation can be done by equation 2-8, 2-9, and 2-10 where "E(Y)" is production effort, "P_i" is the probability of each production effort class required to achieve, and "σ_i" is production effort standard deviation.

3- Suppose there is strong correlation between all classes and zones' geotechnical specifications. In that case, the standard deviation will be calculated using equations 2-11 and 2-12 where "L" is total tunnel length, and "δ_l" is the distance of each similar segments group with the same geotechnical characteristics.

4- Then, for calculating normal cost, it is decided to use equation 2-13 where "j" refers to the type of cost in Issaksson's (2002) cost estimation model.

5- Also, to calculate time-dependent cost "Z", it is decided to use equation 2-14 where "Q" is normal.

6- To calculate and find out the quantity dependent costs, it is decided to use equations 2-15 and 2-16.

7- Finally, to estimate and calculate fixed costs, it is decided to use equation 2-17; and it is decided to use equation 2-18 to calculate the total estimated normal costs.

Nevertheless, a set of modelling equations has to be taken into consideration in case of having a non-desirable situation which can cause time and cost more than the normal estimated time and cost And, it is used for estimating and calculating the time and cost of each situation as the following (Isaksson 2002, p.154):

1. Calculating probability "X" value exceeding a critical value "X_c" using equations 2-19 and 2-20.
2. Calculating geotechnical random situation probability in projects using equation 2-21.
3. Calculating mechanical random situation probability in projects using equation 2-22.
4. Calculating accordance probability of "gross error" situations in tunnel projects.
5. Calculating time or cost special situations by using equations 2-23, 2-24, and 2-25.
6. Finally, cost and time modelling calculation was based on the Monte Carlo technique and using equations 2-26 and 2-27.

Therefore, in this research study, cost modelling will be covered through probability analysis, mathematical modelling, and error calculation to end with more accurate outputs.

After that, researchers found that most risk identification, assessment, and control are based on cost overrun and time delay (Boateng 2014; Heralova 2014; Flynn et al. 1990; Gilbert et al. 2016; Guo & Sultan 2017). Thus, it is important to get accurate decisions regarding available uncertainties in mega construction projects by studying the project's feasibility (Boateng 2014; Heralova 2014; Flynn et al. 1990; Gilbert et al. 2016; Guo & Sultan 2017). This can be based on the company's resources and capabilities to accurately estimate costs and time (Boateng 2014; Heralova 2014; Flynn et al. 1990; Gilbert et al. 2016; Guo & Sultan 2017).

$$C_{Ni} = \int_L z * g(x(l))dl$$

(Eq. 2-5)

$$m_i = (a+b+c)/3$$

(Eq. 2-6)

$$\sigma_i = ((a^2+b^2+c^2-a*b-a*c-b*c)/18)^{0,5}$$

(Eq. 2-7)

$$E(y) = \sum P_i m_i$$

(Eq. 2.8)

$$\sigma_y = \sqrt{\sum(\sigma_i^2 + a_i^{\,2} * P_i)}$$

(Eq. 2.9)

$$a_i = E(y) - m_i$$

(Eq. 2-10)

$$\sigma_Q = L * \sigma_y$$

(Eq. 2-11)

$$\sigma_Q = \sqrt{L} * \sqrt{\delta_l} * \sigma_y$$

(Eq. 2-12)

$$C_{N_i} = \sum_j (z_j \int_L g_j(x(l))dl)$$

(Eq. 2-13)

$$C_{N_t} = \sum \int z_t * g_t(x(l))dl \approx \sum z_t \int g_t(x(l))dl = \sum z_t Q_t$$

(Eq. 2-14)

$$C_{N_q} = \sum \int z_q * g_q(x(l))dl \approx \sum z_q * Q_q$$

(Eq. 2-15)

$$C_{N_q} = \sum_j (z_q g_q(x(l))) \int dl = \sum z_q Q_q * L$$

(Eq. 2-16)

$$C_{N_f} = \sum \int z_f g_f(x(l)) = \sum z_f$$

(Eq. 2-17)

$$C_{N_i} = \sum_j \int z_j * g_j(x(l))\partial l = \sum z_j \int g_j(x(l))\partial l = \sum z_j Q_j$$

(Eq. 2-18)

Figure 2-8: Cost Modelling Equations from Eq.2-5 to Eq.2-18 (Isaksson 2002).

$$P(X > x_c) = \int_{\infty} f(x)dx$$

(Eq. 2-19)

$$P_x(x) = \binom{n}{x} p^x (1-p)^{n-x}$$

(Eq. 2-20)

$$p(x) = \frac{(\lambda L)^x e^{-\lambda L}}{x!}$$

(Eq. 2-21)

$$P_s(failure) = 1 - \exp(-\sum_{i=1}^{n} \lambda_i t)$$

(Eq. 2-22)

$$S_{ik} = \begin{cases} 1 & event\ \ k\ \ occurs\ \ with\ \ probability\ \ p \\ 0 & event\ \ k\ \ does\ \ not\ \ occur\ \ with\ \ probability\ \ (1-p) \end{cases}$$

(Eq. 2-23)

$$C_{e_k} = S_{ik} * C_{ik}$$

(Eq. 2-24)

$$C_e = \sum_{k=1}^{n} C_{e_k}$$

(Eq. 2-25)

$$C_{tot} = C_N + C_e = \sum_{zone} \sum_j \int z_j * g_j(x(l))\partial l + \sum C_{e_k}$$

(Eq. 2-26)

$$E(C_{tot}) = \sum_{zone} (L * g[E(x)] * E(z) + \sum P_k C_k)$$

(Eq. 2-27)

Figure 2-9: Cost Modelling Equations from Eq.2-19 to Eq.2-27 (Isaksson 2002).

However, feasibility studies are essential to cover uncertainties and risks for construction client and contracting companies; for example, the “BIG DIG” tunnel project was estimated to cost 2.6 billion dollars and to finish in 2002 while it was completed with a cost of 14.6 billion and finished on 2005 (Boateng 2014, p.20). According to Boateng (2014), it is required to have a very well structured risk management system plan to achieve a successful risk management practice; however, it is based on accurate cost and time feasibility studies to achieve end-users' desired requirements (i.e., Quality of work). Risk management studies started in the 1950s deriving too many methodologies to estimate uncertainties and assess and control them based on probability science (Kim & Reinschmidt 2011; Boateng 2014). However, these methodologies could not provide a way to measure them except in the latest studies when researchers started identifying, analyzing, assessing, controlling, and eliminating risks based on time and cost (Boateng 2014). So, Boateng (2014) research measured mega projects risks, including cost and time, as critical factors using system dynamics modelling tools and techniques. However, the budgeted cost and delivery time of mega-projects changes and varies over time and other changing variables (Boateng 2014; Abdallah 2007). His research aims to develop and build a risk assessment model to improve and enhance the process of making decisions in large construction projects; also, its purpose is to help the public and clients of a mega construction project to avoid delay and over cost by assessing risks which are leading to consuming more time and money (Boateng 2014). His model has been built through a combination of three models (i.e., ANP “Analytical-Network-Process”, Monte Carlo, and System Dynamics models) to cover several points such as the following (Boateng 2014, p. 77):

1. Identifying “STEEP (i.e., Social, Technical, Economic, Ecological, and Political)” problems of the large-scale construction projects to study the most significant risks on development processes.
2. Analysing, modelling, and simulating all STEEP factors relationships and understand how they interact with each other.
3. Check all available and possible solutions for assessing possible risks in such public megaprojects.
4. Develop an approach to solving conflicts resulted from risks; or build methodologies to assess and minimise risks by appropriately controlling them if it is not possible to eliminate them.

The methodology used in Boateng's (2014) research is to have a practical approach framework of checking the applicability of research outcomes; so, the developed model was based on an extensive literature review. The model has then been shaped and built using ANP, ANOVA, Monte Carlo, and SD tools (Boateng 2014). Then, the model was tested and validated before using it in the research applications. Finally, a case study was chosen carefully to represent the infrastructure megaprojects while providing valid and valuable data used by the developed model to finalize the results and conclusion (Boateng, 2014). However, two main conditions had to be applied to the model. First, the STEEP characteristics and factors are not discrete or carrying discrete properties (Boateng 2014). Second, the variables and risk factors are not affected by any project’s internal conditions and environment (Boateng 2014). This will open the door for other researchers to use generated models and approaches on many other projects; nevertheless, Boateng (2014) contributes to the construction industry risk management body of knowledge (Boateng 2014). Therefore, project costs risk extracted from

literature and verified in systems dynamics modelling will be used in this research study cost estimation modelling.

Next, Boateng's (2014) research methodology was based on several steps starting with mixing the Meta Theory methodological approaches, shown in Figure 2-10. The methodology will mainly be based on mixing Positivism, Post Positivism, and Interpretivism using qualitative methods with some quantitative methods to generalize outcomes resulting from researching a case study. However, in case of studies, results can be confirmed on a single country's projects, on a few countries' projects, or many countries' projects (Boateng 2014; Westbrook 1995; Yasin et al. 2015; Venkatesh, Brown & Bala 2013). Then, research methodology was used (i.e., ANP and SD) to model construction risks, interpret relationships and apply the model to real data of infrastructure mega construction projects to conclude with new original outputs to the body of knowledge shown in Figure 2-11 (Boateng 2014). Nevertheless, the framework resulting from ANP & SD approaches is based on having risk identification and assessment as risk study research core (Boateng 2014; Ozcan-Deniz & Zhu 2016; Wang, Ding set al. 2016).

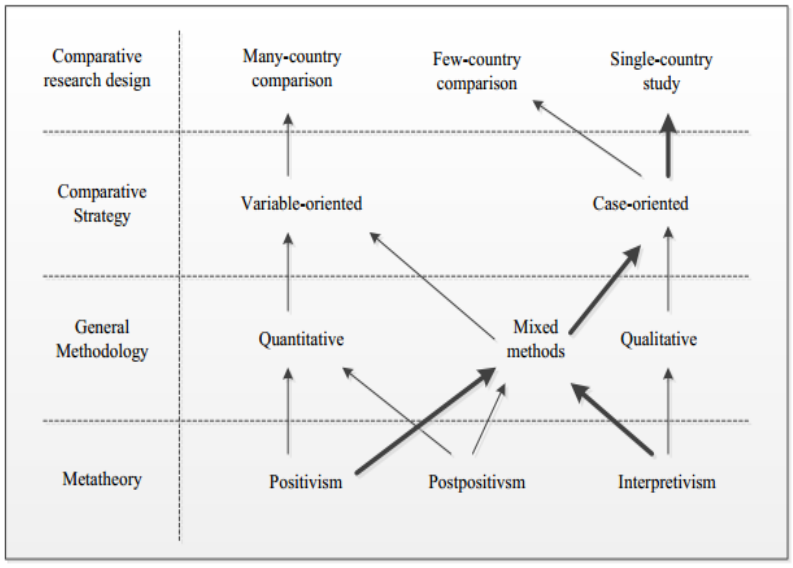


Figure 2-10: The relationship between the Meta Theory choices with the other methodology, strategy, and research design (Boateng 2014).

All other factors are considered variables, including cost and time (Boateng 2014; Chapman 1998). So, research questions focused on how risk events affect transportation projects' delivery, how risk factors affect cost and time, and how risk can be modelled using SD and ANP approaches to set appropriate assessment (Boateng 2014).

Next, the researcher introduced the ANP model and SD model building processes by identifying each STEEP element and risk factor through a detailed literature review and empirical studies (Boateng 2014). This identifies the best situation case study by having expert opinions and verifying available data of relevant available case studies; it also identifies model's feedback through survey questioners to check the significance of allocated risks and study their assessment shown in Figure 2-11 (Boateng 2014). However, Figure 2-12 shows how researchers set the bases of identifying possible and potential risks by studying environmental and technical risks, social and economic risks, and political risks concerning infrastructure mega construction projects (Boateng 2014).

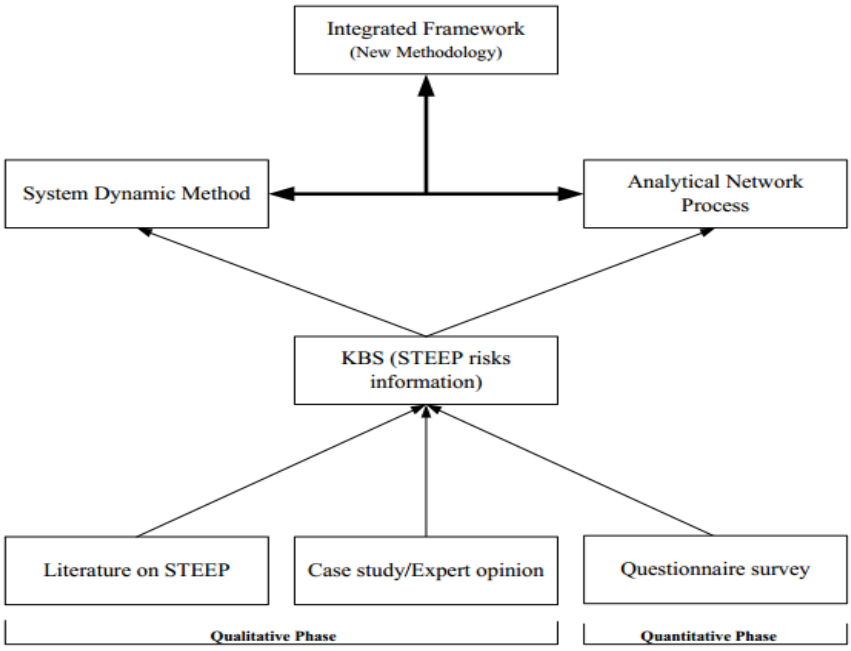


Figure 2-11: The Proposed research Qualitative Framework for Building and developing the Risk Assessing Model (Boateng 2014).

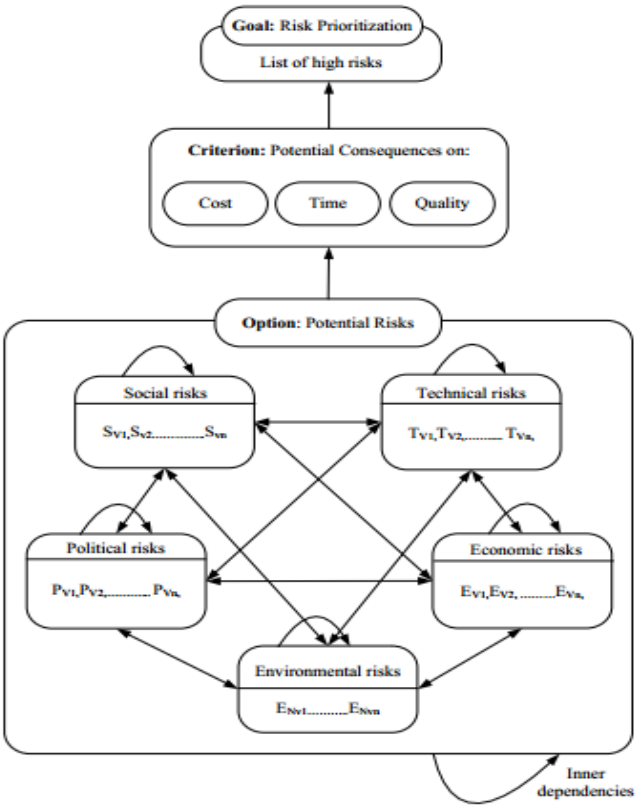


Figure 2-12: The ANP Model building and integrating process (Boateng 2014).

Then, investigating possible impacts falling on time, cost, and quality are considered risks classification criteria of classifying risk into high and low levels (Boateng 2014; Hess et al. 2001; Hernández-Sancho & Sala-Garrido 2009; Hunter, Fitzgerald & Barlow 2014). Also, investigating possible impacts on time, cost, and quality helps set assessing priorities of each identified risk (Boateng 2014; Hess et al. 2001; Hernández-Sancho & Sala-Garrido 2009; Hunter, Fitzgerald & Barlow 2014). As a result, it was found that all identified risks related to time delay, cost overrun, of poor/low-quality drive to unnecessary extra costs which are considered significant for integrated systems dynamics risks model in the infrastructure mega construction projects (Boateng 2014; Hess et al. 2001; Hernández-Sancho & Sala-Garrido 2009; Hunter, Fitzgerald & Barlow 2014). Therefore, investigating cost, time, and quality factors and risks in residential projects is mandatory for this research study to end with more

accurate, valid, and significant outputs. This research study will also work on group and classify risks and factors based on valid criteria to have a more accurate cost estimation systems dynamics model.

Next, the ANP model is aimed to be feed into the SD model at the model and development integrating stage; however, both ANP and SD models are using separate data sets from the chosen case study and then merged to gather to form Risk Assessment Model for Mega Infrastructure Construction Projects (Boateng 2014). Therefore, this research study will conduct a clear, detailed mapping using separate cost risks to create accurate system dynamics sub-models to end with a valid Systems Dynamics Approach for Whole Life Cycle Cost Modelling of Residential Buildings Projects in UAE.

After that, researchers have introduced the risks system dynamics model's elements focusing on three main components, as shown in Figure 2-13. First, reinforcing loops are the relationships between variables and each other in a dynamical behaviour (Boateng 2014). Second, balancing loop error actions (i.e., the desired value for each variable to satisfy criteria) included integrating an accurate, realistic risk assessment process model (Boateng 2014).

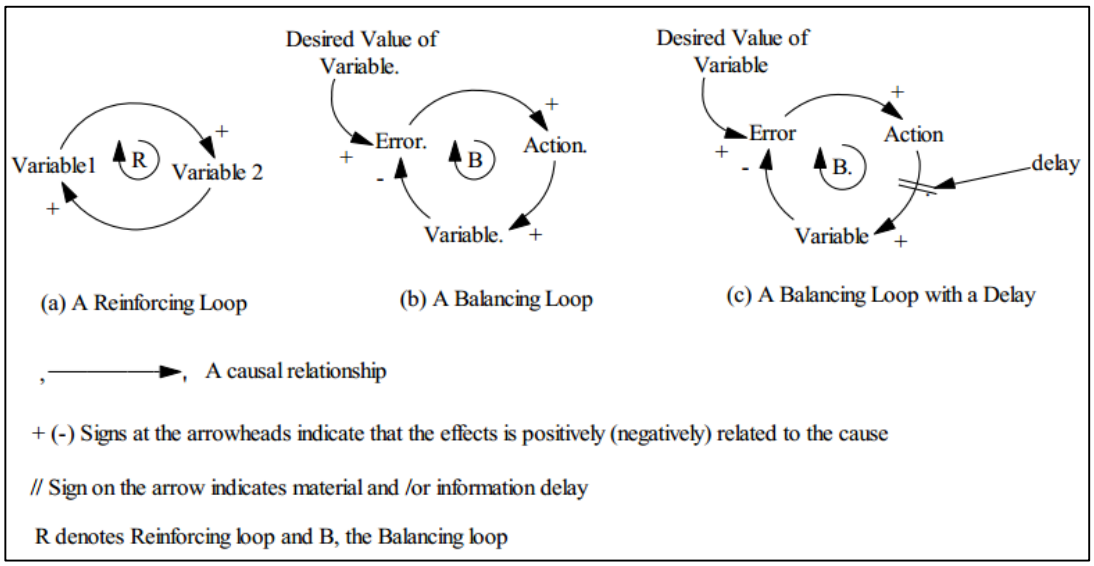


Figure 2-13: Elements and components of how to build system dynamics model (Boateng 2014).

Third, balancing loop delay elements resulted from actions maintaining project progress within a time framework, desired quality, and budgeted cost (Boateng 2014). However, this will be translated into cost overrun (i.e., the main factor of projects' failure) (Boateng 2014). As a result, it is imperative to conduct cost estimation modelling research to enhance costs' prediction accuracy and avoid overrun. Simultaneously, researchers have considered that the real case study model will be very complex and include too many components, having very high dynamical variables in each model component (Boateng 2014; Barratt, Choi & Li 2011; Easton 2010; Voss, Tsikriktsis & Frohlich 2002). This is including several processes of feedbacks that can be multiple or single at each stage and including nonlinear characteristics of soft and hard data in the utilized case study (Boateng 2014). However, it proves that the dynamical mathematical relationship can be nonlinear in costs and risk modelling, which will be considered in this research study. As a result, in Figure 2-14, the final SD model shows all dynamical components with their interaction with each other after feeding results of ANP and verifying it in a simulated model of risk assessment (Boateng 2014).

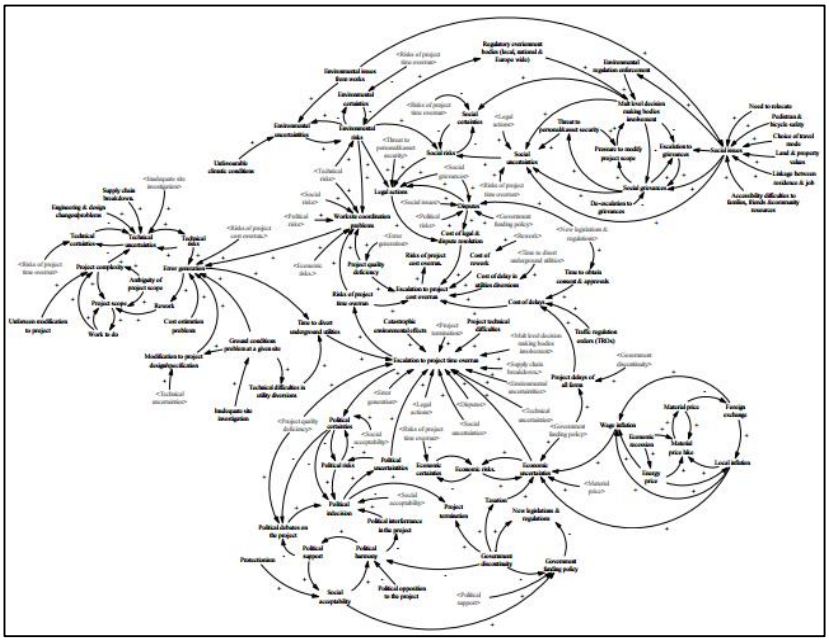


Figure 2-14: The final simulated system dynamics model used for assessing risks in mega infrastructure construction projects (Boateng 2014).

In the end, the developed model "MegaDS" has identified the risks, level, priorities, and assessment propositions of the entire project life cycle; however, it reached results and concluded that risks and their factors are required to be handled carefully and equally (Boateng 2014, p.334). All risks are connected, and the effect of any failure in dealing with risk will generate other risks (Boateng 2014). This may lead to a failure to handle quality, cost, and time properly (Boateng 2014). Therefore, this research study will be carefully handled, and mapping collected costs risks ending with accurate estimated cost using systems dynamics. Also, the developer and clients of mega construction projects are required to enhance their capability to understand the contractor's actions (Boateng 2014). This is mainly based on reducing costs and maximizing profitability by assessing risk factors to successfully deliver public products (Boateng 2014). One of the advantages of the integrated model is that it can predict a construction project's performance based on its risk availability and assessment, which will be included in this research study via cost s-curve performance (Boateng 2014). Hence it gives the ability to see project projection in the next stages to make a good decision using the developed system dynamics model (Boateng 2014).

As a result, the latest research regarding risk events for optimizing money value in projects has been conducted related to the large-scale projects in the Kingdom of Saudi Arabia construction industry (Alzahrani 2015). It is based on having the optimum value of money in construction projects by modelling risk events, factors, and variables with their construction risk cost interrelation to study risk estimation effectiveness and cost resulting from construction projects' life cycle risk events.

On the other hand, it was proved that performance risks and their indicators have strong relationships with stakeholders and activities related to costs and budget (Takim & Akintoye 2002). It is changing for each of them through project operations' time and processes, which

require being modelled and analysed in a dynamical approach to delivering a successful project (Takim & Akintoye 2002). Also, even when system dynamics can improve cost analysis related to risks, it is necessary to consider Monte Carlo techniques to reach more reliable and précised values and results (Koul et al. 2016; Vanbrabant, Schoot & Rosseel 2015; Ioannou, Angus & Brennan 2017; Bagnara et al. 2018). However, besides Monte Carlo techniques for analysing risks, the cost-benefit method is considered valuable for some researchers to analyse costs and budgets related to risks (Feuillette et al. 2016). Therefore, the causal relationship in the system dynamics model is the main criterion for getting relevant results based on logical and valid assumptions and input (Park et al. 2012). This is very important to make and make a decision because it depends solely on the relationships between estimated costs and identified risks covered by cost-effectiveness investigation at the pre-construction stage; however, the system dynamics approach can optimize these variables' relationships accurately (Sher & Punglia 2014). Therefore, systems dynamics will be used in this research study to model cost estimation based on changing risks. Nevertheless, most of the concerned risks causing over costs are based on expected performance issues (Shen, Nguyen & Ojiako 2013). This is due to the characteristics of performance and progress in the construction industry that include cost running during on hold progress and zero performance; however, researchers tried to control this issue by modelling the expected performance based on expected inputs in each stage of construction execution (Shen, Nguyen & Ojiako 2013). This makes performance variables extremely valuable to dynamical cost modelling of this study to deliver the actual view of the real costs to make appropriate decisions.

In summary, risk analysis and investigations related to cost and budget modelling have shown that the best way to get reliable results is to use the system dynamics approach. However, it is proved by evidence that construction risks at the tendering stage from

procurement perspective due to ineffective identification of costs sources making it varying after setting estimated budgets (Elhag, Boussabaine & Ballal 2005). Thus, previous research evident that costs contingency must be handled and managed effectively to increase the probability of projects' success (Kujawski 2007). Moreover, time series modelling of costs forecasting was used to predict CCI "Construction Costs indices" to cover risks of plans, bids, and costs as a method substituting system dynamics (Shahandashti & Ashuri 2013, p.1241). Nevertheless, it did not achieve the desired results level because of difficulties in choosing an appropriate "multivariate time series model" to analyse the project's capital (Shahandashti & Ashuri 2013, p.1241). Therefore, CCI risk will be included in this research study. After that, BIM helped in a wide range to identify many risks and clashes at the pre-construction stage (Jrade & Lessard 2015). The disadvantage is that it does not cover all dimensions and cannot customize the required dimensions as required (Jrade & Lessard 2015). This can be done in the system dynamics modelling of this research study. Also, risk identification and assessment is based on time frames and vary between periods due to the stakeholders' conflict (Doloi 2011; Mills 2001). This makes it difficult to track and understand risks that change costs (Doloi 2011; Mills 2001). These factors are essential to analyze and classify with weightage according to its impact qualitatively and quantitatively to accurately describe financial models and get accurate estimated outputs (James 2014; Vanhoucke 2012). However, system dynamics approaches are required to monitor costs based on updating changes on the integrated cost model of most construction firms. These updates happened or will happen in the short- term future using tools such as primavera to find out the earned value through mathematical equations (Salling & Leleur 2015; Hunter, Fitzgerald & Barlow 2014). Finally, risk factors will be modelled in this research study using a system dynamics approach to overcome all challenges mentioned in previous research related to cost estimation and modelling.

2.4 Projects Cost Estimation Modelling Literature Review

More than 90% of finished and completed projects ended with a tolerance between ±10%, while less than 80% have tolerance of ±5% of estimated costs after studying more than 1500 projects in the United Kingdom (Ahiaga-Dagbui & Smith 2014). However, in the early nineties, research has proved that the using system dynamics role gained more value than any other approach or technique in the project management field due to its efficiency in obtaining accurate decision-making results (Bowers 1996). This is because of system dynamics accuracy in allocating each model part and its cost (Lindemann & Jahnke 2017). Also, system dynamics shows costs position in the industrial chain to understand its impact on projects profitability and processes (Lindemann & Jahnke 2017). After that, components parts choice of required products or its process during projects' life cycle is a significant criterion for deciding whether cost-efficiency meets the required level. So, estimated costs are necessary for decision-making based on system dynamics modelling and simulation (Rahman et al. 2012; Cople & Brick 2010). Nowadays, the demand for developing cost estimation models became higher to reach better and effective results because projects are more expensive, complicated, and urgent to end-users than before (Ahiaga-Dagbui & Smith 2013). However, due to optimizing project costs, the performance and quality will be improved, considering cost as one of the most core factors of deciding project success and failure after the construction stage (Ahiaga-Dagbui & Smith 2012). One of the critical and significant approaches is controlling costs through managing the project's earned value (Acebes et al. 2013). This is done by drawing and initiating a framework of managing schedules, risks, and integrated costs during buildings construction using Monte Carlo Simulation techniques (Acebes et al. 2013). For example, the cost control index will monitor costs and schedules during execution stages and keep them under control (Acebes et al. 2013). This will avoid being out of control related to projects cash flow (Acebes

et al. 2013). It is then proposed to control and optimise cost prediction by optimizing the work and activities scheduled from initiation until the end of projects using the Neural approach dynamically approach in an integrated general mathematical equations and calculations model (Adeli & Karim 1997). However, this can be through using linear planning and scheduling methods while connecting them with cost to monitor and control it after setting and approving budgets (Adeli & Karim 1997). Therefore, works and activities changing risks will be included in this research study's final model. On the other hand, it was suggested by another researcher to optimize construction costs by applying the "Neural Dynamics Model" at the design stage to minimizing construction costs before starting its execution (Adeli & Karim 1997, p.450). The cost will be minimal by calculating construction materials and components' costs at the design stage (Adeli & Karim 1997). This does not cover cost variables and cannot give the best estimation to avoid overrun (Adeli & Karim 1997). Next, cost analysis and control in infrastructure projects such as road projects require cost modelling for determining projects' benefits to clients, contractors, and other stakeholders (Adey et al. 2012). This can be done accordingly by integrating the project cost model at the pre-construction stage, including its operational cost (Adey et al. 2012). After that, if the construction industry is treated as the manufacturing industry, some researchers proposed that the best way to model value streams and predict cost is by developing a cost estimation model by utilizing multi-product approaches and methodologies (Agyapong-Kodua et al. 2012). However, construction activities produce several products to act and work as one unit representing the project's final product (Agyapong-Kodua et al. 2012). In 2013, conducted research led to fuzzy modelling using a neural approach for optimizing final estimated results of infrastructure cost at the pre-construction stage (Ahiaga-Dagbui et al. 2013; Adeli & Kim 2001). This will help significantly manage financial flows during the execution stage at the project managers' level from the client's perspectives

(Ahiaga-Dagbui et al. 2013). This “Artificial Neural Network” is developed through the historical database of 1600 previous projects showing 92% validity and ±5 % final predicted cost accuracy (Ahiaga-Dagbui & Smith 2014, p.39). So, by proving its efficiency in forecasting the water infrastructural construction costs at the pre-construction stage (Ahiaga-Dagbui & Smith 2014). It is also proved in published literature reviews that the main constraints affecting quality and progress speed are costs and time (Ahiaga-Dagbui & Smith 2014). This is deciding the ability and probability of having a highly effective final functional project (Ahiaga-Dagbui & Smith 2014). From a project management perspective, cost modelling can be improved by optimizing other engineering components with minimum cost and the highest efficiency (Ahmed & Avetisyan 2016). However, it is not a method of modelling construction cost, and it can be considered one of its factors, which is how this research will deal with it (Ahmed & Avetisyan 2016). From the early nineties, the integration of accurate systems to provide the best cost models in the construction industry became one of the most important project management priorities (Burns et al. 1993). This is deciding the efficiency of managing construction projects effectively (Burns et al. 1993). So, the invention of the “Construction Cost Management and Analysis System” was made by the United States of America's military to optimize the consumed amount of money in its construction projects (Burns et al. 1993, p.33). Therefore, this research study will investigate building a more accurate model using a system dynamics approach to include the construction stage as a part of the project's whole life cycle estimated costs. However, according to other researchers, quality is a cost phenomenon, reflecting time-effective management in projects (Atkinson 1999). In other words, the time delay can cause more cost and funding problems can cause time delay to proves that the project management golden triangle elements are connecting each other significantly, and optimizing cost models will enhance project management efficiency and success (Atkinson 1999).

Researchers concluded that cost estimation plays a significant role in any investment decision-making, especially when it is related to long-term investments (Donovan & Corbishley 2016). It is based on the cost of capital prediction and estimation through detailed calculations of invested projects' capital IRR "Internal Rate of Return", NPV "Net Present Value", and PBP "Pay Back Period" before making and taking decisions (Donovan & Corbishley 2016, p.3). This is important in Public-Private Partnership such as infrastructure and other public projects, which put into consideration time and value of money in both private and public sectors to reach targeted 2030sustainable developments and agenda (Assad et al. 2007; Dubai-Government 2016; KSA-Government 2016; Abu Dhabi-Government, 2016a, 2016b, 2016c, 2016d, 2016e, 2016f). Moreover, green building direction from design to execution stages has been mandatory in many countries in the Middle East and Arabian countries such as Egypt, Kingdom of Saudi Arabia, and the United Arab Emirates (Assad et al. 2007; Dubai-Government 2016; KSA-Government 2016; Abu Dhabi-Government, 2016a, 2016b, 2016c, 2016d, 2016e, 2016f). After that, sustainability costs increased significantly due to the huge demand for applying it on all future development projects (Anderson et al. 2015; Becchio et al. 2016; Battistoni et al. 2016). It had to be analysed and investigated using several methods and approaches to prove that cost-benefit analysis is incompatible and require different methods to replace it (Anderson et al. 2015; Becchio et al. 2016; Battistoni et al. 2016). This is due to the great number of debates that show opposite results proved by evidence; however, it is useful and efficient in analysing and estimating infrastructure projects' cost (Anderson et al. 2015; Becchio et al. 2016; Battistoni et al. 2016). Construction sustainability proved that it presents a large cost percentage making researchers focus on dividing it into several components (Ashrafian et al. 2016). This concluded that energy is the highest cost in a project's whole life cycle, starting with execution and continue through its operation after delivering it to the end-

users (Ashrafian et al. 2016). Therefore, in this research, energy risks will be included in the cost estimation system dynamics model. Previous research proved that cost liner programming interrelates with project time and quality and can optimize resource allocation to avoid cost overrun by satisfying budget, targeted quality, and planned time frame (Babu & Suresh 1996). It can be done using Monte Carlo Simulation wand add more processes such as probabilistic hypothesis (i.e., based on the likelihood of uncertain events or risks regarding estimated elements) and deterministic (i.e., based on certain valid information about estimated elements) (Chou 2011; Cassettari et al. 2016). Cost estimation modelling processes need to be based on past deterministic information and present facts to estimate risks and uncertainties' probabilistic predictable facts (Chou 2011). On the other hand, uncertainties should take into consideration the dynamical shape of cost variable, which can be handled by CPM-Critical Path Method, CBT-Cost-Benefit Analysis and PERT-Program Evaluation and Review Technique analysing tool (Alzraiee et al. 2015; Attoh-Okine 2002; Cheng 2014; Belay et al. 2016). This will build an accurate, effective system dynamics model of future prediction (Alzraiee et al. 2015; Attoh-Okine 2002; Cheng 2014; Belay et al. 2016). However, factors related to contracts, design, external, economic, market conditions, and governments are studied and ranked based on relative importance index (RII) concerning construction performance, risks, and cost management (Bari et al. 2012; Gunaydın & Dogan 2004; Broeke et al. 2017). Then, common factors are analysed to study the relationship between cost and other project management areas, while containing the impacts of construction project management areas on cost estimation results (Bari et al. 2012; Gunaydın & Dogan 2004; Broeke et al. 2017). Therefore, those verified factors will be included in this research study model, and further investigation shall be done covering a wider literature review in chapter 3 before finalizing the model risks and factors.

In order to analyse factors and their impact on cost, researchers reached to several effective techniques for monitoring and controlling construction costs at execution stages such as “Variances Method”, “Leading Parameters”, and “Activity-Based Ratios” (Al-Jibouri 2003, p.145). This is providing accurate checks and analyses through the project’s implementation data (Vanhoucke 2012). It can also analyse and check applications of factors impacting costs for a more accurate conclusion about each factor's impact weightage on construction cost using actual, empirical, and assumed data (Vanhoucke 2012). Therefore, this research study shall use actual, empirical, and justified assumptions to end with a more accurate cost estimation model. Most of the cost control and monitoring studies have been conducted on construction projects from a contractor's perspective. This is because the contractor signed and agreed on planned budgets from tendering stage (Benjaoran 2009). Also, the reason is that contractors carry a larger amount of financial and success risks than the client (Benjaoran 2009). Nevertheless, the client is also carrying a huge risk because if contractors did not manage costs and risks appropriately, the project would have more possibility of failing and losing all invested money (Benjaoran 2009). Also, as a result of cost monitoring and control from a contractor perspective, the concept of value engineering started to be an interesting research point for contractors to save money and to compensate loss or maximizing profit (Berg et al. 2006). This method focuses on redesigning expensive elements after studying the cost of designed elements and their requirements for execution to optimize functionality results and minimize costs (Berg et al. 2006). However, in 1986, construction costs were optimized using the “decomposition technique” (Ong & Ong 1986, p.979). This was done by estimating function constants used in construction and build cost estimating models using the algorithm and computational techniques (Ong & Ong 1986). Then, with time passing from 1989 to 2016, mathematical approaches were developed through research to optimize project cost estimation using

probability techniques and methods (Signor et al. 2016). Therefore, mathematical modelling in this research study is mandatory for accurate estimated results.

Researchers have also covered cost modelling of construction industries using artificial approaches (Ahiaga-Dagbui 2014; Petroutsatou & Lambropoulos 2010; Alshamrani 2017; Stasiak-Betlejewska & Potkány 2015; Jin et al. 2012). This approach showed that it could reach about 92% accuracy of estimated costs and validity reached to ±10% of the final construction project's actual cost (Ahiaga-Dagbui 2014; Alshamrani 2017; Jin et al. 2012; Elhag, Boussabaine & Ballal 2005). Using "Artificial Neural Networks" (ANN) model for predicting construction cost showed high estimation accuracy at the pre-construction stage; however, using artificial models made a significant contribution in construction project management body of knowledge by proposing to change the term "Costs Overrun" to "Cost Growth" (Ahiaga-Dagbui 2014, pp.36-105). This is due to the truth discovered from cost modelling and facts interpretations in the construction industry during its execution (Ahiaga-Dagbui 2014). That truth is based on predicting costs based on several variables that will behave in a certain way as expected (Ahiaga-Dagbui 2014). However, the reality analysis can exclude or add more variables behaving differently from the modelled expected behaviour (Ahiaga-Dagbui 2014). The second significant contribution is adding artificial models as a new approach for cost estimation processes and practices (Ahiaga-Dagbui 2014). Nevertheless, the 2014 research found that one of ten projects are executed within the estimated budget; on the other hand, nine of ten projects are overrunning costs beyond planned budgets (Ahiaga-Dagbui 2014; Gardiner & Stewart 2000; Bauer et al. 2017). For example, infrastructure projects showed about 86% of costs overrun at execution stages of projects (Ahiaga-Dagbui 2014). However, these overruns in projects include three categories. First, rail projects cost exceeding budget by approximately 45%; second, tunnels and bridges projects costs exceeding budget by approximately 34%;

third, roads projects costs exceeding budget by about 20% (Ahiaga-Dagbui 2014). Besides, researchers studied 258 transportation projects and concluded that most inaccurate estimates are because of contractors' underestimation (Flyvbjerg, Holm & Buhl 2002). This underestimation has been investigated and found it to be based on political, economic, technical, and psychological challenges (Flyvbjerg, Holm & Buhl 2002; Flyvbjerg 2005). Researchers proved that underestimates are not errors and preferred justifying it because of "strategic misrepresentation" (Flyvbjerg, Holm & Buhl 2002, p.279). Research had five major facts that cost estimators should know about the cost overrun (Flyvbjerg et al. 2018). First, it is important to measure accurately project cost overrun. Second, data collection should be valid and reliable. Third, understand that cost overrun is not normally distributed, but it is fat-tailed; finally, the fourth and fifth facts are overrun bias behaviour and cost estimating de-biasing, respectively (Flyvbjerg et al. 2018). Researchers concluded that the actual cost could fall between 170% to 183% of project estimated costs at the pre-construction stage, while cost forecast can be inaccurate to represent 20% to 60% of actual costs (Ahiaga-Dagbui 2014; Skamris & Flyvbjerg 1996). Therefore, researchers agreed on that projects large projects have few studies and still have a problem in cost estimation results, but they disagree on how much percentage is costs overrun budget (Ahiaga-Dagbui 2014; Gardiner & Stewart 2000; Bauer et al. 2017; Skamris & Flyvbjerg 1996; Abdul-Rahman et al. 2012; Aljohani, Ahiaga-Dagbui & Moore 2017; Flyvbjerg 2005; Flyvbjerg et al. 2018; Flyvbjerg, Holm & Buhl 2002). Hence, this research study will consider all mentioned cost risks and investigate systems dynamics modelling to check its ability to estimate projects' full life cycle costs. As a result, it has been concluded over years that the chance of having more valid and accurate cost models is always available (Ahiaga-Dagbui 2014; Gardiner & Stewart 2000; Bauer et al. 2017; Skamris & Flyvbjerg 1996; Abdul-Rahman et al. 2012; Aljohani, Ahiaga-Dagbui & Moore 2017;

Flyvbjerg 2005; Flyvbjerg et al. 2018; Flyvbjerg, Holm & Buhl 2002). This continuous development and improvement of the existing cost models to achieve significant progress in different fields serve operation management and cost estimation purposes. For example, engineering software programs such as CAD and BIM can visualise and simulate construction elements, components, and requirements, providing better cost prediction ability (Ahiaga-Dagbui 2014; Klassen & Jacobs 2001; Wacker 1998; Mallasi & Dawood 2000). IT software developers focused on having more accurate costs estimation systems compared to final projects actual cost after execution (Ahiaga-Dagbui 2014; Reina et al. 2016; Maylor et al. 2006; Nematchoua & Orosa 2016; Forza 1995; Lundesgaard et al. 2007; Woodward et al. 2017; Eid, Moghrabi & Eldin 1997). Therefore, this research will consider software programs such as SPSS and VENSIM to deliver more accurate cost estimates. Nevertheless, researchers' developed cost models in the construction industry field included fuzzy logic, Monte-Carlo simulation, feature-based simulation, and generic algorithms (Ahiaga-Dagbui 2014). It was a chance in 2014 to release the artificial cost model based on infrastructure pre-construction stages networks from the client's perspective (Ahiaga-Dagbui 2014). The artificial cost estimating model is developed through the following stages:

1- Identify the needs and demands of having an accurate predicted total cost for different project stakeholders such as designers, financiers, project operators, project contractors, clients, and developers (Ahiaga-Dagbui 2014).

2- Building a cost estimation model based on historical prices, budgets, and costs of previously executed projects, including details required for executing construction projects, will provide a reliable model and results at the pre-construction stage (Ahiaga-Dagbui 2014).

3- Finally, initiate the model conceptualization using some of the qualitative approaches and then complete designing, establishing, implementing, and validating the model using the quantitative methods. However, quantitative techniques are the main approaches to reach a successful final "Artificial Neural Networks" (ANN) model (Ahiaga-Dagbui 2014, p.36).

Therefore, all identified and validated needs and requirements will be included in the final cost model after obtaining their risk of changing this research costs. This research will then complete modelling the residential project's whole life cycle cost using system dynamics mapping/diagram and pure mathematical equation modelling system. Cashflow estimation of projects' whole life cycle will be modelled along with the final estimated cost value.

However, the "Artificial Neural Networks" (ANN) model is based on identifying the over cost reasons in construction projects; for example, Ahiaga-Dagbui (2014, p.36) found that projects execution cost overrun is due to its time frame (i.e., long or short), complexity dynamics (i.e., simple or complex), risk management, optimism bias, corruption, rework/wastes (i.e., quality issues), and scope of work. This is causing over cost in both building and infrastructure projects (Ahiaga-Dagbui 2014). Also, it was found that cost overrun in construction projects are systematically due to under-estimates of the public sector's requirements intentionally to get the best contract of each project; so, it leaded researchers to set the equation of successful cost estimating process in public sectors' infrastructure as shown in Eq. 2-28 (Ahiaga-Dagbui 2014).

"Underestimated costs + overestimated benefits = funding"

Eq. 2-28: is extracted from the conducted research in the field of construction cost modelling and represent a successful cost estimation equation to provide funding for public infrastructure projects (Ahiaga-Dagbui 2014).

This equation (i.e., Eq. 2-28) is concluded because of the strategic misrepresentation of possible challenges that may occur in the project's execution stage and lead to underestimating costs (Ahiaga-Dagbui 2014; Flyvbjerg et al. 2018). The optimism bias leads to over benefits estimation and overlooking project's uncertainties, while some estimating results are conducted by non-construction practitioners (Ahiaga-Dagbui 2014; Flyvbjerg et al. 2018). Consequently, the surprising unplanned and unbudgeted costs will most probably lead to a significant construction infrastructure project failure (Ahiaga-Dagbui 2014).

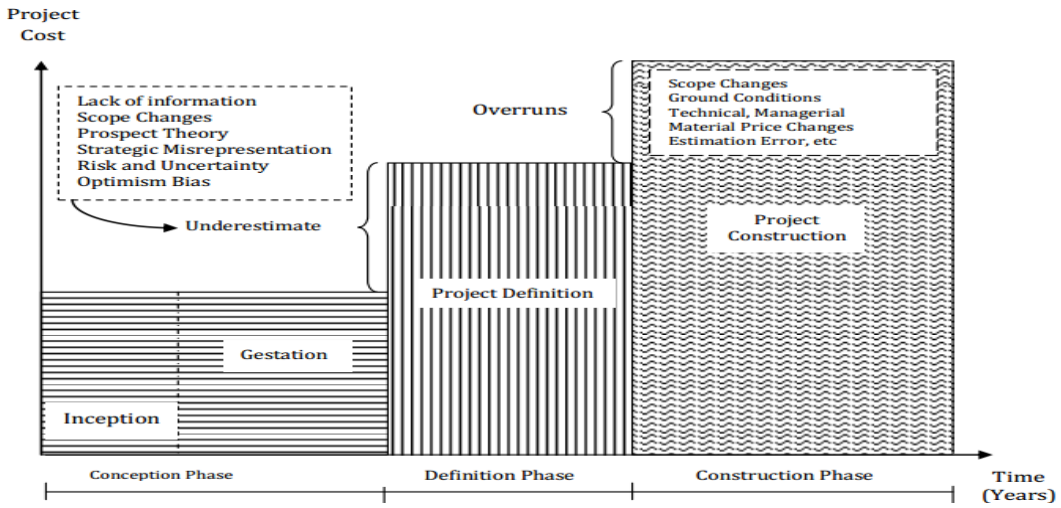


Figure 2-15: The conceptual model of how to understand construction cost variables and phases prior modelling its costs (Ahiaga-Dagbui 2014).

Figure 2-15 shows three main phases of project cost modelling evolution, its financial position, and status (Ahiaga-Dagbui 2014). The first phase is keeping costs as low as possible by not including too many construction details, avoid scope changing, avoid theory prospect, avoid strategic misrepresentation, avoid risks, and avoid optimism bias for getting financial and funding approval for the project (Ahiaga-Dagbui 2014; Ahiaga-Dagbui & Smith 2014; Tokede et al. 2014). The second phase is about making more details for skipped items in phase one to define and set a reasonable budget for the project (Ahiaga-Dagbui 2014; Ahiaga-Dagbui

& Smith 2014; Tokede et al. 2014). If detailed factors were not covered efficiently, then the project will be underestimated and experience cost overrun (Ahiaga-Dagbui 2014; Ahiaga-Dagbui & Smith 2014; Tokede et al. 2014). The last phase of the ANN conceptual cost model is considering appeared changes in the ground, technical, managerial, material prices, errors, and other factors in the construction stage to show the variation between planned budget and required amount of money to cover costs (Ahiaga-Dagbui 2014; Ahiaga-Dagbui & Smith 2014; Tokede et al. 2014). Hence, cost overrun starts to appear significantly when actual total costs exceed the planned budget, while total planned progress is higher than actual progress (Ahiaga-Dagbui 2014; Ahiaga-Dagbui & Smith 2014; Tokede et al. 2014). Thus, system dynamics cost modelling in this research will be divided into several phases as required to end with more accurate results.

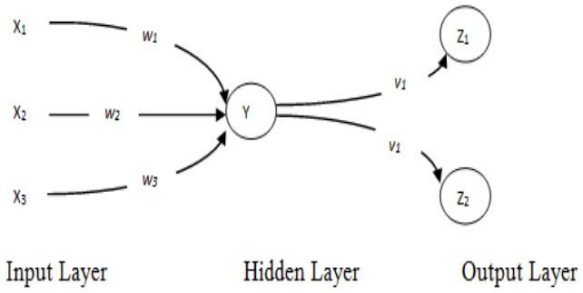


Figure 2-16: showing the basic structure of Neural Network Architecture used for modelling cost in ANN final model (Ahiaga-Dagbui 2014).

In Figure 2-16, the structure of the Neural Network is based on having three components. First, the input layer (X_n, where "n=1, 2, 3… etc."); second, the hidden layer (W_n, Y, and V_n where "n=1, 2, 3… etc."); third, the output layer (Z_n, where "n=1, 2, 3… etc.") (Ahiaga-Dagbui 2014, pp.46-88). However, the input layer is the quantitative data that feeds the numerical model requirements; then, hidden data is the computational and mathematical equations set to analyse data for producing accurate outputs in the last layer using cost

weightage and sensitivity (Ahiaga-Dagbui 2014). Nevertheless, if the model performance requires improvement, then the hidden layer shall be increased and developed to meet estimation results requirements (Ahiaga-Dagbui 2014). Finally, the third layer calculates input results using weighted functions to generate accurate outputs (Ahiaga-Dagbui 2014). Therefore, this research first layer will be the graphically mapped stock and flow dynamical relationship. Furthermore, this research hidden layer will be cost modelling mathematical equations to build accurate system dynamics cost model for residential projects whole life cycle.

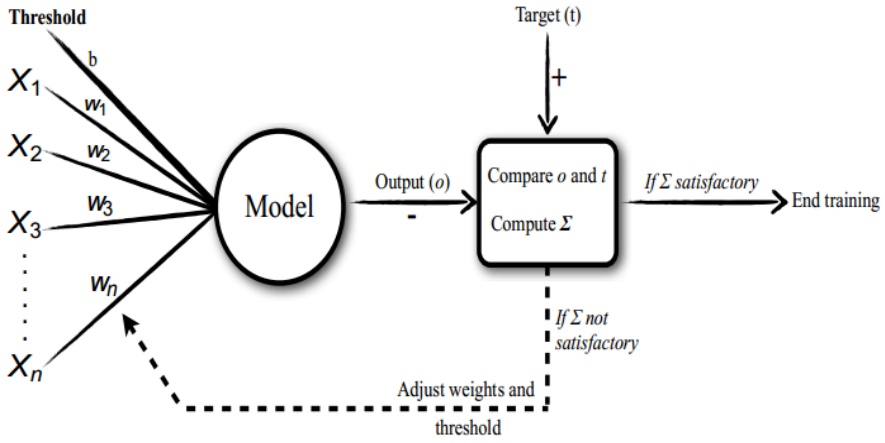


Figure 2-17: Showing how to reach the satisfactory targeted performance of the predicted construction project cost in ANN model (Ahiaga-Dagbui 2014).

Next, in Figure 2-17, it is clear that applying estimation analysis in the model to reach satisfactory targets and results is shown using the inputs layer (X_n), weightage hidden layer (W_n), modelling functions, simulated results, and testing / validating results (Ahiaga-Dagbui 2014). However, if results are not satisfactory, then the process must be repeated starting from the hidden layer stage to adjust each variable input number and weightage as per its impact and sensitivity on the project's cost for acceptable results (Ahiaga-Dagbui 2014).

$$\text{Model Performance}(\%) = \frac{Actual\ Final\ Cost - Predicted\ Final\ Cost}{Actual\ Final\ Cost} * 100\%$$

Equation 2-29: ANN model performance equation in percentage (Ahiaga-Dagbui 2014).

The required performance in the ANN model, as shown in Figure 2-16, can be calculated in percentage using Equation 2-29 based on comparing actual and predicted final cost (Ahiaga-Dagbui 2014). Therefore, this research will measure system dynamics cost modelling performance for improving the final model and obtain more accurate results.

In private-public partnership studies, risks during the project's lifecycle have been investigated to achieve higher infrastructure NPV (Jang 2011). This is due to research's agreement that risk and uncertainty are higher in large complex projects causing underestimation (Jang 2011; Florio, Forte & Sirtori 2016; Chapman 1998; Flyvbjerg 2005; Nguyen, Ogunlana & Lan 2004). For example, life cycle operations' dynamics complexity causes high and independent risks in large construction projects (Jang 201; Tsang 2014; Alvarez-García et al. 2017; Lambert, Emmelhainz & Gardner 1996; Yoon, Kim & Sohn 2008). Researchers also agreed that large infrastructure projects, including building, operating, and transfer stages, have risks interact with each other (Jang 2011; Tareghian & Taheri 2006; García et al. 2016). This is based on the nonlinear relationship of those risks and cost change (Jang 2011; Tareghian & Taheri 2006; García et al. 2016). Risk change during project's life cycle and researchers proposed system dynamics analysis approaches and methods to study, analyse, and understand how to optimize the project benefits, outcomes, profit, and cost (Jang 2011; Tareghian & Taheri 2006; García et al. 2016; Easton 2010; Carlile & Christensen 2005). The decision was made to consider the system dynamics approach to study more accurate approaches for uncertainties and risks (Jang 2011; Shen et al. 2007). As a result, the research

found that time and net present value are the most critical research interest in the project life cycle to investigate change over the project's execution time. Thus, this research will model costs based on time and risk change for residential project's whole life cycle.

Previous research presented that around one per cent of world GDP is required to be invested in infrastructure projects while maintaining these projects will consume around 1.2 per cent of world GDP (Jang 2011; Todorov 2014; Al-Hamadi 2020; Stasiak-Betlejewska & Potkány 2015). This will require a total of 2.2 % of world GDP to build and operate infrastructure projects worldwide from 2005 to 2010 (Jang 2011; Todorov 2014; Al-Hamadi 2020; Stasiak-Betlejewska & Potkány 2015). This provided significance and importance of risks and time research areas, especially after releasing the world bank reports identifying risks and time as necessary in the 1994 - 2002 road map conclusion (Jang 2011). However, studies in this ocean size field proved that a longer project executing period would cause an exceptionally low net present value and a considerable loss in societies' assets and needs (Jang 2011). Finally, the NPV system dynamics model has five main characteristics controlling risks and uncertainties in choosing contractors for large construction projects based on time and cost modelling, according to Steve Jang (2011) as the following:

1- First, projects lifetime: Project long life of an infrastructure project will have a big impact on build operate and transfer projects based on PPP criteria. So, if the project lifetime is larger, the benefit delivered to society will be higher.

2- Second, risk and supply chain heterogeneity: The combination of contributing fields in any large infrastructure project is totally different from each other and essential. This is because it is critically defining the last product outcome; however, those interacting fields include systems, civil, electrical, and mechanical engineering. It is required to add tracking and maintenance systems because it will need several stations'

construction. Risk heterogeneity in design to construction and operation stages will include economic, financial, organizational, technological, contractual management, environmental, and political agents to have a heterogeneity nonlinearly connected risk system impacting the project's NPV.

3- Private financing: to have successful infrastructure developments, it is critical to ensure enough project WLC starting from design, construction, and operation stages.

4- Risk allocation and sharing prior assessing: from agreements and contracts between private and public sectors, risk start to appear and be more critical during the project lifecycle. This is due to more cost and time caused by conflicts between stakeholders, as shown in figure 2-18.

5- SPV (Special Purpose Vehicle): the mechanism of financing before designing and constructing a build-operate-transfer project must provide the best result of investing quality, time, and money in the product of built environment projects. On the other hand, it is handled aggressively by other projects' stakeholders.

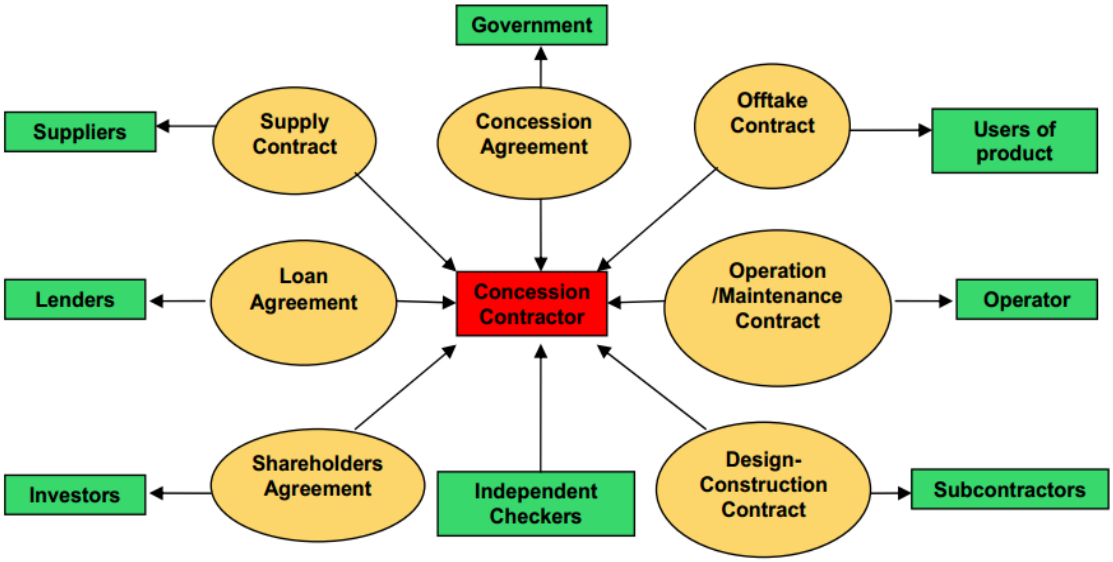


Figure 2-18: The summarizing chart of researchers focus area as per Steve's literature review to find researching gap (Jang 2011).

Therefore, this research study will investigate the heterogeneity of cost risks and their interaction with residential projects' whole life cycle time; besides, the system dynamics approach will be used for more accurate results.

After that, research in the construction system dynamics field did not cover all perceptions and answers to possible questions (Jang 2011; Mawdesley & Al-Jibouri 2009; Reichelt & Lyneis 1999; Schell, Claro & Guikema 2017; Bertrand & Fransoo 2002; Doan & Chinda 2016; Lindemann & Jahnke 2017; Ibanez-Lopez, Martinez-Val & Moratilla-Soria 2017). Jang's (2011) research purpose is based on developing a theoretical approach to solving public sector projects contractor selection process's real problems to create more value of money. Modelling project's net present value completes this based on time and risks influencing final NPV (Jang 2011). Public sector projects time overrun negatively impacts the net present value and is considered unnecessary over cost (Jang 2011). However, NPV modelling required the following stages to achieve more accurate PPP projects contractor selection (Jang 2011):

1- First, build- operate- transfer project require to link between contractors' selection and risk analysis. This will have the feature of increasing the risk level for all related project parties. Those commitments and assumptions need a new approach to risk analysis, such as system dynamics modelling.

2- Second, system dynamics is enhancing the capability to handle real-life structured, unstructured, or semi-structured problems. For instance, mega infrastructure projects have many critical uncertainties because of finance, economy, technology, contract management, politics, organization, regulation, and many other variables. These variables exist in real-world problems and represent structured and unstructured problems. NPV modelling included the project's non-financial risks, qualitative risks,

and unstructured risks. For instance, the contractual negotiation automated model ignored non-financial risks and their impact on large projects. The project's cash flow and funding investigation management system did not include non-financial risks to analyse cost and NPV. Finally, existing cost analysis models were found not able to quantify non-cash terms.

3- Third, NPV modelling required addressing dynamics and interactions independently of nonlinear risks. For instance, risks are nonlinear in a large scale project's long life cycle, and their relationships are independent. The United States, the United Kingdom, and Australian governments considered decision-making based on independent factors. This is ignoring the correlation and relationship between contributing variables and impact negatively on risk estimates.

4- Fourth, NPV risk modelling considered outcomes' uncertainty to show the significant variation between project planned and actual results. It is imperative to make estimates based on the estimation range rather than having a single estimate.

5- Fifth, the NPV risk model includes all project life cycle elements. Existing methodologies used in selecting contractors to execute projects are based on cost, quality, and time risks. It excludes operational and design risks, which is not enough to make a final decision regarding project lifetime performance.

Therefore, adding all excluded risks from existing cost and risk models will increase this research accuracy after using cost modelling non-linear system dynamics relationships of residential building projects' whole life cycle.

After that, the NPV contractor selection model analysed risk relation interaction using system dynamics VENSIM software (Jang 2011). This software can be used for modelling expectations, desires, goals, and perceptions (Jang 2011; Ozcan-Deniz & Zhu 2016; Marzouk

& Azab 2014; Lee, Pena-Mora & Park 2006). The NPV contractor selection model then analysed the bidding proposal using the Monte Carlo approach for accurate probability simulation (Jang 2011; Maiwenn 2013; Xu & Moon 2013). NPV contractor selection model also used SPSS to making accurate statistical analysis for bidding proposal and net present value (Jang 2011; Ariffin, Omar & Sharif 2010; Fan & Yan 2010; Ruiz et al. 2017; Khalilzadeh & Tasci 2017; Coluci, Alexandre & Rosecrance 2009). Figure 2-19 shows how all software programs are used to build the NPV final model. Therefore, this research study decided to use Monte Carlo Simulation approaches and VENSIM and SPSS software to maximize cost modelling accuracy for residential building project's whole life cycle.

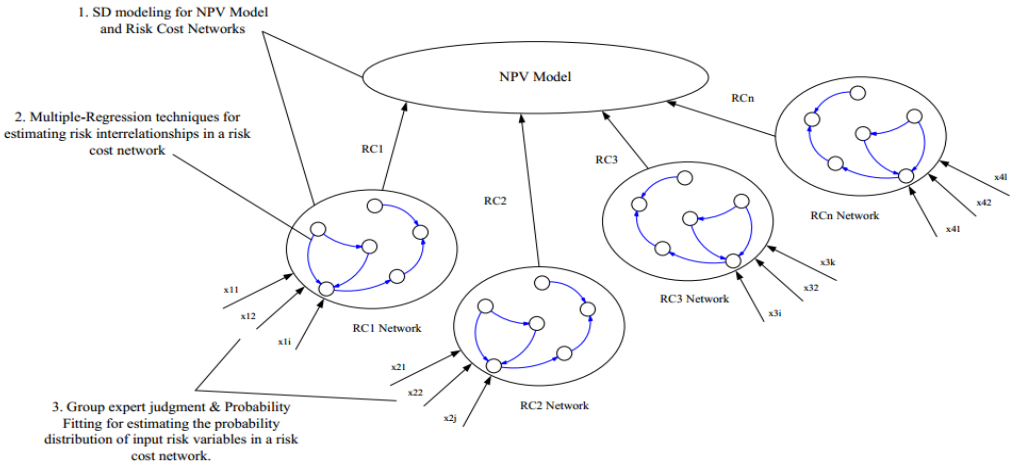


Figure 2-19: The techniques of building NPV model to identify over costs or profits base on design-build-operate lifetime projects (Jang 2011).

NPV model is based on identifying risks and variables cost network to start checking and calculating estimation probability distribution. This is plain input of the NPV SD model (Jang 2011). As shown in Figure 2-20 (i.e., RC1, RC2…, RCn), these networks are analysed using SPSS multiple regression to check variables correlation and interrelationships (Jang 2011). Risks-cost's system dynamics model is based on time modelling to end up with the NPV model (Jang 2011).

It can estimate cost by calculating the risk probability of having imbalanced time behaviour between build-operate-transfer infrastructure projects stages, as shown in Figure 2-20 (Jang 2011).

System dynamics model can be built successfully after confirming the relationship between the variables shown in each event of Figure 2-20 using multiple regression analysis (Jang 2011). However, researchers found that delay risk events cause unnecessary over cost including Land availability, Resource availability, Performance availability, Design changes, Construction over cost, Construction delay, and Construction defects, as shown in Figure 2-20.

Thus, the system dynamics model can be shaped and achieved for each event separately by studying their variables and dynamical relationship, as shown in Figure 2-21 (Jang 2011).

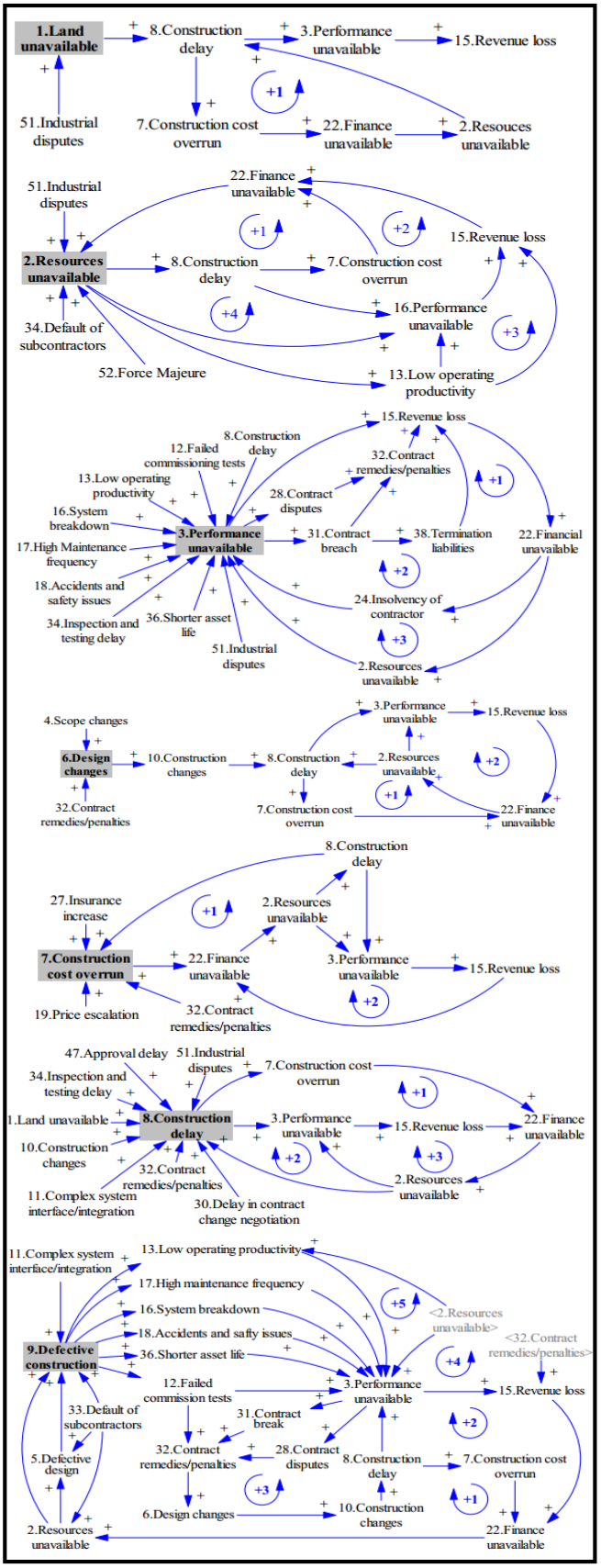


Figure 2-20: How risk events cause delay and cost overrun in NPV SD model (Jang 2011).

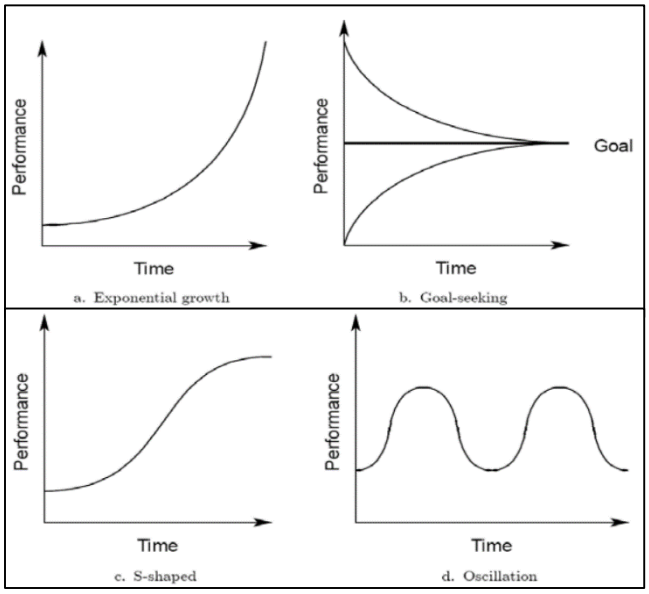


Figure 2-21: The time behaviour patterns of the SD analysis in the NPV model (Jang 2011).

It is proven that unavailable land and resources to proceed with activities cause significant delays, cost, and poor performance (Jang 2011). This proof is shown in system dynamics causal loops of the first event (i.e., Land availability), the second event (i.e., resource availability), the fourth event (i.e., Design changes), and the seventh event (i.e., Construction defects) (Jang 2011).

On the other hand, poor performance will cause losses through contract disputes and penalties. It will lose operation revenue and delay profit (Jang 2011; Coughlan & Coghlan 2002; Karwan & Markland 2006; Boyer & Swink 2008). Construction over cost impacts financing availability and can be considered a variable causing delay (Jang 2011). Hence, a significant loss in planned revenue occurs. Delay is a net present value model variable affecting performance, cost, revenue, and many other variables in a significant undesired way (Jang 2011; Poh & Tah 2006; Frimpong, Oluwoye & Crawford 2003; Aziz & Abdel-Hakam 2016). Therefore, time and costs will be connected accordingly in this research to end with more accurate and reliable results.

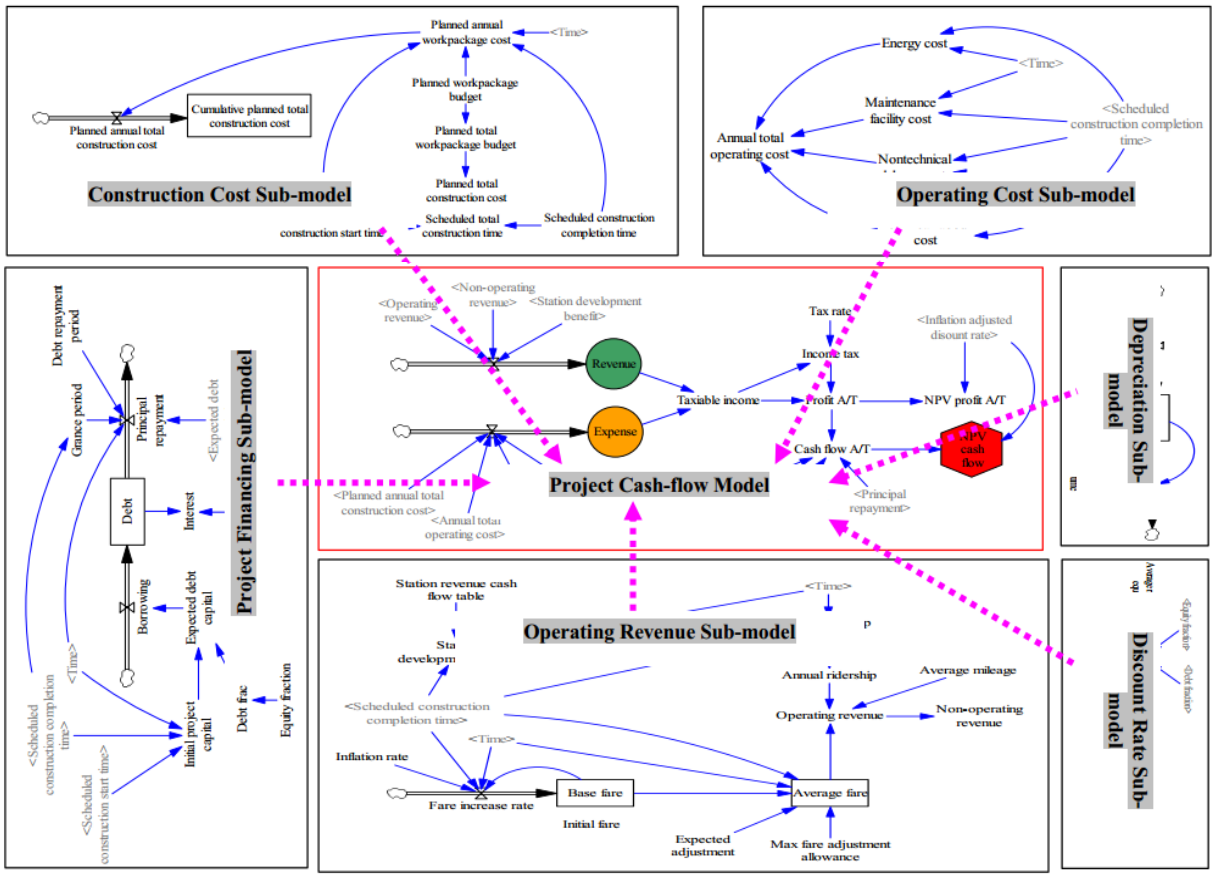


Figure 2-22: Final NPV model showing the main 6 sub models including: Construction Cost, Operating Cost, Project Financing, Discount Rate, and Operating Revenue which are utilized in Final Project's Cash Flow model (Jang 2011).

Figure 2-22 shows that the final net present value (NPV) model is completed after compiling and using the outcomes of probability analysis, regression analysis, system dynamics, and time behaviour analysis (Jang 2011). However, it gives a time-based cash flow model from the project's estimated risk (Jang 2011). Thus, the data used in this model is divided into budgeted data from the analysed case study and risk variables/events from SD analysis and modelling (Jang 2011). In Figure 2-22, these two data analysis costs have been compared and modelled together in the infrastructure project's cash flow model (i.e., NPV model) (Jang 2011). Then, after simulating data in NPV final model and find each variable interaction and impact on BOT mega construction project's cost and cash flow system using estimated risks,

it is found that cost is the most critical factor of construction industry deliverables, especially in the big or complex projects (Jang 2011). Therefore, this study will include cost cash flow and NPV in the residential project's whole life cycle final system dynamics cost estimating model.

After that, researchers concluded that multivariate and univariate approaches are not appropriate when regression is used on a single observed data (Jang 2011; Lee 1989; Malhotra & Grover 1998; Lu & Qiao Department 2018; Meredith 1998; Currall 1999; Kushner, Choi & Burns 2016; Tongco 2007). That is because numerical scales can be changed and impact risk factors relationship ratio scales (Jang 2011). The value of money must also be examined for getting appropriate risk assessment and expectations in large projects (Jang 2011; Myskova & Myskova 2015; Akter, Mahmud & Oo 2017). So, researchers will need to investigate more about risk factors to examine their impact on projects and operations performance (Jang 2011; Iyer & Jha 2005; Doloi 2011). Nevertheless, this research study will investigate costs risk impact on residential projects cost estimation.

The univariate approach has reliable statistical data analysis, while it is not supported enough by literature reviews and has many limitations such as sensitive impacts of probability on expected risk values for each measure (Jang 2011). However, it can be reduced by increasing the sample size, which will change the estimated risk value (Jang 2011; Singh & Masuku 2014; Brunnström & Barkowsky 2018; Viechtbauer et al. 2015). Examining the value of money to evaluate net present value was not possible by researchers for the project's whole life cycle (Jang 2011). Therefore, this final research model will examine money value by calculating NPV for each time step in a residential project's whole life cycle; however, it will be a major research contribution to the project management body of knowledge.

On the other hand, the multivariate approach does not have consistent results at a confidence level of 95% because probability impacted by technical problems does not correspond in portion size degrees/dimensions (Jang 2011; Trafimo et al. 2018). Thus, the risk estimate will be wrong if researchers ignored correlation relationships between risk factors (Jang 2011; Cabitza, Ciucci & Locoro 2017). Furthermore, making changes while determining assumptions will cause a significant difference in estimated results; this will make them far from reality and true values (Jang 2011). Therefore, this research study will ensure collecting sufficient data sets of each factor before any analysis.

Besides, research lacked data even after taking approvals to discuss real infrastructure projects because of confidentiality issues (Jang 2011). As a result, several assumptions have to be made before analysis stages, although these assumptions should be structured and minimized as much as possible (Jang 2011; McCutcheon & Meredith 1993; West, Kreuter & Jaenichen 2013; Benbasat, Goldstein & Mead 1987; Kaplan & Duchon 2011). However, this is opening the door for further research in cost and risk estimation and to enhance the model's accuracy and end up with a powerful impacting method for modelling risks and NPV (Jang 2011). Therefore, this research study will further investigate modelling costs using its impacting risks and consider all possible accurate solutions before proceeding with valid assumptions.

In 2015, researchers found that system dynamics is the most accurate approach for modelling risk cost (Alzahrani 2015; Rodrigues & Bowers 1996; Park et al. 2012; Liu et al. 2012; Nasirzadeh, Khanzadi & Rezaie 2014). Conducted research included several risk groups related to the construction of PPP projects in the Kingdom of Saudi Arabia-KSA (Alzahrani 2015). The research investigated how to use system dynamics to find out maximum and minimum possible costs that a project can reach in KSA PPP projects (Alzahrani 2015;

Nasirzadeh, Khanzadi & Rezaie 2014; Ökmen & Öztaş 2010; Zakis, Zakis & Arfridsson 2017; Salling & Leleur 2015). The contribution was based on changing the perspectives of how to look at risks; however, instead of looking at them from the management viewpoint, it is optimum to change the perspective to have risks studied and evaluated before making decisions based on risks cost (Alzahrani 2015). The second contribution is about connecting all independent risks causal loops diagram in one modelling approach and proving that they can be gathered while investigating their impact on construction cost outturn (Alzahrani 2015; Chapman 1998; Park et al. 2012; Liu et al. 2012).

After that, project risks impact construction cost outturn interactions based on integrating regression analysis with system dynamics modeling to simulate independent risks functional inter-relationships quantification (Alzahrani 2015; Nasirzadeh, Khanzadi & Rezaie 2014; Williams 2003). Therefore, correlation and regression analysis will be made for all variables to maximize the final cost model's accuracy in this research study.

On the other hand, researched risks cost impact using system dynamics had several limitations (Alzahrani 2015). This gave them the strength and significance of proceeding with further research studies. First, the extracted data are not individually separated based on the type of projects such as infrastructures, buildings, or dams (Alzahrani 2015). Second, the model does not allow users the possibility to select risk events (Alzahrani 2015). However, identified risks are extracted from literature and can be useful and add value to other researchers interested in construction/projects risk and its cost (Alzahrani 2015). Therefore, this research study will use previous literature risks to build the final system dynamics model. However, this is a good reason to consider empirical research in collecting related adjusting risk for this research study.

The developed risks cost for KSA PPP Project's model is applicable only for a specific region and applicable only in Saudi Arabia (Alzahrani 2015). That allows developing system dynamics modelling, and simulation approach is related to projects located in the United Arab Emirates. Nevertheless, in Figures 2-23 and 2-24, mapping contrasts, sub-models, and causal loop diagrams have been created to form the final risks System dynamics model (Alzahrani 2015). A similar approach in diagramming residential projects' whole life cycle cost variables will be followed to enhance the final model accuracy.

Previous research recommends conducting further research, including and considering any new risks uncertainties that impact future research risks (Alzahrani, 2015). Therefore, this research study will be reviewing all possibly found related literature to end with more accurate results.

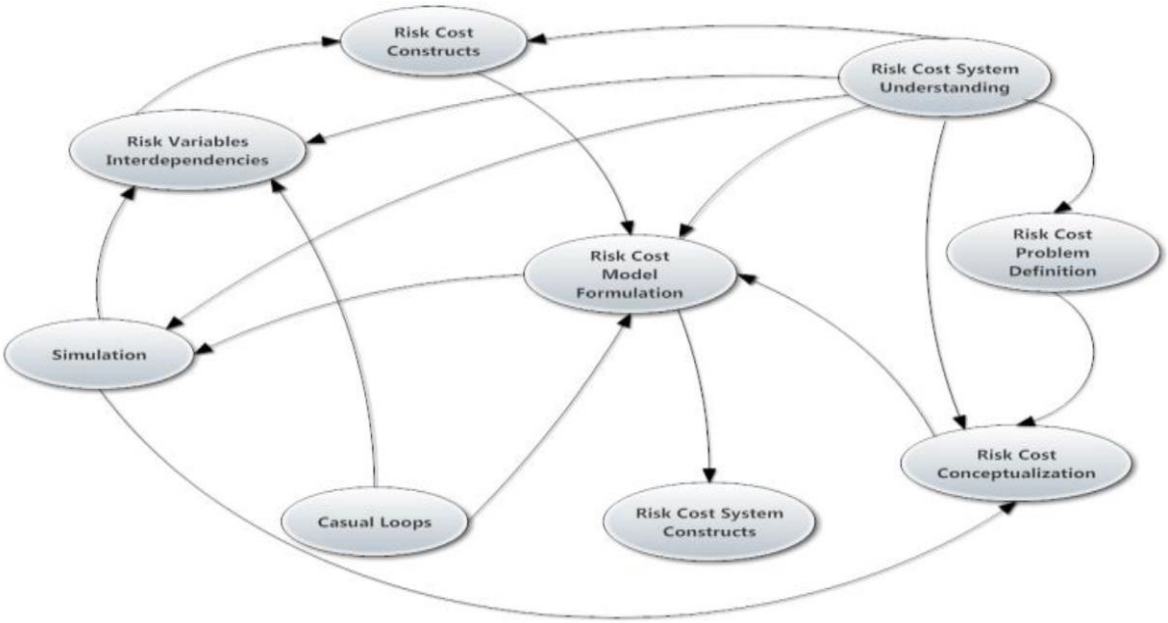


Figure 2-23: Risk Cost System Dynamics Constructs (Alzahrani 2015).

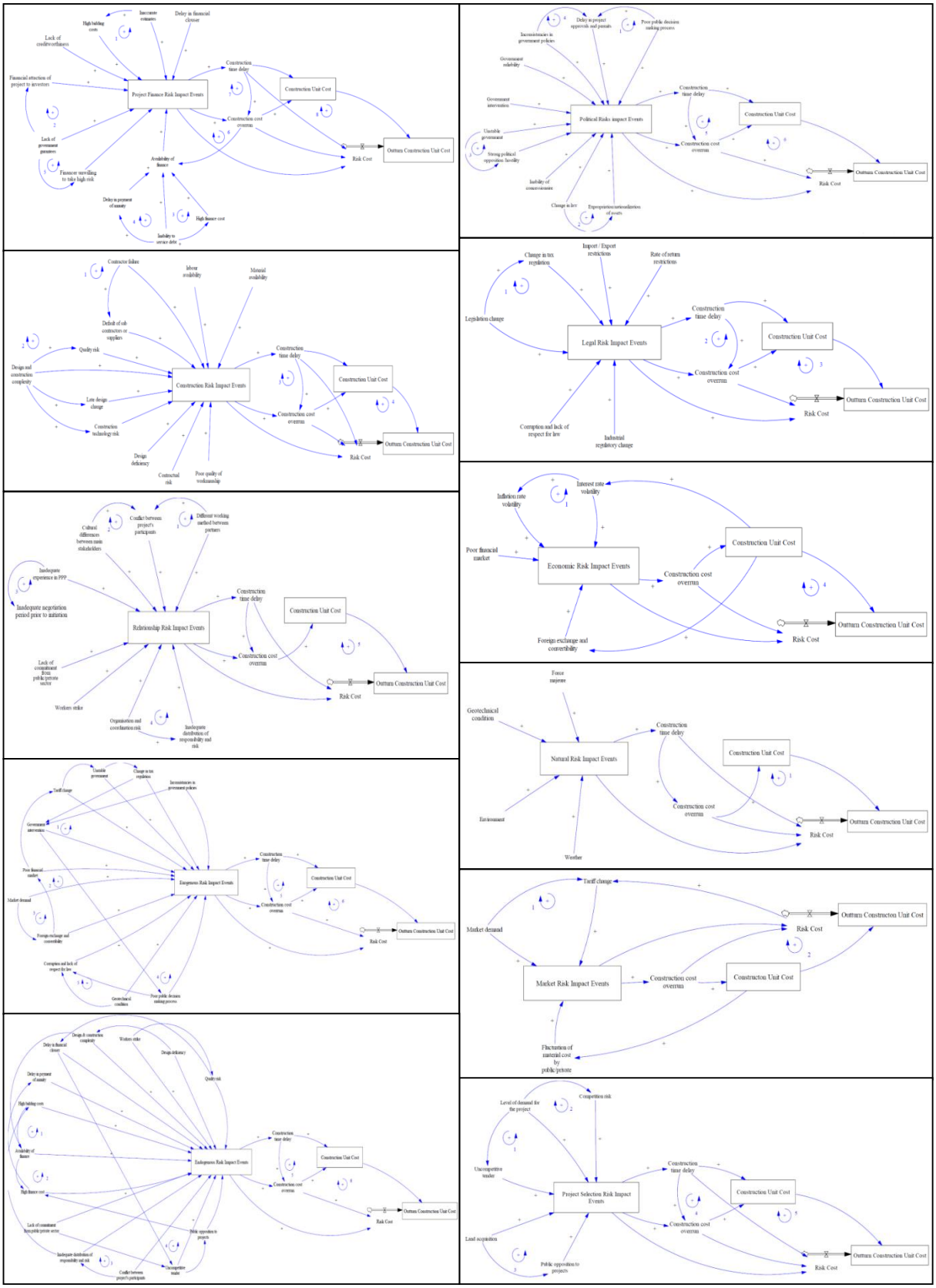


Figure 2-24: Risks cost system dynamics model for KSA PPP projects showing risks groups and their interaction in each sub-model (Alzahrani 2015).

Then, in 2019, researchers in the project management field concluded and proved that system dynamics VENSIM can model and analyse technical resilience (i.e., fixable pavement resilience) of projects based on the impact of other technical factors (i.e., climate risks) while including project's construction and maintenance stages using causal loops and stock/flow simulation as shown in Figure 2-25 (Al-Aryani 2019). Finally, in this research study, the project's whole lifecycle system dynamics model of cost estimation will be including construction, maintenance, and equipment replacement; however, the chosen accurate software program which has been proved effective in similar scenarios will be VENSIM software. As a result, this supports the aim of modelling technical aspect (i.e., cost) based on the impact of risks found in residential projects' whole life cycle (i.e., CAPEX and OPEX).

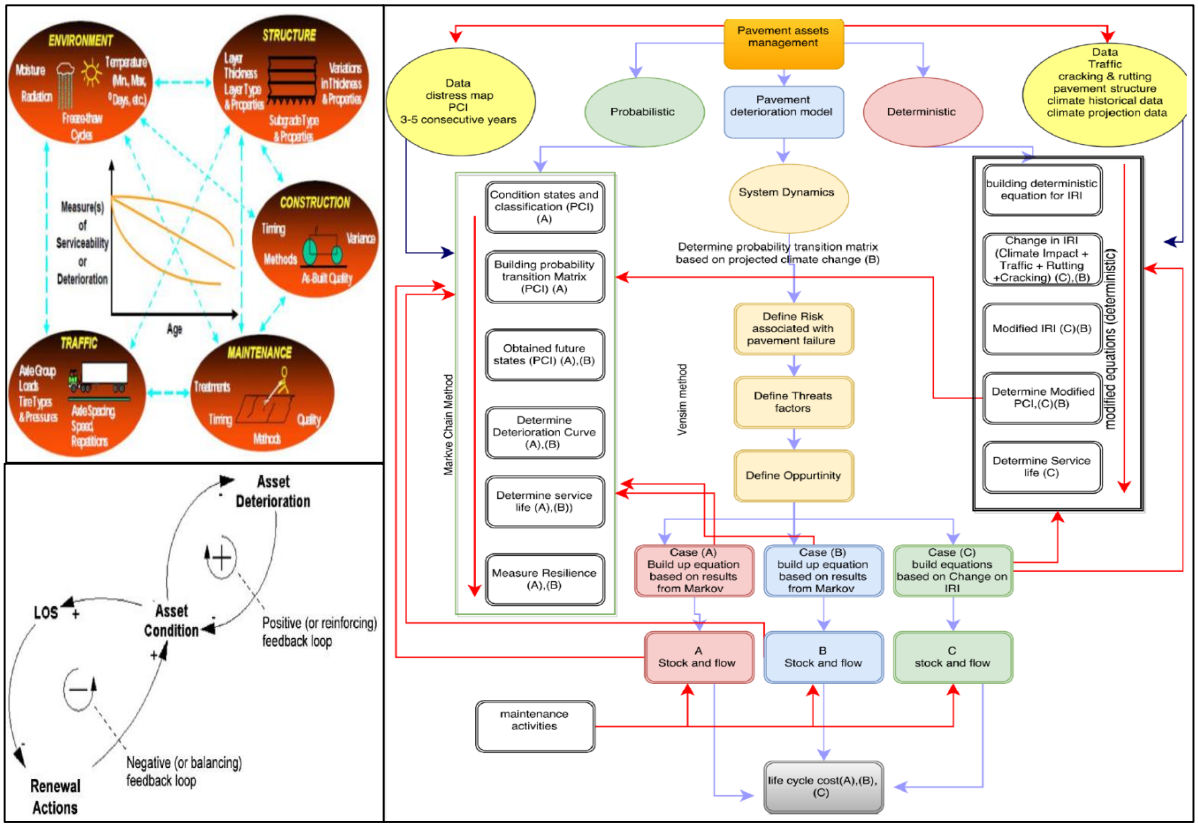


Figure 2-25: The use of structured system dynamics as shown in the right side of the figure and causal loops shown in the lower left side of the figure to satisfy modelling fixable pavement resilience measurement under climate impact in UAE as shown in the left upper side of the figure (Al-Aryani 2019).

2.5 Summary

After reviewing published literature and other empirical studies about modelling and optimizing cost estimation in project management, this research study concluded that previous achievements covered the following:

1. Researchers modelled construction projects cost information to optimize cost prediction at the pre-construction stage from the client perspective; however, they used quantitative mathematical systems in the United Kingdom (Hardcastle 1992).
2. Then, previous research modelled the project's profitability systems to optimize warehouse projects' cost forecasting at bidding and to tender pre-construction stages; however, they used a system dynamics approach from a contractors' point of view in the United States America (Cui 2005).
3. After that, researchers Modelled risk management and assessment to optimize costs and time forecasting processes in infrastructure tunnel projects; however, they used mathematical approaches to calculate risks probability to estimate construction project costs in Sweden from the client's point of view (Isaksson 2002).
4. Next, previous research modelled risk assessment to optimize cost and time prediction of infrastructure tram network projects; however, they used the system dynamics approach from client perspectives in the United Kingdom (Boateng 2014).
5. Finally, researchers Modelled cost estimation of infrastructure water projects based on more than 1600 projects' historical data; however, they used "Artificial Neural Network" modelling and mathematical equations in the United Kingdom (Ahiaga-Dagbui 2014, p.36).
6. Most previous research was conducted to study (Public-Private- Partnership) projects (Cui 2005; Isaksson 2002; Boateng 2014; Ahiaga-Dagbui 2014).

Thus, the research field has been left with certain gaps. These gaps require to be filled, investigated about, and demand further research; nevertheless, this research study found cost estimation modelling gapes in previous relevant works as the following:

1. They missed using system dynamics and probability to analyse and model cost estimation in the projects' whole life cycle.
2. They did not include costs underestimate and cost overrun issues in their proposed solutions.
3. They did not study residential building projects, although they validated and implemented their infrastructure projects' cost models.
4. They did not include any cost modelling study to predict and estimate residential buildings' actual costs cash flow at the pre-construction stage.
5. They did not include any cost modelling of the building project's whole life cycle in the United Arab Emirates.
6. They did not include any data related to cost variables and constraints in the United Arab Emirates residential built environment.
7. They did not generalize their work and models on all geographical areas nor all projects' types.
8. They recommended further research on their models or initiating new models to open better opportunities. This is to know about the best and most effective cost models in providing accurate and optimum forecast results in construction and project management fields.
9. They did not include modelling residential project costs from client's and developers' points of view.
10. They did not include residential building projects in the United Arab Emirates.

Therefore, this research-validated topic is: ***System Dynamics Approach for Whole Life Cycle Cost Modelling of Residential Building Projects in the United Arab Emirates***. This will be done using system dynamics, mathematical modelling, and probability simulation. However, this research approach will be pure quantitative.

Chapter 3

MAPPING PROJECT'S WHOLE LIFE CYCLE COST RISKS

"*Mapping makes people feel like they're doing Lean, but it is simply drawing pictures…if I hand you a blueprint, it does not mean you can build a house*".

(King & King 2006, p. 45)

3.0 Introduction

After reviewing researchers' literature in chapter 2 and provide a theoretical framework for this research study, it is necessary to justify all collected cost risks and factors in this research cost estimation final model. First, CAPEX risk collection and identification are based on the Royal Institution of Chartered Surveyors (RICS) cost analysis and benchmarking officially published guidance note (RICS 2011). In the RICS guidance note, major factors were introduced, while it was stated several times that future cost estimates should include additional cost factors to maintain accurate construction cost prediction (RICS 2011). Otherwise, the difference between estimated and actual values will increase due to ignoring necessary additional factors (RICS 2011). Therefore, this research has included RICS identified risks and added all verified additional cost risks from previously published literature and empirical studies based on trusted guidelines, frameworks, methodologies, and regulations. This research study used the Australian Government's Capital Expenditure Forecasting Methodology and Capital v Revenue Expenditure Toolkit (Adams & Bentley 2012; Australia-Government 2020). Then, this research collected and identified OPEX risks from literature guided by the requirements of Australia Government Operating Expenditure Forecasting Methodology, the United Kingdom Northern Ireland Utility Regulator guidelines, and Queensland Regulatory Proposals 2020-2025 Expenditure Forecast (Gniel 2012; UK-Government 2017; Australia-Government 2019). However, it is proved in government technical reports and published research that operational expenditure and capital expenditures are connected based on regulations and operation behaviours (Cambini, Congiu & Soroush 2020; Australia-Government 2017). This result is based on studying the Australian OPEX behaviour and based on the European Union regulations related to CAPEX & OPEX investments in energy sectors (Cambini, Congiu & Soroush 2020; Australia-Government 2017). Therefore, this research used

the Australian Government Total expenditure frameworks and the United Kingdom Government technical report guidelines called The cost of London's infrastructure requirements to 2041 and the funding gap (Australia-Government 2017; UK-Government 2019). Finally, this research followed a systematic, trusted approach to ensure that the final model is including the most possible updated cost risks/factors collection. Nevertheless, it is recommended to update the identified cost risks/factors in future estimates to obtain accurate prediction values. The reviewed references' summary for published literature and empirical studies, which is used to extract the final model's 117 factors of this research study, is shown as in Figure 3-1 and Table 3-1:

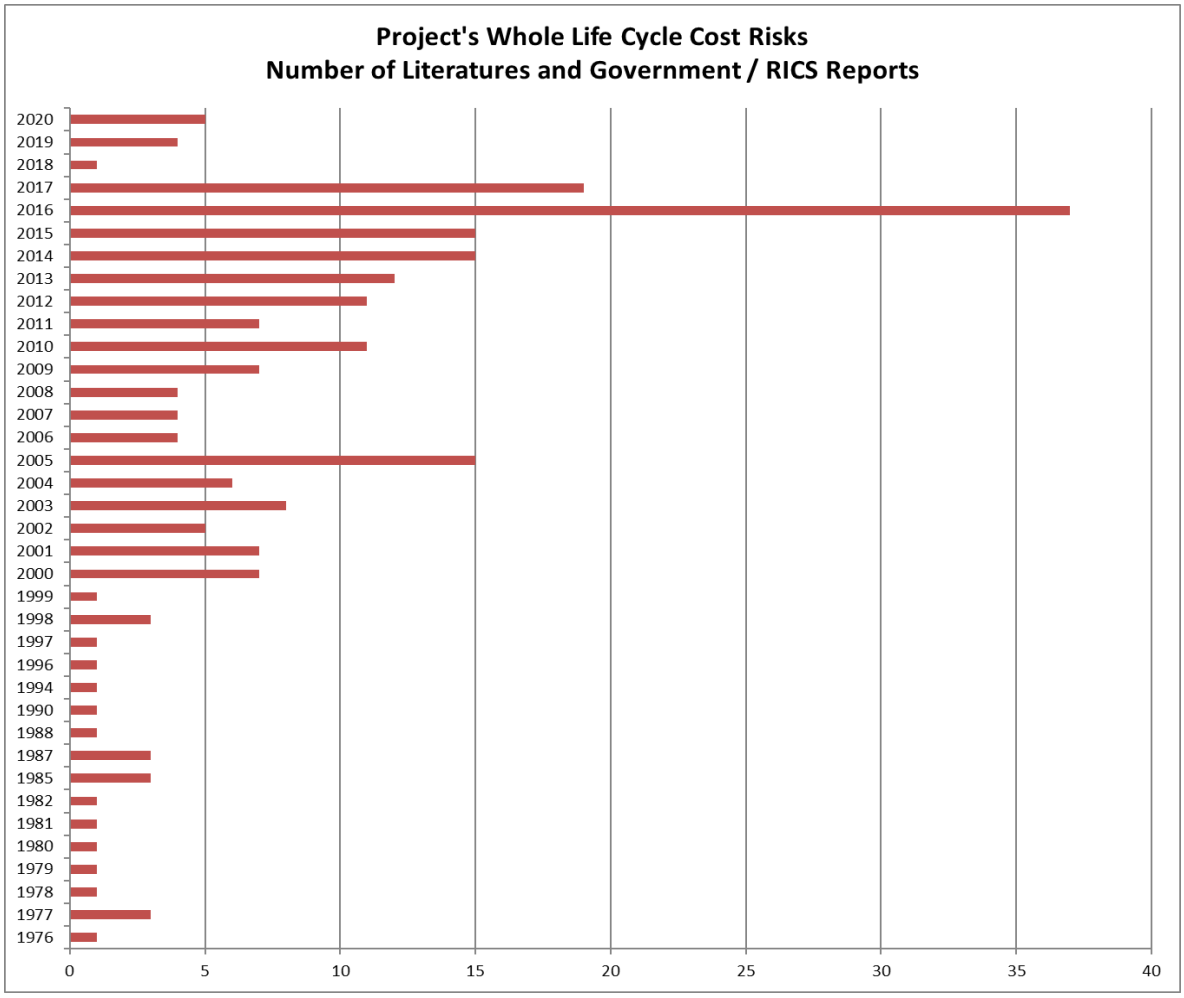


Figure 3-1: Distribution of reviewed literature and governments/ RICS reports related to cost risk identification and allocation in buildings project's whole life cycle from 1976 to 2020.

SN	Literature/Report Author	SN	Literature/Report Author	SN	Literature/Report Author
1	McCaffer 1976	77	Wu & Clements-Croome 2007	153	Yana, Yana & Rusdhi 2015
2	Walace 1977	78	Abdallah 2007	154	Ibn-Homaid & Tijani 2015
3	Taylor 1977	79	Assad, et al. 2007	155	Wibowo 2015
4	Neufville et al. 1977	80	Dikmen, Birgonul & Han 2007	156	Flyvbjerg 2015
5	Strandell 1978	81	Kleyner & Sandborn 2008	157	Stasiak-Betlejewska & Potkány 2015
6	Harvey 1979	82	Nelson 2008	158	Xu et al. 2015
7	Morrison & Stevens 1980	83	Turskis 2008	159	Kosla 2015
8	Jupp & McMillan 1981	84	Diskienė, Galinienė & Marčinskas 2008	160	Alzahrani 2015
9	Adrain 1982	85	Toor & Ogunlana 2009	161	Andom 2015
10	Smith & Jolly 1985	86	Johnsen, Howard & Miemczyk 2009	162	Qureshi & Kang 2015
11	Skitemore 1985	87	Dillman et al. 2009	163	Chowdhury, Sharma & Platz 2016
12	Koehn 1985	88	Ayangade, Wahab & Alake 2009	164	Mättö & Sippola 2016
13	Collier 1987	89	Akinyemi et al. 2009	165	Aziz & Abdel-Hakam 2016
14	Wilson et al. 1987	90	Abd-ElRazek, Bassioni & Mobarak 2009	166	Charles & Corbishley 2016
15	Azzaro, Hubbard & Robertson 1987	91	Shane et al. 2009	167	Levitt & Eriksson 2016
16	Loannov 1988	92	Liu & Wang 2010	168	Kirkwooda et al. 2016
17	Lyons, 1990	93	Vincent & Monkkonen 2010	169	Asif 2016
18	Skitmore & Wilcock 1994	94	Aftab et al. 2010	170	Charles & Corbishley 2016
19	skamris & Flyvbjerg 1996	95	Kimand & Reinshmidit 2010	171	Bigsten 2016
20	Wright 1997	96	Schieg 2010	172	Kuricheva & Popov 2016
21	Watson, Pitt & Kavan 1998	97	Fan & Yan 2010	173	Torp et al. 2016
22	Chapman 1998	98	Memon et al. 2010	174	Jarkas 2016
23	Akintoye 1998	99	Koo et al. 2010	175	Wang et al. 2016
24	Yasin et al. 1999	100	Ali & Kamaruzzaman 2010	176	Flyvbjerg 2016
25	Wier 2000	101	Linderman & Chandrasekaran 2010	177	Lovering, Nordhaus & Yip 2016
26	Ng et al. 2000	102	First Gulf Bank Design Standard Contracts 2010	178	Levitt & Eriksson 2016
27	Akintoye 2000	103	Wu, Olson & Birge 2011	179	Becchio et al. 2016
28	Mayer & Somerville 2000	104	Jang 2011	180	Battistoni et al. 2016
29	Wang 2000	105	Laryea & Hughes 2011	181	Signor et al. 2016
30	Gardiner & Stewart 2000	106	Mumford 2011	182	Florio & Sirtori 2016
31	Howell & Koskela 2000	107	Gundes 2011	183	Yusof et al. 2016
32	Chimwaso 2001	108	Kaklauskas 2011	184	Matto & Sippola 2016
33	Akintoye et al. 2001	109	RICS 2011	185	Poucke, Matthyssens & Weeren 2016

34	Shen et al. 2001	110	Gniel 2012	186	Mehran 2016
35	Partnership Victoria 2001	111	Adams & Bentley 2012	187	García et al. 2016
36	Mills 2001	112	Abd Karim 2012	188	Florio, Forte & Sirtori 2016
37	South Africa 2001	113	Chang & Ko 2012	189	Babashamsi et al. 2016
38	Mills 2001	114	Kaiser & Snyder 2012	190	Donovan & Corbishley 2016
39	Flyvbjerg, Holm & Buhl 2002	115	Doloi 2012	191	Cassettari et al. 2016
40	Love et al. 2002	116	Rahman et al. 2012	192	Cai et al. 2016
41	Dey 2002	117	Liu et al. 2012	193	Hurt & Schrock 2016
42	Mott-MacDonald 2002	118	Bari et al. 2012	194	Doan & Chinda 2016
43	Chang 2002	119	Torriti 2012	195	Alagidede, 2016
44	Thomas 2003	120	Cheung et al. 2012	196	Donaubauer et al 2016
45	European Commission 2003	121	Abanda & Cheung 2013	197	Titaya 2016
46	Treasury 2003	122	Sharma, Najafi & Qasim 2013	198	Stephan & Crawford 2016
47	Naoum 2003	123	Odeyinka, Lowe & Kaka 2013	199	Balló 2016
48	Baloi & Price 2003	124	West, Kreuter & Jaenichen 2013	200	McLean & McGovern 2017
49	Frimpong, Oluwoye & Crawford 2003	125	Acebesa et al. 2013	201	Abanda, Kamsu-Foguem & Tah 2017
50	Williams 2003	126	Abdul Rahman et al. 2013	202	First Abu Dhabi Bank Design Standard Contracts 2017
51	Love & Irani 2003	127	Abanda, Tah & Cheung 2013	203	Akter, Mahmud & Oo 2017
52	Boussabaine & Kirkham 2004	128	Cesa-Bianchi 2013	204	Rodrigues & Freire 2017
53	Hodge 2004	129	Griffis & Choi 2013	205	Geissmann 2017
54	Harbuck 2004	130	Grimes & Hyland 2013	206	Seo & Park 2017
55	Ghosh & Jintanapakanont 2004	131	Myers 2013	207	Ballarini et al. 2017
56	Iyer & Jha 2004	132	Crompton & Howard 2013	208	Zakis, Zakis & Arfridsson 2017
57	Cassell & Symon 2004	133	Forbatok 2014	209	Zhao, Chen & Thomson 2017
58	Riley et al. 2005	134	Asal 2014	210	Santos et al. 2017
59	Wilke 2005	135	Osei-Fosu 2014	211	Guo & Sultan 2017
60	Hamaker & Componation 2005	136	Naderpajouh & Hastak 2014	212	Hasançebi 2017
61	Elhag, Boussabaine & Ballal 2005	137	James 2014	213	Kubba 2017
62	Modell 2005	138	Hunter, Fitzgerald & Barlow 2014	214	Enezy et al. 2017
63	Williams & Ackermann 2005	139	Ramasesh & Browning 2014	215	Shabniya 2017
64	Kazaz, Birgonul & Ulubeyli 2005	140	Tsang 2014	216	Australia- Government 2017
65	Flyvbjerg 2005	141	Asal 2014	217	UK-Government 2017
66	Iyer & Jha 2005	142	Cheng 2014	218	Zhao et al. 2017
67	Seshadri & Subrahmanyam 2005	143	Shehu et al. 2014	219	Flyvbjerg et al. 2018
68	Li 2005	144	Sydor et al. 2014	220	Terracon-Consultant 2019
69	Cooper et al. 2005	145	Wang, Xia & Zhang 2014	221	Al-Aryani 2019
70	Nguyen & Ogunlana 2005	146	Macek & Dobias 2014	222	Australia- Government 2019

71	García 2005	147	Han, Srebric & Enache-Pommer 2014	223	UK-Government 2019
72	Love et al. 2005	148	Abu Dhabi-Government 2015	224	Australia- Government 2020
73	Moody 2006	149	Zahir 2015	225	Cambini, Congiu & Soroush 2020
74	Poh & Tah 2006	150	Spickova & Myskova 2015	226	Al-Hamadi 2020
75	Friedler & Pisanty 2006	151	Sayed & Sawant 2015	227	Dubai-Municipality 2020
76	National Research Council 2006	152	Salling & Leleur 2015	228	Abu Dhabi Ministry of Health and Population 2020

Table 3-1: Reviewed literatures and governments/ RICS reports for risk identification and allocation which impact cost in construction and project's whole life cycle from 1976 to 2020. This is an adapted table summary from literatures (Boussabaine & Kirkham 2004; Jang 2011; Forbatok 2014; Asal 2014; Osei-Fosu 2014; Andom 2015; Alzahrani 2015; Zhao et al. 2017; Al-Aryani, 2019).

Therefore, it is clear from Figure 3-1 that researchers started to focus on projects' whole life cycle cost risks from the year 2000 up to date. In other words, 204 out of 228 reviewed literature found in the 2000s weighing nearly 99%. Furthermore, 81 out of 228 reviewed literature found in the last five years, weighing more than 35%. However, those identified risks shall be considered for this research while allocating residential buildings' whole life cycle risks. Then, these risks will be grouped into clusters through this mapping chapter before proceeding with any modelling. The following parts of this chapter will discuss each cost risk/ factor and how it affects costs through the final model.

3.1 CAPEX Risks

First, capital expenditure clusters and factors will be discussed and detailed to explain how they impact this research cost estimation model during the construction stages of the residential project's whole life cycle. The connection between these factors will be shown and described in a mapping Figure representing their interaction in the final cost model. However, the eleven groups and clusters under CAPEX are (1) Construction Activities' Risks, (2) Political Risks, (3) Legal Risks, (4) Economic Change Risks, (5) Natural Forces Risks, (6)

Market Risks, (7) Project Selection Risks, (8) Project Finance Risks, (9) Building Functionality, and Serviceability Risks, (10) Stakeholders Relationship Risks, and (11) Knowledge Risks.

A- Construction Activities' Risks

Construction activities risks are those risks taking place during the project construction stage. It will group all related risks to represent them with one mathematical equation as per their graphical relationship. This will be reflected in the model's final cost estimation calculations and results. A1 to A29 risks will be detailed to clarify how they will impact the final cost model while interacting with each other to understand better.

A1- Selection Method

The selection method has an impact on the CAPEX phase during construction activities. This is due to the ignorance of risk importance included in the project (Jang 2011). Furthermore, how does it apply to each investment project selection and supplier/contractor selection (Jang 2011)? Thus, the required weight for this factor is the one impacting construction activities only.

A2- Type of Client: Solo Individual

The solo individual type of client risk is mainly about the extreme frequency of changes happening through the project. The impact is directly and indirectly on costs because of the deference appearing in the project's agreed estimated elements (Zhao, Mbachu & Domingo 2017). Therefore, when ignorance increases, knowledge will decrease related to what will happen after making decisions (Zhao, Mbachu & Domingo 2017).

A3- Type of Client: Bank- Individual Partnership

A bank-individual partnership client type impacts cost when failure to agree on mandatory changes (Zhao, Mbachu & Domingo 2017). These changes are required for project success, and many other activities depend on it (Zhao, Mbachu & Domingo 2017). However, agreeing on making changes will significantly impact costs if reworks and/or re-supply will be needed (Zhao, Mbachu & Domingo 2017). The required weight for this factor is the one impacting construction activities only

A4- Type of Client: Developer

Developers as clients usually create challenges in the construction stage because they are not the end-users (Boussabaine & Kirkham 2004; Zhao, Mbachu & Domingo 2017). Nevertheless, the requirements of having maximum profit, in some cases, push them to make wrong decisions due to lower cost (Boussabaine & Kirkham 2004; Zhao, Mbachu & Domingo 2017). As a result, developers increase the cost significantly when taking wrong decisions and risks are maximized, instead of minimizing the risks (Boussabaine & Kirkham 2004; Zhao, Mbachu & Domingo 2017). Finally, this factor's probability and impact are required to get more accurate cost prediction whenever this type of client is involved (Boussabaine & Kirkham 2004; Zhao, Mbachu & Domingo 2017).

A5- Type of Client: Group of People

The group of people risk is created when deferent perspectives occur between decision-makers, such as clients of the same project (Boussabaine & Kirkham 2004; Zhao, Mbachu & Domingo 2017). However, stakeholders' risks will be included in the model as a separate

group. On the other hand, the required weight for this risk is related to clients' conflict based on the probability and impact of its occurrence (Boussabaine & Kirkham 2004; Zhao, Mbachu & Domingo 2017).

A6- Location: City Area

Project's city area risk may have several meanings, such as the time of equipment access, traffic, supply chain, material price changes, precautions required to be taken, and other criteria; on the other hand, cost estimation is considering all these possibilities prior its occurrence (Harvey 1979; Azzaro, Hubbard & Robertson 1987; Boussabaine & Kirkham, 2004; Jang 2011; Forbatok 2014; Asal 2014; Osei-Fosu 2014; Andom 2015; Alzahrani 2015; Zhao, Mbachu & Domingo 2017; Al-Aryani 2019). Thus, city location cost change risks will impact the project's pre-construction stage and will take place in the final model (Harvey 1979; Azzaro, Hubbard & Robertson 1987; Boussabaine & Kirkham, 2004; Jang 2011; Forbatok 2014; Asal 2014; Osei-Fosu 2014; Andom 2015; Alzahrani 2015; Zhao, Mbachu & Domingo 2017; Al-Aryani 2019).

A7- Location: Regional Area

Regional area risk is giving the first impression of being away from facilities, supplies, and stable processes in working and living location (Harvey 1979; Azzaro, Hubbard & Robertson 1987; Boussabaine & Kirkham, 2004; Jang 2011; Forbatok 2014; Asal 2014; Osei-Fosu 2014; Andom 2015; Alzahrani 2015; Zhao, Mbachu & Domingo 2017; Al-Aryani 2019). However, this will increase the cost of labour, equipment supply, operations, fuel, and frequent visits due to far cities and accommodated areas (Harvey 1979; Azzaro, Hubbard & Robertson

1987; Boussabaine & Kirkham, 2004; Jang 2011; Forbatok 2014; Asal 2014; Osei-Fosu 2014; Andom 2015; Alzahrani 2015; Zhao, Mbachu & Domingo 2017; Al-Aryani 2019). Therefore, this study model found that it is essential to take this risk weightage in adjusting predicted costs based on its occurrence probability and impact (Harvey 1979; Azzaro, Hubbard & Robertson 1987; Boussabaine & Kirkham, 2004; Jang 2011; Forbatok 2014; Asal 2014; Osei-Fosu 2014; Andom 2015; Alzahrani 2015; Zhao, Mbachu & Domingo 2017; Al-Aryani 2019).

A8- Location: Beach Area

The beach area cost is increasing due to the extreme environmental and dewatering requirements; also, projects infrastructure and complexity require activities due to its luxury (Harvey 1979; Azzaro, Hubbard & Robertson 1987; Boussabaine & Kirkham, 2004; Jang 2011; Forbatok 2014; Asal 2014; Osei-Fosu 2014; Andom 2015; Alzahrani 2015; Zhao, Mbachu & Domingo 2017; Al-Aryani 2019). Nevertheless, the required risk weight to be considered will be added to the prediction cost model to improve its accuracy.

A9- Location: Desert Area

Desert area cost risk is significant because of the danger coming from transportation, supply chain, environment condition, labour cost, equipment, and other challenging criteria; therefore, usually, residential projects are lump-sum contracts, and the desert location is increasing contractual value with the high possibility of an increase during execution (Harvey 1979; Azzaro, Hubbard & Robertson 1987; Boussabaine & Kirkham, 2004; Jang 2011; Forbatok 2014; Asal 2014; Osei-Fosu 2014; Andom 2015; Alzahrani 2015; Zhao, Mbachu & Domingo 2017; Al-Aryani 2019). Therefore, this should be included in this research's final cost estimation modelling.

A10- Building Services Complexity: Operational Services

Project complexity will require extreme technical expertise, equipment, and technologies (Boussabaine & Kirkham 2004; Jang 2011; Forbatok 2014; Andom 2015; Alzahrani 2015; Zhao, Mbachu & Domingo 2017; Al-Aryani 2019). The complexity of this service will cause more building requirements and will demand more complex processes; therefore, this study is considering its risk adjustment factor to implement it in the final model. (Boussabaine & Kirkham 2004; Jang 2011; Forbatok 2014; Andom 2015; Alzahrani 2015; Zhao, Mbachu & Domingo 2017; Al-Aryani 2019). The type of operational services complexity became a mandatory luxury requirement for environmental purposes as well; therefore, it is having lower risk than in fitness services complexity, but the risk remains impacting the projects whole lifecycle final cost and shall be included in this final study model (Boussabaine & Kirkham 2004; Jang 2011; Forbatok 2014; Andom 2015; Alzahrani 2015; Zhao, Mbachu & Domingo 2017; Al-Aryani 2019).

A11- Building Services Complexity: Fitness Services

In a different way from operational service complexity, fitness services complexity is changing significantly from a residential project to another; however, this is making risks be higher and should be covered in the prediction model (Boussabaine & Kirkham 2004; Jang 2011; Forbatok 2014; Andom 2015; Alzahrani 2015; Zhao, Mbachu & Domingo 2017; Al-Aryani 2019). So, risk value will depend on its occurrence probability and impact in the United Arab Emirates.

A12- Number of Basement Levels

The number of basement levels is causing big concerns for any project's leading stakeholder participant, but it results from having hidden facts such as soil, ground, and geotechnical conditions (Boussabaine & Kirkham 2004; Jang, 2011; Forbatok 2014; Alzahrani 2015; Shabniya 2017). Thus, to cover all those uncertainties impacting the number of basement levels risk, the probability of its change and its impact will be considered in the final model to create the adjusted estimated cost accurately.

A13- Procurement Method

The procurement approach chosen to be followed during construction is impacting cost; however, it is affecting project's quality and price range (Harvey, 1979; Azzaro, Hubbard & Robertson 1987; Boussabaine & Kirkham 2004; Jang 2011; Osei-Fosu 2014; Andom 2015; Alzahrani 2015; Zhao, Mbachu & Domingo 2017; Al-Aryani 2019). So, it has been decided to include it in this study to increase the final project cost estimation model's accuracy.

A14- Site Topography

Site topography controls several required pre-activities and activities that are changing costs from project to project; this risk is crucial because it is considered to adjust other factors such as site access and work needs (Elhag & Boussabaine 2005). Therefore, since the United Arab Emirates include a wide range of topography, then the impact measure should be included in the model.

A15- Site Conditions

Site condition at the time of executing projects is varying based on the built area, and if it included previous building, activities, or dumping wastes (Boussabaine & Kirkham 2004; Jang 2011; Forbatok 2014; Asal 2014; Osei-Fosu 2014; Andom 2015; Alzahrani 2015; Zhao, Mbachu & Domingo 2017; Al-Aryani 2019). Therefore, it is essential to include the impact of site actual conditions at the time of execution to increase this research model accuracy (Boussabaine & Kirkham 2004; Jang 2011; Forbatok 2014; Asal 2014; Osei-Fosu 2014; Andom 2015; Alzahrani 2015; Zhao, Mbachu & Domingo 2017; Al-Aryani 2019).

A16- Working Space

Compared with workers and equipment to complete required tasks, the working space will increase the cost if it is not adequate; for example, fewer workers to achieve the same total productivity will demand higher skills and technologies (Boussabaine & Kirkham 2004). Therefore, this risk should be included in the final cost prediction model.

A17- Site Access

Site access depends on location and surrounding environments; in other words, some locations require a permit for all working personals to access, while other locations require permits for equipment only (Boussabaine & Kirkham 2004; Jang 2011). The requirements and precautions required to prepare site access changes from site to site and cost more (Boussabaine & Kirkham 2004; Jang 2011). Therefore, this adjustment requires to be included in the final cost model.

A18- Frame Structure

The building structure frame will decide how much working space is required and the required structural execution and procurement methods. Sometimes, structures require manufactured elements and parts such as precast, steel trusses, and other elements based on the frame design (Boussabaine & Kirkham 2004). Therefore, this risk change costs and require to be included in the final cost model.

A19- Foundation Type

Foundation type will impact the methods of procurement, execution, and time of construction (Forbatok 2014). Foundation is critical for any further activity of the building (Forbatok 2014). In the United Arab Emirates, the type of footing may vary significantly within one project based on the covered area. It can be a shallow or deep foundation based on their location in the same project, such as housing projects.

A20- Ground Conditions

The ground condition in the United Arab Emirates has a wide range of types and status; therefore, it will impact the foundation and works' needs (Alzahrani 2015). Other factors, as applicable, make it important for the final model (Alzahrani 2015). The water content, type of existing infrastructure, and maximum depth limits make this risk critical (Alzahrani 2015). It will be included in the final cost model.

A21- Type of Soil

The type of soil impacts the construction cost because of excavation and backfilling activities in the project location (Boussabaine & Kirkham 2004; Alzahrani 2015). However, if the soil is demanded in the region for other business activities, this will save transportation and disposal costs. If the excavation removed soil is required for backfilling in the same development project, it will save the cost of supplying the soil with the required specifications. Hence, cost estimation will change, and this cost risk requires to be considered in the model.

A22- Mark-up Size

Researchers prove that the cash flow and material prices impact the mark-up size; however, researchers also agreed that the construction mark-up would impact the cost estimation and how it will be changed over time. (Asal 2014; ElSawy, Hosny & Abdel-Razek 2017). Therefore, this should be taken into consideration when estimating the construction cost at the pre-construction stage.

A23- Need for Work

The unexpected extra hidden tasks needed to complete construction activities may vary in cost, time, and complexity from one project to another (Jang 2011). It is crucial to identify this risk value in cost estimation while predicting the project's cost at the pre-construction stage (Jang 2011).

A24- Deadline Requirements

According to most cost estimation empirical research, it is agreed over 45 years that the deadline requirements is one of the main factors impacting projects duration and cash bleeding; therefore, this adjusting risk is significant and will be included in the final model for better accuracy (Jang 2011; Osei-Fosu 2014; Alzahrani 2015; Andom 2015).

A25- Number of Stories

The number of stories has been proved through research to impact building costs; however, this impact is not per floor. The change in cost is un-systematically and non-linear based on completed works and consumed time (Boussabaine & Kirkham 2004; Jang 2011; Forbatok 2014; Alzahrani 2015; Shabniya 2017). The probability of this change and its impact percentages will decide how much this risk will be significant in residential projects. Therefore, it will be included in the final cost model.

A26- Project Duration

Project duration change varies in weightage based on ratios of the total cost to time, or the ratio of variations cost to time (Boussabaine & Kirkham 2004; Jang 2011; Asal 2014; Osei-Fosu 2014; Andom 2015; Alzahrani 2015; Al-Aryani 2019). Therefore, residential projects' risk is essential for the final cost prediction model resulting from this study (Boussabaine & Kirkham 2004; Jang 2011; Asal 2014; Osei-Fosu 2014; Andom 2015; Alzahrani 2015; Al-Aryani 2019).

A27- Gross Floor Area

The gross area changes of designed floors are rarely changing after tendering cost issues (i.e., contract value) (Boussabaine & Kirkham 2004; Jang 2011; Forbatok 2014; Alzahrani 2015; Shabniya 2017). However, research and literature worldwide decided that its important; however, the possibility of this change exists and cannot be neglected (Boussabaine & Kirkham 2004; Jang 2011; Forbatok 2014; Alzahrani 2015; Shabniya 2017). Therefore, this research study will include this factor based on its probability and impact on the United Arab Emirates' residential buildings project.

A28- Equipment Required

Equipment requirements change with quality and accuracy levels demanded the project based on legal, end-user, and serviceability requirements (Boussabaine & Kirkham 2004; Jang 2011; Asal 2014; Forbatok 2014; Andom 2015; Alzahrani 2015; Al-Aryani 2019). So, equipment requirements change during projects risk is significant, and its weightage is required to be added in the final cost model.

A29- Construction Technology

Construction technology is not only equipment related to executing works, but its information technology and software tools required to improve performance of works, analyses, and forecasts of construction activities (Boussabaine & Kirkham 2004; Jang 2011; Forbatok 2014; Andom 2015; Alzahrani 2015; Al-Aryani 2019). Therefore, this weightage cannot be added with equipment requirements because they have a different occurrence

probability and impact on project cost. However, this research decided to include it in the final cost model due to its significance.

- **Construction Activities Risks Mapping**

After covering each risk factor of Construction Activities Risks, the relationship mapping in Figure 3-2 show how the flow of risk is connected and with the CAPEX variable in the proposed project whole life cycle cost estimation model. Therefore, based on this concept, data collection shall consider these connections to understand how accurate risk weightage should be set clearly.

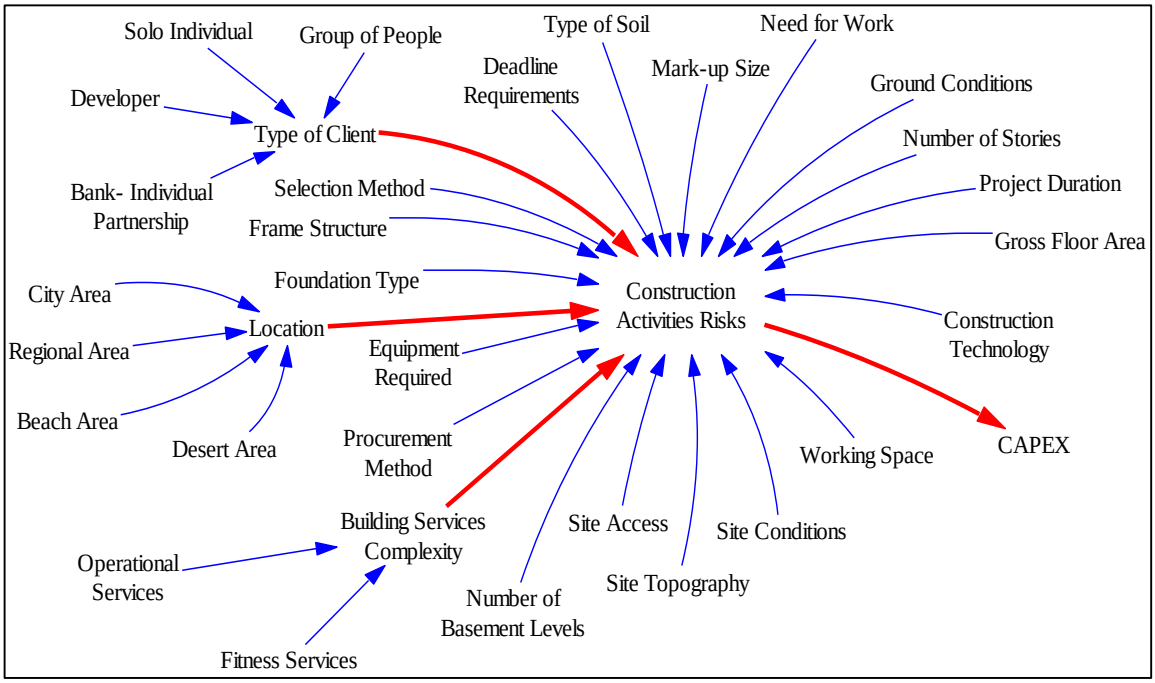


Figure 3-2: Construction Activities' Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.

B- Political Risks

Political Risks are those risks which are taking place through the project execution stage. This will group all related risks to include them with one mathematical equation and a graphical relationship. These risk values will be reflected in the model's final cost estimation calculations and results. So, the following risks from B1 to B10 will be detailed to clarify their impact on the final model to better understand this group's variables.

B1- Change in Law

The government's change in the law in the regulation or requirements will affect projects' whole life cycle cost; however, researchers consider it a significant risk factor (Osei-Fosu 2014; Chang & Ko 2012; Abd-ElRazek, Bassioni & Mobarak 2009; Schieg 2010; Seshadri & Subrahmanyam 2005). Change in law risk in the United Arab Emirates is happening periodically due to challenges or improvement vision on the strategic government leadership level. Therefore, this study will include it to adjust the final estimated cost value.

B2- Delay in Project Approvals and Permits

Approvals and permits delay were found significant by cost estimation researchers (Jang 2011; Kaiser & Snyder 2012; Stasiak-Betlejewska & Potkány 2015). It was frequently found in various construction projects, including buildings (Jang 2011; Kaiser & Snyder 2012; Stasiak-Betlejewska & Potkány 2015). However, it is proved that approvals and permits delay issues cause significant cash bleeding without control until the issue is solved. This significant risk must be included in this cost estimation model to enhance its accuracy.

B3- Poor Public Decision-Making Process

The public decision-making process is one of the highest risk weights of political risks (Jang 2011; Alzahrani 2015; Chowdhury, Sharma & Platz 2016; Flyvbjerg 2015; Mättö & Sippola 2016; Aziz & Abdel-Hakam 2016). This research study is considering it to improve the accuracy of cost estimation. On the other hand, poor public decision-making in residential buildings housing projects appears when it is not appropriate to change the end-users' requirements while violating their cultural needs, such as changing the number of floors, the number of rooms, and building size area, and utilities.

B4- Government Intervention

Government interventions are the government's actions toward completing a project (Alzahrani 2015; Wu, Olson & Birge 2011; Charles & Corbishley 2016; Aziz & Abdel-Hakam 2016). Those actions can be safety requirements such as supplying and installing a certain level of firefighting system in all villas in the country or any other regulating requirement. It is mandatory to include it in this research cost estimation model.

B5- Unstable Government

The government in the United Arab Emirates is stable, and this factor is rare in this country. However, researchers in different places in the world, including the Kingdom of Saudi Arabia, proved that it is essential to have it in all risks and costs studies even if it is weak or rare (Alzahrani 2015; Aziz & Abdel-Hakam 2016). Then, let experts and data collection decide how much this weight might be critical (Alzahrani 2015). Therefore, scientifically, this factor's

real impact can be too small or significantly high, which will be reflected in this research cost model analyses and results accordingly.

B6- Government Reliability

This is where government reliability should cover several perspectives, such as financial, security, political, economic, and social; however, as high this risk will be, the project cost will be high to cover unexpected significant cost uncertainty (Alzahrani 2015; Aziz & Abdel-Hakam 2016). Therefore, this research cost model should include it to improve its accuracy.

B7- Inconsistencies in Government Policies

In this risk, inconsistencies appear from deferent governmental departments and affairs due to the lack of communication and improper requirements and rule organization (Alzahrani 2015; Aziz & Abdel-Hakam 2016; Naderpajouh & Hastak 2014). However, it is being solved by building a united automated system of government-related projects or services; therefore, the risk still exists and must be considered in this study's cost estimation model.

B8- Strong Political Opposition / Hostility

Although researchers showed that this risk exists in all countries, including gulf countries, political opposition and hostility are not significant in the United Arab Emirates due to its culture. Nevertheless, its weightage might vary significantly from place to place (Alzahrani 2015; Wu, Olson & Birge 2011; Akinyemi et al. 2009). Therefore, it will be included in this research system dynamics model.

B9- Expropriation/ Nationalization of Assets

Expropriation and nationalization of project assets are normal actions from countries toward its developments to satisfy targeted self-sufficiency (Alzahrani 2015; Wu, Olson & Birge 2011). Therefore, the cost calculation already includes it, but the targeted level of self-sufficiency may change, impacting final costs. The cost prediction model of this research study will include it.

B10- Inability of Concessionaire

All projects concessionaire is finalized before the United Arab Emirates' execution stage, although researchers showed its existence in GCC countries (Alzahrani 2015; Chowdhury, Sharma & Platz 2016; Chang & Ko 2012; Doloi 2012; Levitt & Eriksson 2016). However, it is granted by law, and processes/procedures are systematic and clear. Therefore, this research will include it to adapt any possible change impacting cost estimation.

- **Political Risks Mapping**

After explaining, in details, each risk factor of Political Risks, the relationship mapping in Figure 3-3 show how risks are connected and with CAPEX variable in the proposed project whole life cycle cost estimation model. Therefore, based on this concept, data collection shall consider these connections to understand risk weightage clearly. It will be reflected in the cost estimation final model.

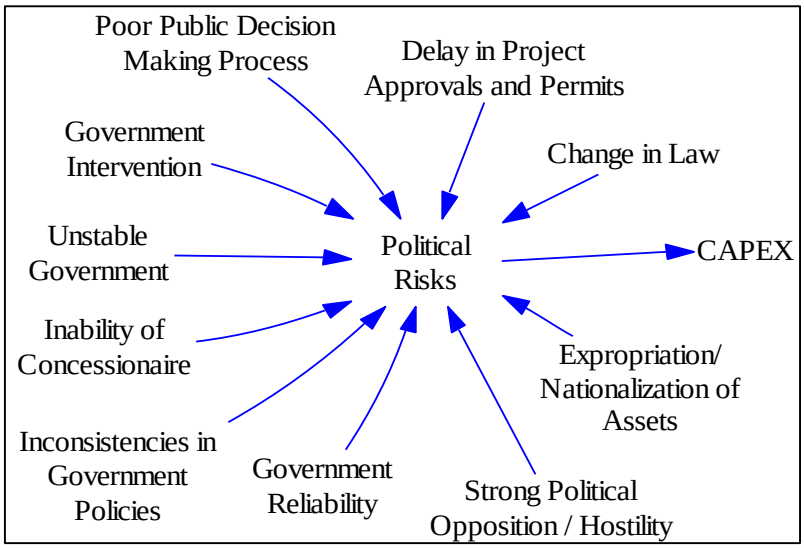


Figure 3-3: Political Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.

C- Legal Risks

The Legal Risks are those risks which are taking place through the project execution stage. This will group all related risks to include them with one mathematical and graphical relationship, which will be reflected in the model's final cost estimation calculations and results. The following risks will be detailed to clarify how they will impact the model and for better clarification and understanding of how the model interacts with its variables related to this group.

C1- Change in Tax Regulation

According to researchers' outputs, this risk did not exist before 2018 in GCC countries, although it is mandatory in all construction risk and cost studies (Jang 2011; Alzahrani 2015; Al-Hamadi 2020; Wu, Olson & Birge 2011). However, in 2018, the United Arab Emirates launched VAT (i.e., Value Added Tax) on all trades, including goods and services. Therefore,

this research study must include it to provide accurate cost estimation outputs from its final created model.

C2- Corruption and Lack of Respect for Law

The consideration of this risk is included because of having a large layer of international employees who have deferent religions, ethics, and culture (Alzahrani 2015; Abanda, Tah & Cheung 2013; Kirkwooda et al. 2016; Love et al. 2002; Ayangade, Wahab & Alake 2009; Asif 2016). So, it is mandatory to cover the risk of any corruption or ignorance/lack of respect for United Arab Emirates Law to provide successful model outputs.

C3- Legislation Change

This risk relates to the improvement and development of legal processes finalizing and formal projects' requirements; as a result, the plan of how to conduct legislation requirements should adopt every legislation change which impacts cost throughout project execution (Jang 2011; Alzahrani 2015; Abanda, Tah & Cheung 2013; Kirkwooda et al. 2016; Love et al. 2002; Ayangade, Wahab & Alake 2009; Asif 2016). Therefore, it will be included in the final cost model.

C4- Import / Export Restrictions

Import and export restrictions are based on the country's political relationship (i.e., the United Arab Emirates) with other countries and based on sudden barriers blocking import/export activities (Alzahrani 2015). For example, in December 2019, coronavirus disease (COVID-19) appeared in China and suddenly reached all countries globally (World

Health Organization 2019; UAE Ministry of Health 2020). This made the United Arab Emirates Ministry of Health recommend, advise, and direct to stop certain imports/exports (World Health Organization 2019; UAE Ministry of Health 2020). In Mach 2020, UAE prevented people from travelling from the country due to the high-risk and refused travellers from high-risk countries to enter the UAE (World Health Organization 2019; UAE Ministry of Health 2020). Thus, it is mandatory to cover these risks in an accurate cost prediction model.

C5- Rate of Return Restrictions

The return rate is not usually restricted unless it is misused by investors and started to impact societies and economics negatively; for example, *"Law No. 26 of 2007", "Decree No. 62 of 2009 and Decree No. 2 of 2011"* and *"Decree No. 43 of 2013"* are restrictions for the rate of return in the last 15 years in UAE-Dubai Emirate (Dubailand 2013, p.18; Alzahrani 2015). However, recently, the UAE government removed these restrictions and allowed a free return rate (Dubailand 2013). This risk is significant and will be included in the final cost model (Dubailand 2013; Alzahrani 2015; Wibowo 2015; Charles & Corbishley 2016; Fan & Yan 2010).

C6- Industrial Regulatory Change

The change of industrial regulatory is happening between projects and usually not during projects' executions; however, it has been proved by other researchers that it is essential to consider this risk in costs and risks modelling (Jang 2011; Alzahrani 2015; Bigsten 2016; Kuricheva & Popov 2016). Therefore, it will be included to enhance accuracy.

- **Legal Risks Mapping**

After explaining in detail each risk factor of Legal Risks, the relationship mapping in Figure 3-4 show how risks are connected and with CAPEX variable in the proposed project whole life cycle cost estimation model. Therefore, based on this concept, data collection shall consider these connections to understand what accurate risk weightage should be set clearly. Finally, it will be reflected in the validation process of collecting data and the final cost model.

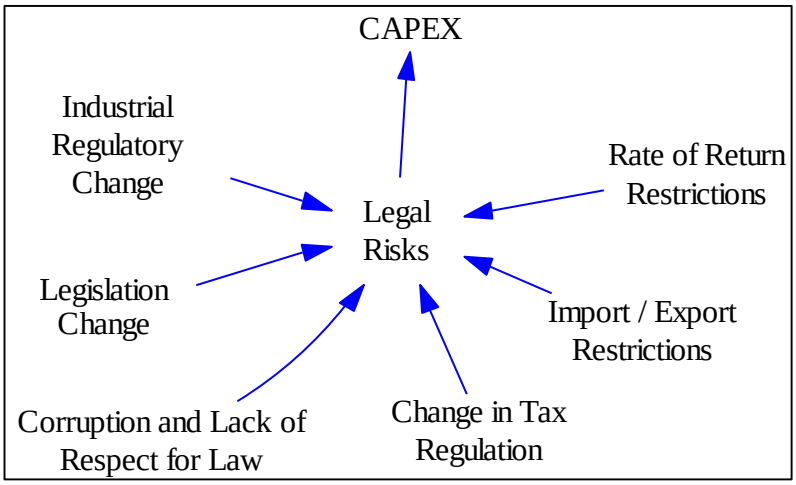


Figure 3-4: Legal Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.

D- Economic Change Risks

Economic Change Risks are these risks taking place through the project execution stage. This is going to group all related risks to include them with one mathematical and graphical relationship. It will be reflected in the model's final cost estimation calculations and results. So, the following risks will be detailed to clarify how they will impact the model and better understand how the model interacts with its variables related to this group.

D1- Interest Rate Volatility

Interest rate fluctuation is a significant risk in cost modelling, as proved by previous empirical and published research (Jang 2011; Alzahrani 2015; Gardiner & Stewart 2000; Stasiak-Betlejewska & Potkány 2015). This is fixed once the financial contract is signed; however, some economic changes may change the amount of financial support needed and require additional finance. If the investment market is active and has high demand by investors to finance investments, the interest rate will be too high compared with the initial project finance rate. On the other hand, if the investment market is down, and there are no demands for investments, the interest rate will be lower. Therefore, this risk will be included in the final cost model.

D2- Inflation Rate Volatility

The inflation rate is usually stable and measured and monitored by the United Arab Emirates central bank; however, it fluctuates significantly in an unexpected trend based on oil or regional political/economic directions (Jang 2011; Alzahrani 2015; Kaiser & Snyder 2012; Chang & Ko 2012). Therefore, it should be included in the final research cost estimation model.

D3- Foreign Exchange and Convertibility

This risk is usually considered based on supplying and importing (Jang 2011; Alzahrani 2015; Bigsten 2016; Baloi & Price 2003). However, there will be no risk of total cost change if supplying and importing are done using deferent currencies with fixed relationships (i.e., UAE Dirham is fixed with the United States Dollars). On the other hand, the threats and

opportunities will be created based on risk occurrence situations if they have a free exchange ratio.

D4- Poor Financial Market

The financial market's primary role refers to the investment's strengths and weaknesses (Jang 2011; Alzahrani 2015; Ibn-Homaid & Tijani 2015; Memon et al. 2010; James 2014). In other words, if investments in a city are low risk, all investors will take the opportunity to conduct business activities, and the demand/supply will start growing with the price growth. Therefore, this significant risk will be included in the final cost estimation model.

- **Economic Change Risks Mapping**

After explaining each risk factor of Economic Change Risks, the relationship mapping in Figures 3-5 shows how risks are connected and with CAPEX variable in the proposed project whole life cycle cost estimation model. Therefore, based on this concept, data collection shall consider these connections to understand what accurate risk weightage should be set clearly. Therefore, it will be reflected in the collected data's validation process and the final cost model.

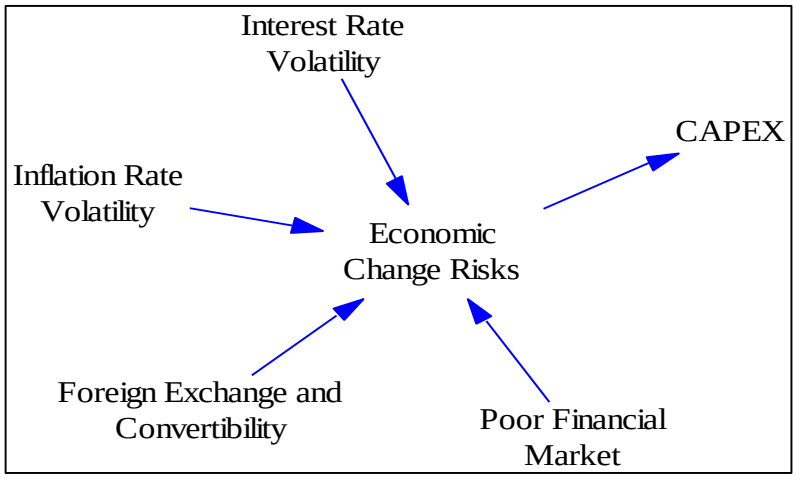


Figure 3-5: Economic Change Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.

E- Natural Forces Risks

Natural Forces Risks are those risks taking place during the project construction stage. This group is including all related risks together to connected with mathematical and graphical relationships. It will be reflected in the model's final cost estimation calculations and results. The following risks will be detailed to clarify their impact on the final model and better understand the model's interaction with its variables related to this group.

E1- Force Majeure

All unavoidable and negatively impacting events related to the project are considered under this risk (Jang 2011; Alzahrani 2015; Torp et al. 2016; Chang & Ko 2012; Love et al. 2002; Doloi 2012). For example, tornados, floods, and earthquakes are above and beyond the project intent and capabilities; however, they will be considered under this risk category. These considerations are analysed during the project selection, design, and execution stages. However, risk changing possibilities during construction still exist and should be included in the final system dynamics cost estimation model.

E2- Environment

The environmental risks are those risks related to environmental required status/condition after impacting or being impacted by the development projects from its start to the end of its lifecycle (Jang 2011; Alzahrani 2015; Jarkas 2016; Yana, Yana & Rusdhi 2015). For example, the precaution of protecting living beings around the project is a risk that should be considered. Also, noise and water pollution have many constraints falling under this

risk. Other examples exist; however, researchers proved that this is a significant risk and must be added to cost models (Jang 2011; Alzahrani 2015; Jarkas 2016; Yana, Yana & Rusdhi 2015).

E3- Weather

Over the last decade, the weather changes made this risk critical on projects' long lifecycle (Jang 2011; Alzahrani 2015; Jarkas 2016; Yana, Yana & Rusdhi 2015). This change should be compared with other development projects (Jang 2011; Alzahrani 2015; Jarkas 2016; Yana, Yana & Rusdhi 2015). For example, the need for a sudden heating/cooling system after starting construction is considering the available design capabilities and the electrical supply in great challenge. Adding equipment without proper study in the facility's units can cause fire incidents or other fatalities situation. Therefore, this risk should be considered by the final cost estimation model.

E4- Geotechnical Condition

The geotechnical condition is deciding the type of foundation, required equipment, and processes needed for construction projects' activities and jobs (Jang 2011; Alzahrani 2015; Doloi 2011; Aziz & Abdel-Hakam 2016; Wang et al. 2016). Therefore, any mistake in this condition conclusion will change the estimated cost significantly. This risk requires to be added to the final cost model.

- **Natural Risks Mapping**

After explaining each risk factor of Natural Risks, the relationship mapping in Figures 3-6 shows how risks are connected and with CAPEX variable in the proposed project whole

life cycle cost estimation model. Therefore, based on this concept, data collection shall consider these connections to understand what accurate risk weightage should be set clearly. Therefore, it will be reflected in the validation process of collecting data and the final cost model.

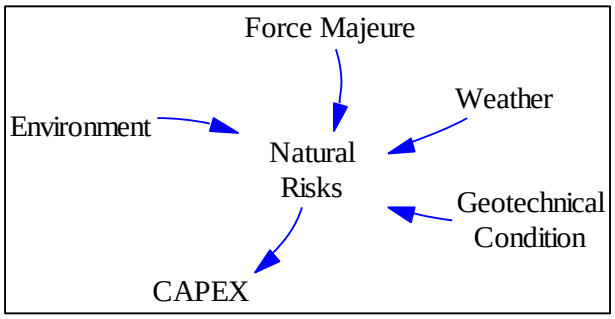


Figure 3-6: Natural Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.

F- Market Risks

The Market Risks are those risks which are taking place through the project execution stage. This will group all related risks to include them with one mathematical and graphical relationship, reflected in the model's final cost estimation calculations and results. The following risks will be detailed to clarify how they will impact the model and better clarify and understand how the model interacts with its variables related to this group.

F1- Market Supply

The market supply for project's outputs (i.e., apartment unit/villa unit) and the market supply for materials used in the construction stage significantly impact cost estimation (Jang 2011; Alzahrani 2015; Doloi 2011; Kaiser & Snyder 2012). Furthermore, it is required to be considered in the final cost estimation model.

F2- Market Demand

The demands on materials throughout the construction lifecycle have a risk of change and impact the calculated costs (Jang 2011; Alzahrani 2015; Doloi 2011; Kaiser & Snyder 2012). For example, if a material type has a specific price at the time of project construction start, while its demand increased, then the price will increase accordingly. From another perspective, if project-type demand by end-users changed during its execution, then the project's final cost will vary based on the actual changes. However, these changes can be pressure cards with suppliers because you are a client who provides highly demanded products, and hence prices may significantly increase. Therefore, this risk will be added to the final cost estimation model.

F3- Fluctuation of Material Cost by Public/Private

The material price fluctuations risk is based on whether the supply and demand are between suppliers and the public sector or between the supplier and private sector (Jang 2011; Alzahrani 2015; Koo et al. 2010; Ayangade, Wahab & Alake 2009). However, it is also impacted by the quality and quantities of materials and its price category offered for consumers; for example, if a public manufacturer or supplier offers the same material, then the price will be different from private manufacturers' prices and suppliers. Therefore, the project cost should consider those risks to increase this research output cost estimation model's accuracy.

F4- Value of Production Effort

The expected value of a project's outcomes can change its production value through time based on the reasons (Jang 2011; Howell & Koskela 2000). For example, the taxes change, materials cost, and construction needs will create a production value and change it every time they change over the project's duration. Therefore, it should be included in the final estimation model.

- **Market Risks Mapping**

After explaining in detail each risk factor of Market Risks, the relationship mapping in Figure 3-7 show how risks are connected and with CAPEX variable in the proposed project whole life cycle cost estimation model. Therefore, based on this concept, data collection shall consider these connections to clearly understand what accurate risk weightage should be set. Therefore, it will be reflected in the validation process of collecting data and the final cost model.

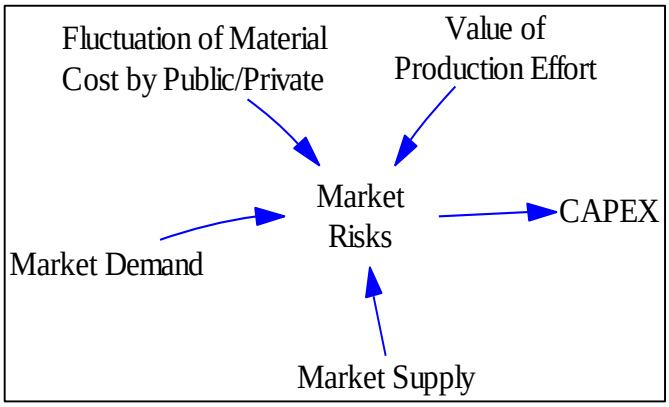


Figure 3-7: Market Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.

G- Project Selection Risks

Project Selection Risks are those risks taking place during the project construction stage. This group collects all related risks to include them with one mathematical and graphical relationship and reflect it in the model's final cost estimation calculations and results. The following risks will be detailed to clarify how they will impact the model and better understand how the model interacts with variables related to this group.

G1- Public Opposition to Projects

The public opposition at the preconstruction stage is rare after project selection (Alzahrani 2015; Wu, Olson & Birge 2011; Chowdhury, Sharma & Platz 2016). If the project is executed to follow specific requirements resulting from solving the challenge of public opposition to the desired project, then the construction stage should consider public impact regarding these requirements and consider the change of this impact. So, this risk should be in the final cost estimation model.

G2- Uncompetitive Tender

Having uncompetitive tenders risky at the project selection stage is critical and can increase costs (Alzahrani 2015; Wu, Olson & Birge 2011). However, this risk can appear at the time of requirements misunderstanding by suppliers. It will cause a decrease in suppliers' adequacy and show uncompetitive characteristics after starting construction stages. Therefore, the risk should be included in the final cost model.

G3- Level of Demand for the Project

The demand level of projects in developing regions is essential. This important is to check if its completion will still need the project or not (Alzahrani 2015; Enezy et al. 2017). Nevertheless, the cost will vary based on the demand level over time. For example, if the demand level for the project's specification still there at the time of completion, then the cost will not be impacted (i.e., will not increase). On the other hand, if the demand changed to include other specifications or requirements (e.g., luxury-level), the process will change, and cost will increase. So, this risk should be included to have an accurate cost estimation model.

G4- Land Acquisition

According to researchers in cost and risk models of construction, land acquisition is vital to optimizing accuracy (Alzahrani 2015; Mills 2001; Kubba 2017). For example, if new developments are located in other people's places due to government carelessness in development and control, it is mandatory to compensate these owners before proceeding with the project. However, this process can be risky because it can delay, stop, or change activities during the construction stage. It is due to the conflicts and challenges between owners, legal requirements, and permissions. Thus, the risk should be included in the cost estimation model.

G5- Competition Risk

The competition on the project's type between clients can significantly increase the final cost (Alzahrani 2015; Iyer & Jha 2005; Hunter, Fitzgerald & Barlow 2014). For instance, more available clients competing on having the same project type will push contractors and

suppliers to increase costs to maximize their profit. Therefore, it is essential to include this risk in the final cost model.

- **Project Selection Risks Mapping**

After explaining each risk factor of Project Selection Risks, the relationship mapping in Figures 3-8 shows how risks are connected with the CAPEX variable in the proposed project whole life cycle cost estimation model. Therefore, based on this concept, data collection shall consider these connections to clearly understand what accurate risk weightage should be set. Therefore, it will be reflected in the collected data's validation process and the final cost model.

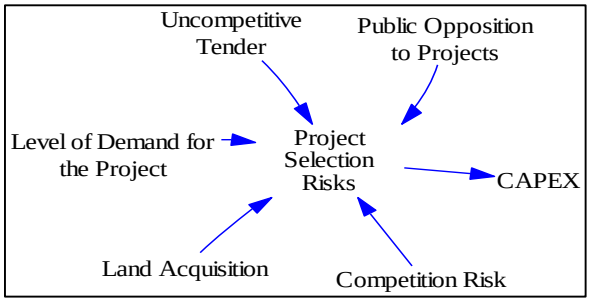


Figure 3-8: Project Selection Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.

H- Project Finance Risks

Project Finance Risks are those risks taking place during the project construction stage. This group collects all related risks to include them with one mathematical and graphical relationship and reflect it in the model's final cost estimation calculations and results. Thus, the following risks will be detailed to clarify how they will impact the model and better understand how the model interacts with variables related to this group.

H1- Inaccurate Estimates

The possibility of having inaccurate estimates of contract value by contractors is high and may change the actual costs at the end of the project (Alzahrani 2015; Salling & Leleur 2015; Ali & Kamaruzzaman 2010; Flyvbjerg 2016; Flyvbjerg, Holm & Buhl 2002; Flyvbjerg 2005; Skamris & Flyvbjerg 1996; Flyvbjerg et al. 2018).

H2- High Finance Cost

Sometimes the construction finance cost is high for several reasons (Alzahrani 2015; Lovering, Nordhaus & Yip 2016; Levitt & Eriksson 2016). For example, if the finance rates change based on conditions made according to the project's specific progress or time frame and that progress and time have been changed because of other risks, the finance cost will be changed to include a higher rate client.

H3- High Bidding Costs

The high bidding costs impact the actual cost estimates because of the inaccurate costs from the beginning of the project (Alzahrani 2015; Dikmen, Birgonul & Han 2007; Turskis 2008). For example, risks of costs and financing will be higher, and the actual project value will be less than the paid amount in case of requiring more financial support to cover unnecessary costs. So, this will impact the net present value and the ability to complete the project investments.

H4- Delay in Payment of Annuity

The delay of paying the projects' annuity or financed investment is having significant risk on the project lifecycle (Alzahrani 2015; El-Razek, Bassioni & Mobarak 2009; Frimpong, Oluwoye & Crawford 2003). However, it should be included in the final cost estimation model for more accurate results

H5- Financial Attraction of Project to Investors

This risk is available if the competition starts between investors to have a higher profit margin (Alzahrani 2015; Ibn-Homaid & Tijani 2015; Sayed & Sawant 2015; Assad et al. 2007; Becchio et al. 2016). However, other risks will start to be adjusted and may be increasing due to this risk impact. The completion time frame is the main tool for activities' crashing and fast-tracking to maximize projects' investment outcomes, which will change the final actual costs. Therefore, it will be included in this research's final cost model.

H6- Lack of Creditworthiness

This risk varies in investments over time. It is based on the economy and the investor's economic status (Alzahrani 2015; Wu, Olson & Birge 2011; Akinyemi et al. 2009). Thus, it is high in some periods and low in other periods during the project execution, and it is not fully guaranteed that the high rates can be avoided at lack of creditworthiness time. Thus, this risk should be considered in the model.

H7- Delay in Financial Closure

The project's financial cost will be increasing until appropriate closure takes place successfully on time without delay (Alzahrani 2015; Abdul Rahman et al. 2013; Chowdhury, Sharma & Platz 2016). However, this risk depends on other factors such as the delay in closing the construction project during the final taking over, and the delay in closing struggling claims requires to be finalized at the end of the project. Therefore, this risk will be included in the final cost model.

H8- Inability to Service Debt

The inability to service debts will increase the interest rates and increase investors' lack of creditworthiness (Alzahrani 2015; Akinyemi et al. 2009; Ibn-Homaid & Tijani 2015). Therefore, this risk should be considered in the final cost estimation model.

H9- Lack of Government Guarantees

Sometimes the lack of government guarantees related to financial decisions such as tax regulations/change can add more risks to the project (Alzahrani 2015). This will appear in the final project's actual costs, and it will be included in this research's final cost model.

H10- Financer Unwilling to Take High Risk

Sometimes financiers unwilling to take high risks in critical situations such as the economic crises in 2008 (Alzahrani 2015). This will cause finance to use more expensive sources than the regular financing entities (i.e., banks, financial companies, etc.). However, this will increase actual costs and have more interest rates. This risk will be included in the final cost model for this research study.

- **Finance Risks Mapping**

After explaining in detail each risk factor of Finance Risks, the relationship mapping in Figure 3-9 show how risks are connected with CAPEX variable in the proposed project whole life cycle cost estimation model. Therefore, based on this concept, data collection shall consider these connections to clearly understand what accurate risk weightage should be set. Therefore, it will be reflected in the validation process of collecting data and the final cost model.

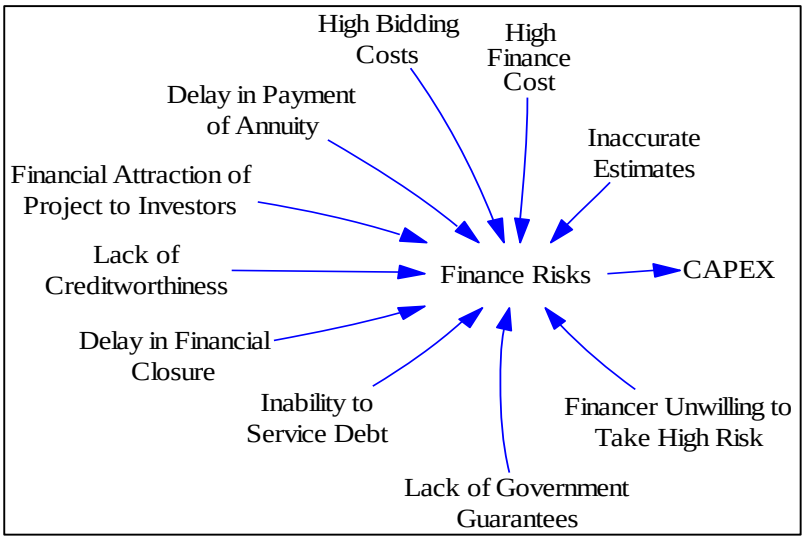


Figure 3-9: Finance Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.

I- Building Functionality and Serviceability Risks

Building Functionality and Serviceability Risks are those risks taking place during the project construction stage. This group collects all related risks to include them with one mathematical and graphical relationship and reflect it in the model's final cost estimation calculations and results. Thus, the following risks will be detailed to clarify how they will impact the model and better understand how the model interacts with variables related to this group.

I1- Construction Time Delay

Researchers have proved that construction delay is connected significantly with the actual cost and cost estimation (Alzahrani 2015; James 2014; Aziz & Abdel-Hakam 2016; Williams 2003; Dikmen, Birgonul & Han 2007; Doloi 2012; Poh & Tah 2006; Acebesa et al. 2013; Kamaruzzaman 2010). However, this is going to impact the building functionality and serviceability due to the planned time compensation to finish the project on time over the aim of the project function (Alzahrani 2015; James 2014; Aziz & Abdel-Hakam 2016; Williams 2003; Dikmen, Birgonul & Han 2007; Doloi 2012; Poh & Tah 2006; Acebesa et al. 2013; Kamaruzzaman 2010). Therefore, this risk should be considered in the estimation model to avoid cash flow bleeding.

I2- Material Availability

Researchers have proved that material availability risk is significant (Alzahrani 2015; Rahman et al. 2012; Hasançebi 2017; Love & Irani 2003; Guo & Sultan 2017). It because of the ability to supply the full quantity of materials to the site. This risk might also appear because of the absence of required material specifications (Alzahrani 2015; Rahman et al. 2012; Hasançebi 2017; Love & Irani 2003; Guo & Sultan 2017). Finally, materials availability over time will be based on different market costs (Alzahrani 2015; Rahman et al. 2012; Hasançebi 2017; Love & Irani 2003; Guo & Sultan 2017). Therefore, this risk is not avoidable and must be included in the final cost estimation model.

I3- Labour Availability

Researchers proved that labour availability risk is significant on cost change (Alzahrani 2015; Santos et al. 2017; Sayed & Sawant 2015; Battistoni et al. 2016; Signor et al. 2016; Doloi 2012; Florio & Sirtori 2016; West, Kreuter & Jaenichen 2013). It is because of having specific skilled labour speciality that should come from certain regions and require special recruitment at the time of construction; however, it may happen because of wadge changes and job security requirements (Alzahrani 2015; Santos et al. 2017; Sayed & Sawant 2015; Battistoni et al. 2016; Signor et al. 2016; Doloi 2012; Florio & Sirtori 2016; West, Kreuter & Jaenichen 2013). The un-availability of labours in the United Arab Emirates is rare due to extreme facilitation to have laboured from different places in the world without limits.

I4- Poor Quality of Workmanship

The quality of workmanship impact acceptable progress and time of successfully completing the project; thus, researchers agreed that it is significant (Alzahrani 2015; Watson, Pitt & Kavan 1998; Kazaz, Birgonul & Ulubeyli 2005; Yasin et al. 1999; Love & Irani 2003). So, it is mandatory to include this risk in the final cost model of this study.

I5- Default of Sub-Contractors or Suppliers

The defaults of subcontractors create conflicts between the client and other stakeholders without being able to load the risk and its impact on specific stakeholder; however, this is due to the claims or arbitration between contractors and sub-contractors; therefore, this risk is significant, and it is mandatory to choose wisely the contractor who appropriately chooses his sub-contractors (Alzahrani 2015; Doloi 2011; Ramasesh & Browning 2014; Memon et al. 2010; Iyer & Jha 2005). This risk will be included in the final cost estimation model.

I6- Design & Construction Complexity

Understanding how to execute completed designs that require complex construction must have a high risk (Alzahrani 2015; Assad et al. 2007; Ramasesh & Browning 2014; Kamaruzzaman 2010; Doloi 2012; Chapman 1998). This is because changing people who work in the project will take time and increase the probability of executing works with mistakes if it is not appropriately managed (Alzahrani 2015; Assad et al. 2007; Ramasesh & Browning 2014; Kamaruzzaman 2010; Doloi 2012; Chapman 1998). Therefore, this significant risk frequently happens in projects and will be included in the final estimating model.

I7- Design Deficiency

Design can be approved at the project's initial stages and hit the fact of having deficiencies; however, this is a significant cost risk (Alzahrani 2015; Assad et al. 2007; Ramasesh & Browning 2014; Kamaruzzaman 2010; Doloi 2012; Chapman 1998). It can happen because of having the design in a foreign country that is not aware of the project's local or cultural requirements. Therefore, this risk is requiring attention and will be added to the final cost model.

I8- Late Design Change

The design changes can be mitigated within the project's execution unless it is late and delaying the project end date (Alzahrani 2015; Assad et al. 2007; Kamaruzzaman 2010; Doloi 2012). However, the compensation of design change can be covered by the profit resulted from its value engineering. Therefore, most contractors approach design change at earlier stages of construction and face late design change. This risk will be added to the final cost model.

I9- Construction Technology Risk

Construction technology contributes significantly to completing complex projects accurately within the acceptable time frame (Alzahrani 2015; Doloi 2012; James 2014; Schieg 2010). However, this can be risky if the technology is very new and faced several negative side-effects; thus, it can reflect lower progress and quality while increasing costs. The complexity of used technologies can be a challenge as well. Therefore, this risk should be included in the cost model for this research study.

I10- Contractual Risk

In the contractual construction risk, stakeholders' game transfers risks to other parties rather than taking it by themselves (Alzahrani 2015; Xu & Moon 2013; Wu, Olson & Birge 2011). However, the variations in the middle of the construction can return some risks to stakeholders, and this study is concerned about the risks that the client takes in developing residential buildings.

I11- Contractor Failure

Contractors' failure is usually because of indirect unpreventable causes; however, researchers decided that this risk is significant and should be considered to measure the remaining risks accurately (Alzahrani 2015; Williams 2003). It will be added to the final cost estimation model.

I12- Quality Risk

The quality of material used in the construction stage is a client concern more than contractors' concern (Alzahrani 2015; Watson, Pitt & Kavan 1998; Kazaz, Birgonul & Ulubeyli 2005; Yasin et al. 1999; Willis & Willis 1995). This is due to the risk of shifting the project from contractors to clients after works' completion. However, quality is the degree of meeting the project's requirements, which will be added to the final cost estimation model.

- **Building Functionality and Serviceability Risks Mapping**

After explaining in detail each risk factor of Building Functionality and Serviceability Risks, the relationship mapping in Figure 3-10 show how risks are connected with CAPEX variable in the proposed project whole life cycle cost estimation model. Therefore, based on this concept, data collection shall consider these connections to clearly understand what accurate risk weightage should be set. Therefore, it will be reflected in the validation process of collecting data and the final cost model.

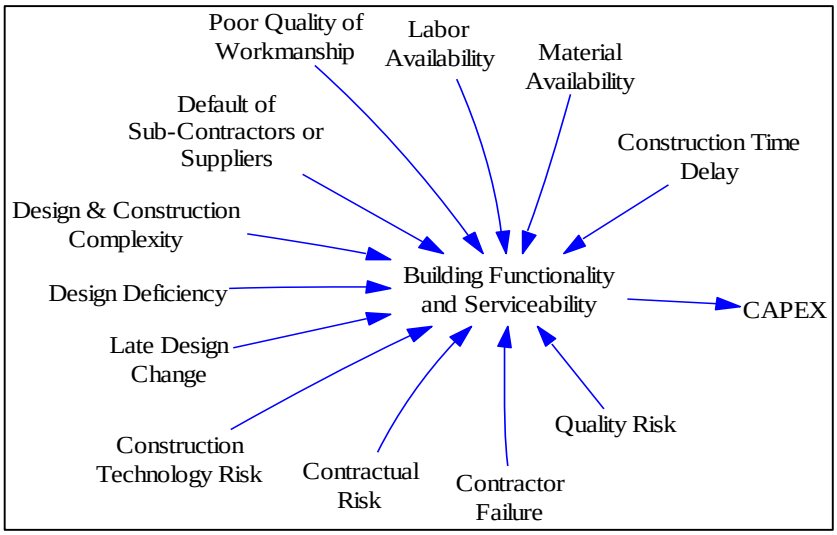


Figure 3-10: Building Functionality and Serviceability Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.

J- Stakeholders Relationship Risks

The Stakeholders Relationship Risks are those risks taking place during the project construction stage. This group collects all related risks to include them with one mathematical and graphical relationship and reflect it in the model's final cost estimation calculations and results. Thus, the following risks will be detailed to clarify how they will impact the model and better understand how the model interacts with variables related to this group.

J1- Different Working Method Between Partners

Managing stakeholders' requirements is a significant risk, including methods and needs to control and deliver their outputs. Thus, the risk management approach/method will require to be included in the final cost estimation model (Alzahrani 2015).

J2- Inadequate Experience in Residential Projects

Each stakeholder's experience in a similar project must be adequate and meet the satisfaction level based on approved specifications and execution criteria (Alzahrani 2015; Yusof et al. 2016; Abdul-Rahman et al. 2013; Aziz & Abdel-Hakam 2016). However, hidden stakeholders dealing with contractors (i.e., suppliers, sub-contractors) may not have the required experience, impacting the progress, quality, and project execution time. Thus, this risk will be added to the final cost estimation model.

J3- Lack of Commitment from Public/Private Sector

The improper commitment between the public and private sectors regarding their obligations toward the development project may create a failure or significant damage to the expected deliverables (Alzahrani 2015; Nelson 2008; Chowdhury, Sharma & Platz 2016). However, all concerned stakeholders usually consider this risk, except that the risk deviation from accurate measures is available and should be included in the final cost model.

J4- Organization and Coordination Risk

As a client, the organization, coordination, and management of stakeholders have been identified by researchers as a significant risk (Alzahrani 2015). It will be included in this research study's final cost estimation model.

J5- Inadequate Distribution of Responsibility & Risk

At the pre-construction stage, all stakeholders work hard on distributing the responsibility and risks to satisfy their good during project completion (Alzahrani 2015; Dillman et al. 2009; Friedler & Pisanty 2006; Matto & Sippola 2016; Naderpajouh & Hastak 2014; Chowdhury, Sharma & Platz 2016; Abdel-Razek, Bassioni & Mobarak 2009). Nevertheless, the inadequate risk allocations between stakeholders make a significant change in the cost if the risk is allocated to other parties than the responsible one of making decisions; therefore, this will create conflict and a tendency for variations to re-allocate these risks. Thus, this risk will be included in the final cost estimation model.

J6- Inadequate Negotiation Period Before Initiation

The period of negotiation should be adequate to avoid missing essential considerations while allocating the risks and finalize the construction cost estimation (Alzahrani 2015; Eden, Williams & Ackermann 2005; Zhao, Chen & Thomson 2017; Johnsen, Howard & Miemczyk 2009; Poucke, Matthyssens & Weeren 2016; Levitt & Eriksson 2016; Toor & Ogunlana 2009). It is significantly essential to enhance the control cost bleeding and variations during construction (Alzahrani 2015). Hence, this risk will be included in the final cost estimation model.

J7- Conflict Between Project's Participants

The appropriate management of conflict between project parties improves the flow of planned progress over time within estimated cash flows (Alzahrani 2015). Also, it will help in satisfying the approved requirements and specifications (Alzahrani 2015). Therefore, this risk will be included in the final cost estimation model.

J8- Workers Strike

Workers strike are rare in the United Arab Emirates; however, since UAE is one of the most capable countries in adapting to change, it is essential to include this risk factor because of the quantity of international labour in the United Arab Emirates from deferent cultures and religions. Researchers proved that this risk is significant (Alzahrani 2015; Iyer & Jha 2005; Odeyinka, Lowe & Kaka 2013; Abdel-Razek, Bassioni & Mobarak 2009). Thus, this research study will include it in the final cost estimation model.

J9- Cultural Differences Between Main Stakeholders

This risk factor starts in any project, including forming, storming, norming, performing (Alzahrani 2015; PMBOK 6th Ed. 2017). The appropriate management of stakeholders minimizes this risk; however, some challenges appear when stakeholder personals are replaced during the project period (Liu et al. 2012; Ramasesh & Browning 2014; Modell 2005; Cassell & Symon 2004; Tsang 2014). Thus, this may change the cost and should be in the final cost model.

- **Stakeholders Relationship Risks Mapping**

After explaining in detail each risk factor of Stakeholders Relationship Risks, the relationship mapping in Figure 3-11 show how risks are connected and with CAPEX variable in the proposed project whole life cycle cost estimation model. Therefore, based on this concept, data collection shall consider these connections to clearly understand what accurate risk weightage should be set. Therefore, it will be reflected in the validation process of collecting data and the final cost model.

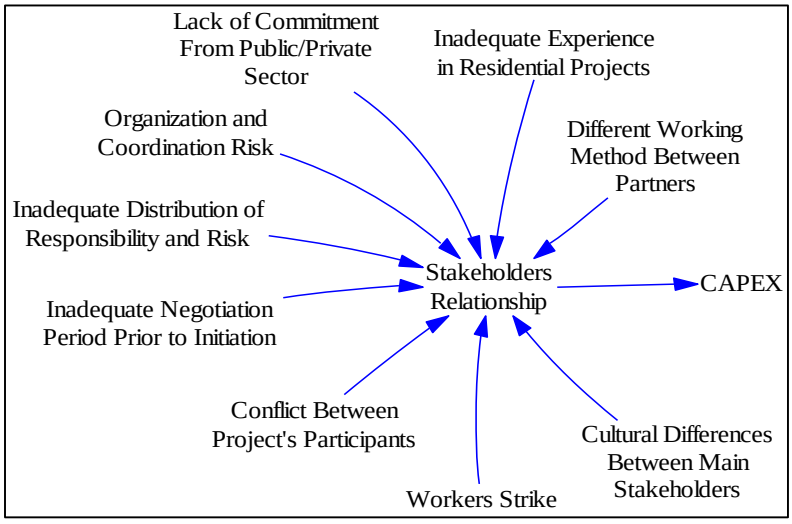


Figure 3-11: Stakeholders Relationship Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.

K- Knowledge Risks

Knowledge Risks are those risks taking place during the project construction stage. This group collects all related risks to include them with one mathematical and graphical relationship and reflect it in the model's final cost estimation calculations and results. Thus, the following risks will be detailed to clarify how they will impact the model and better understand how the model interacts with this group's variables.

K1- Expertise

Expertise within the technical and managerial disciplines is essential throughout the project's life cycle (Ahiaga-Dagbui 2014; Linderman & Chandrasekaran 2010; Liu et al. 2012). The risk of changing them will impact expertise experience implementation on the project's challenges. Thus, it is impacting the cost and should be included in the final cost estimation model.

K2- Familiarities

Being familiar with a similar project before starting new development increases cost estimation optimisation, but the risk of finding cost familiarities to estimate the final actual cost exists (Osei-Fosu 2014; Bari et al. 2012; Mehran 2016). Therefore, this risk is significant and should be included in the final cost estimation model.

K3- Number of Bidders

Knowing the expected number of bidders impact the competition and tenders' costs; therefore, this risk will be added in the final cost estimation model (Asal 2014; Baloi & Price 2003; Levitt & Eriksson 2016; Wu, Olson & Birge 2011; Elhag, Boussabaine & Ballal 2005).

K4- Market Conditions

Knowing the market condition based on historical data and forecast the future conditions are being done by the client to study the investments return and costs (Boussabaine & Kirkham 2004; Cheng 2014; Torp et al. 2016; Torriti 2012). However, the risk occurrence probability and impact exist and should be covered by the final cost estimation model.

K5- Size of the Project

Knowing the project's size is based on several criteria, such as the complexity, built area, facilities, and technology (Boussabaine & Kirkham 2004). Hence, the risk of changing the knowing criteria can impact the decisions made based on expected costs (Boussabaine & Kirkham 2004; García et al. 2016; Bari et al. 2012; Toor & Ogunlana 2009; Shehu et al. 2014). So, this risk should be added in the final system dynamics cost estimation model.

K6- Type of Building

The type of building in this research study is residential; however, this type has sub-types such as low rise buildings, medium-rise building, high rise buildings, individual villas, and compound housing mega-projects (Boussabaine & Kirkham 2004; Zakis, Zakis & Arfridsson 2017; Wibowo 2015; Odeyinka, Lowe & Kaka 2013). However, each type and sub-type is having its impacting criteria on risks and costs. Therefore, this risk will be added to the final cost estimation model.

K7- Extent of Database

The error of having cost deviation will be less tolerant if clients have a more extensive database related to the project's different knowledge (Boussabaine & Kirkham 2004; Florio, Forte & Sirtori 2016; Florio & Sirtori 2016; Hamaker & Componation 2005). However, this risk factor impacts forecasted costs and should be added to the final cost estimation model.

K8- Homogeneity of Samples

The homogeneity of samples is decreasing the standard deviation of the forecasting expected trend (Ahiaga-Dagbui 2014). Thus, it is essential to adopt this risk factor in the final system dynamics cost model to end with more accurate outputs.

K9- Details of Information

The received detailed information about each project's knowledge topic optimizes customized cost estimation modelling based on the desired changes in the future (Alzahrani 2015; Love et al. 2002; Cheung et al. 2012). Thus, information details accuracy risk should be included in this research cost estimation model.

- **Knowledge Risks Mapping**

After explaining in detail each risk factor of Knowledge Risks, the relationship mapping in Figure 3-12 show how risks are connected with CAPEX variable in the proposed project whole life cycle cost estimation model. Therefore, based on this concept, data collection shall consider these connections to understand what accurate risk weightage should be set clearly. Thus, it will be reflected in the validation process of collecting data and the final cost model.

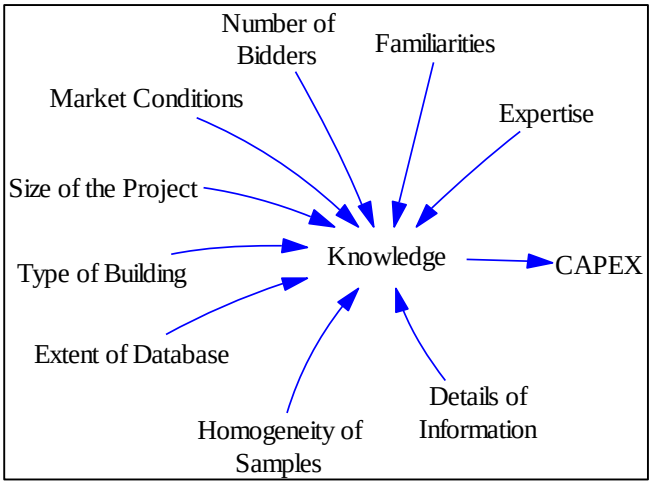


Figure 3-12: Knowledge Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.

3.2 OPEX Risks

Operational expenditure clusters and factors will be discussed and detailed to explain how they impact this research system dynamics final cost estimation model. The connection between these factors will be mapped and described in the same form they will interact with each other in the expected cost estimation and cash flow model. Therefore, there are 15 risks in one group (i.e., OPEX Activities Risks) including Energy Costs, Service Life of Building Components, Building Components' Eco-Costs, Asset Operation Eco-Costs, Disposal Eco-Costs, Components' Deterioration Rate, Fabric Maintenance, Services, Equipment's Maintenance, Overheads, Utilities, Cleaning, Percentage of Current Replacement Value, Ratio of Maintenance to Capital Cost, and Ratio of Operation to Capital Cost.

OPEX Activities Risks are those risks that are taking place through the operational project stage. This group collects all related risks to include them with one mathematical and graphical relationship and reflect it in the model's final cost estimation calculations and results.

The following risks will be detailed to clarify how they will impact the model and better understand how the model interacts with variables related to this group.

O1- Energy Costs

Energy cost change risk is critical in estimating projects full lifecycle costs. However, energy cost is weighted in operational expenditures more than capital expenditures (Jang 2011; Alzahrani 2015). However, this will change according to several other factors such as inflation, delay, time frame, technology, and environmental requirements (Jang 2011; Alzahrani 2015; Kleyner & Sandborn 2008; Sharma, Najafi & Qasim 2013). Energy cost is not necessary to change in the same expected pattern. Therefore, this risk must be added to the final cost estimation model (Jang 2011; Alzahrani 2015; Kleyner & Sandborn 2008; Sharma, Najafi & Qasim 2013).

O2- Service Life of Building Components

The service life of building components is impacted by the quality of used materials and workmanship; however, the risk of not having as-built calculated and expected cost is significant according to researchers and should be included in this research cost estimation model (Boussabaine & Kirkham 2004; Spickova & Myskova 2015).

O3- Building Components' Eco-Costs

Eco-costs of each component are the mandatory costs to reduce a negative impact on the environment (Boussabaine & Kirkham 2004). For example, the eco-cost will increase during operating the facility if the building components cause a more negative impact on the environment. Thus, it is essential to consider this risk due to the unexpected actual eco-costs.

O4- Asset Operation Eco-Costs

Assets operational eco-costs in buildings require adjusting risk factors to consider any unexpected eco-costs; however, smart building systems help optimize assets operations costs (Boussabaine & Kirkham 2004; Asif 2016). Thus, it is going to be added to this research system dynamics cost estimation model.

O5- Disposal Eco-Costs

The operational disposals eco-cost is changing over time unsystematically because of the changes in environmental regulations required for buildings operations (Boussabaine & Kirkham 2004; Sydor et al. 2014; Zakis, Zakis & Arfridsson 2017; Ballarini et al. 2017). Thus, it must include the risk of cost changing in this factor to optimize the cost estimation model.

O6- Components' Deterioration Rate

This risk reflects how the building execution was completed by forecasting deterioration and checking its accuracy against actual deterioration cost rate (Boussabaine & Kirkham 2004; Abanda & Cheung 2013; Babashamsi et al. 2016; Wang, Xia & Zhang 2014).

However, this significant risk relates to the lifecycle time, and it should be included in the final cost estimation model.

O7- Fabric Maintenance

Fabric maintenance cost is based on consumption and replacement of those fabrics; however, researchers agreed that Fabric Maintenance risk impacts cost modelling (Boussabaine & Kirkham 2004). Thus, it will be added to the final cost estimation model.

O8- Services

Services cost is happening because of the deviation between expected cost and unexpected actual cost when renewing or changing the service contracts (Boussabaine & Kirkham 2004). Therefore, since the model covers the operation expenditure of the project's whole life cycle for tens of years, it is essential to include this risk in the cost estimation model.

O9- Equipment's Maintenance

Following the same concept of services risks, equipment maintenance cost changes over time and requires additional cost estimation (Boussabaine & Kirkham 2004; Abdallah 2007; Willis & Willis 1995; Wu, Olson & Birge 2011). However, it cannot be added with the service risks because the criteria and contract duration change over time with different percentages.

O10- Overheads

Managing facilities and buildings operations have mandatory overheads; however, the overhead costs are based on many other risk factors mentioned above (Boussabaine & Kirkham 2004; Seo & Park 2017; Wilke 2005). The overhead risks are including the human resources wages, fixed rents, and other indirect operational costs (Boussabaine & Kirkham 2004; Seo & Park 2017; Wilke 2005). Thus, overhead can change the cost with different weightage from what is mentioned in other risks. It should be included separately in the cost model to improve the cost prediction accuracy (Boussabaine & Kirkham 2004; Seo & Park 2017; Wilke 2005).

O11- Utilities

The utilities of residential buildings can be adjusted over time, especially after changing the equipment during the operational stage; however, this cost change rate is not fixed and require to be included in the final cost estimation model (Boussabaine & Kirkham 2004; Donovan & Corbishley 2016; McLean & McGovern 2017; Asif 2016).

O12- Cleaning

The cleaning risk is based can have deferent requirements for the same residential project through time and situations; for example, after having Coronavirus 2019 (i.e., COVID19), cases started to appear in the United Arab Emirates, and cleaning/sterilization started to follow too high requirements and criteria as minimum legal health requirements. This changed the cost of all cleaning materials, equipment, and labour skills required for operations (Boussabaine & Kirkham 2004; Abu Dhabi Ministry of Health and Population 2020; Rahman

et al. 2012; Cai et al. 2016; Cassettari et al. 2016; Spickova & Myskova 2015). However, this risk will be included in the final cost estimation system dynamics model.

O13- Percentage of Current Replacement Value

The usual percentage of current replacement values (CRV) to the present aggregate replacement value for all concerned facilities excluding its infrastructure is between 2% to 4% (National Research Council 2006; Terracon-Consultant 2019). However, this percentage determines the budget of optimum maintenance and repair costs during the operation stage (Boussabaine & Kirkham 2004; Becchio et al. 2016; Rodrigues & Freire 2017; Akter, Mahmud & Oo 2017). It is controlling additional investments (i.e., CAPEX) implemented if the percentage increased. The additional investment is essential to bring increased CRV within an acceptable percentage. Thus, this risk is required to be included in the final cost estimation model.

O14- Ratio of Maintenance to Capital Cost

The ratio of maintenance to capital cost is significant because it impacts investment return decisions (Boussabaine & Kirkham 2004). For instance, if the percentage of the facility's maintenance is more than 5%, then it means that there is a big issue in CAPEX investments, including quality of workmanship, reliability, and the specifications of that equipment (Wu, Olson & Birge 2011). Therefore, the risk of not having this ratio as required at the time of estimating the project's full life cycle cost at the pre-construction stage has to be included in the final cost estimation model.

O15- Ratio of Operation to Capital Cost

Finally, it is essential to include the Ratio of Operation to Capital Cost because the estimation will be at the pre-construction stage (Boussabaine & Kirkham 2004). However, the project can finance its costs (i.e., finance debts), and it can afford financing other projects if the ratio is equal to 1 or more; on the other hand, the operation is requiring extra funds to maintain during the project's whole life cycle if this ratio is less than one (Wu, Olson & Birge 2011). Thus, this risk is required to be included in the final cost estimation model.

- **OPEX Activities Risks Mapping**

After explaining in detail, each risk factor of OPEX Activities Risks, the relationship mapping in Figure 3-13 shows how risks are connected and with the OPEX Activates variable in the proposed project whole life cycle cost estimation model. Therefore, based on this concept, data collection shall consider these connections to understand what accurate risk weightage should be set clearly. Therefore, it will be reflected in the validation process of collecting data and the final cost model.

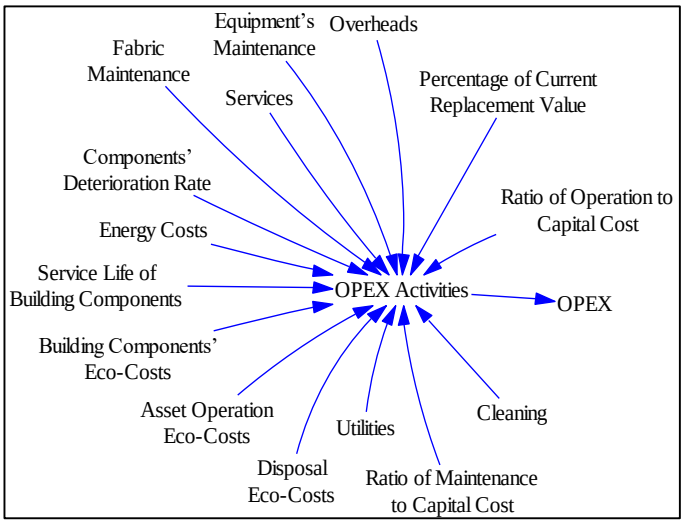


Figure 3-13: Operational Activities Risks Mapping showing their interaction with each other in the proposed project whole life cycle cost estimation model.

3.3 Design, Equipment Replacement, and Demolition Variables

This model's design variable represents the first value entering the CAPEX-OPEX system dynamics model; nevertheless, this value is equal to the construction contract total value and will go through all risks' adjustments until it reaches the final estimated cost value as shown in Figure 3-14.

The design value in the United Arab Emirates is equal to 2% of the construction contract total value in case of designing one residential villa/building, and equal to 2% of the construction contract unit value plus 1% of the construction contract unit value for each additional unit (i.e., villa/building). This value has been extracted from the standard consultant design contracts provided by home banking and financier institutes such as First Gulf Bank (2010) and First Abu Dhabi Bank (2017). In this research study, housing projects were used for model validation; however, in UAE, housing projects are given to contractors based on Design-Build contracts. Thus, in this research, the design cost is included in the construction contract's total value at the tender stage. Construction supervision consultant cost is included with the construction contract total value; however, its related risks are embedded in the CAPEX system dynamics model. This part's limitation is that the design stage has many risks and variables impacting the final design cost on design consultants; however, these design risks fall on consultants only and not from clients' perspectives. Therefore, the design is assumed to smooth and completed on time, while its possible faults' risks are considered during CAPEX and OPEX, as mentioned in the previous section of this study. Finally, the design variable is significant to be included in the final cost estimation model, and its value can be adjusted based on the project and contract types (Assad et al. 2007; Ramasesh & Browning 2014; Kamaruzzaman 2010; Doloi 2012; Chapman 1998).

Equipment replacement value is a mandatory step to have an accurate final estimated cost value. Researchers proved that this variable is important because it will cost additional CAPEX pulses every 25 years (Riley et al. 2005; Macek & Dobias 2014; Wu & Clements-Croome 2007). These pulses are equal to the cost of new equipment sets, considering inflation and new technologies at each replacement's time (Riley et al. 2005; Macek & Dobias 2014; Wu & Clements-Croome 2007). More calculation details will be provided in the following chapters. Therefore, Equipment replacement cost is high and will be included in the final cost estimation model.

Demolition is the last step of the residential project whole life cycle cost estimation modelling. From the literature, researchers proved that the demolition variable is essential for any project's whole life cycle assessment, analysis, or modelling (Han, Srebric & Enache-Pommer 2014; Yuan et al. 2011; Zahir 2015; Doan & Chinda 2016). In this research, residential project's whole life cycle timespan is equal to 60 years; however, most project's life cycle studies included the timespan to be between 14 to 60 years (Hurt & Schrock 2016; Geissmann 2017; Han, Srebric & Enache-Pommer 2014; Yuan et al. 2011). Therefore, this study will set the final cost estimation modelling timespan to 60 years from the design until demolition, including CAPEX and OPEX modelling. It will divide each year into 8 time-steps instead of 12. This is to keep the confidentiality of each monthly project payment used in this study. Previous research, focusing on project critical success factors' mathematical modelling, decided to set the construction period equal to 3 years (García et al. 2016). However, the used housing projects in verifying the final cost estimation model have a construction period of 36 months fixed by Abu Dhabi government executive council circular (Abu Dhabi-Government 2015). Therefore, this study model's construction period will be set as three years with eight timesteps each year as justified previously. Finally, previous research proved that demolition

NPV is too low and can be neglected if the project's whole life cycle equal to or more than 60 years, as shown in Figure 3-14 (Han, Srebric & Enache-Pommer 2014). Therefore, demolition in this research study will not have calculations in VENSIM model analysis, but its cost impact debates will be discussed separately. However, it is not likely to see any total value difference between adding and removing it from the model. In the United Arab Emirates, municipalities set the minimum requirements of the reinforced concrete structure to have 50 years lifespan for normal buildings and 100 years for mega-projects (i.e., more than 1 Billion) such as Burj Khalifa in Dubai (Dubai-Municipality 2020). The Dubai municipality is also researching with UAE University about raising the lifespan of normal building from 50 years to between 75 and100 years (Dubai-Municipality 2020). In this research study, demolition calculation modelling is not expected to impact negatively (i.e., error) on the final cost estimation accuracy. This statement is based on the facts extracted from the literature regarding demolition's low NPV with building's long lifespan and researchers trying to profit from demolition activities instead of affording costs (Han, Srebric & Enache-Pommer 2014; Abanda, Kamsu-Foguem & Tah 2017; Doan & Chinda 2016). Besides, most housing projects are considered mega-projects due to its high cost and the UAE government's new directions to increase the building's lifespan (Dubai-Municipality 2020).

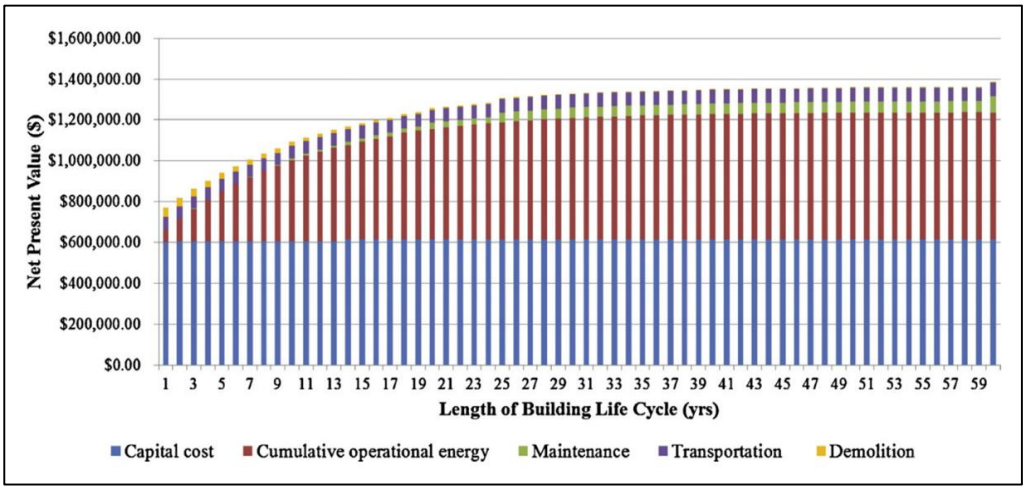


Figure 3-14: project's whole life cycle NPV over 60 years showing that demolition costs will not impact the cost model based on long lifespan (Han, Srebric & Enache-Pommer 2014).

3.4 CAPEX-OPEX Risks Mapping

Finally, CAPEX-OPEX Risks Mapping can be sketched and connected, as shown in Figure 3-15 based on the previously explained relationships in this chapter. However, this sketch is conceptual will be used in building the System dynamics model. Therefore, the mathematical model (i.e., Equations) and the validated data (i.e., adjusted SPSS results by Monte-Carlo simulation) will be inputs of the final system dynamics cost estimation model (i.e., VENSIM Model). This model will cover each variable and simulate all variables' interactions to produce final accurate outputs. It is including detailed cash flows over the project's whole life cycle, detailed CAPEX and OPEX Cost estimation for each time step, and the final total cost of the project in cash spent and net present value (NPV).

3.5 Summary

To sum up, this chapter included the process of identifying and mapping each variable existing in the final system's dynamics cost estimation model. These variables included CAPEX and OPEX required risks for adjusting the project construction contract value resulted from the design stage. Chapter 3 presented how other variables have been included in the final system dynamics model, such as NPV, design, Equipment-Replacement, and demolition. The completed model skeleton is based on time and needs a specific timespan before running any analysis. This chapter defined the period of CAPEX (3 years), OPEX (57 years), and TOTEX (60 years). Therefore, the full model mapping graph is viewed in Figure 3-15, and it will be used based on the defined timespans. The methodology, analysis, discussion, and conclusion will be presented in the following chapters of this research study.

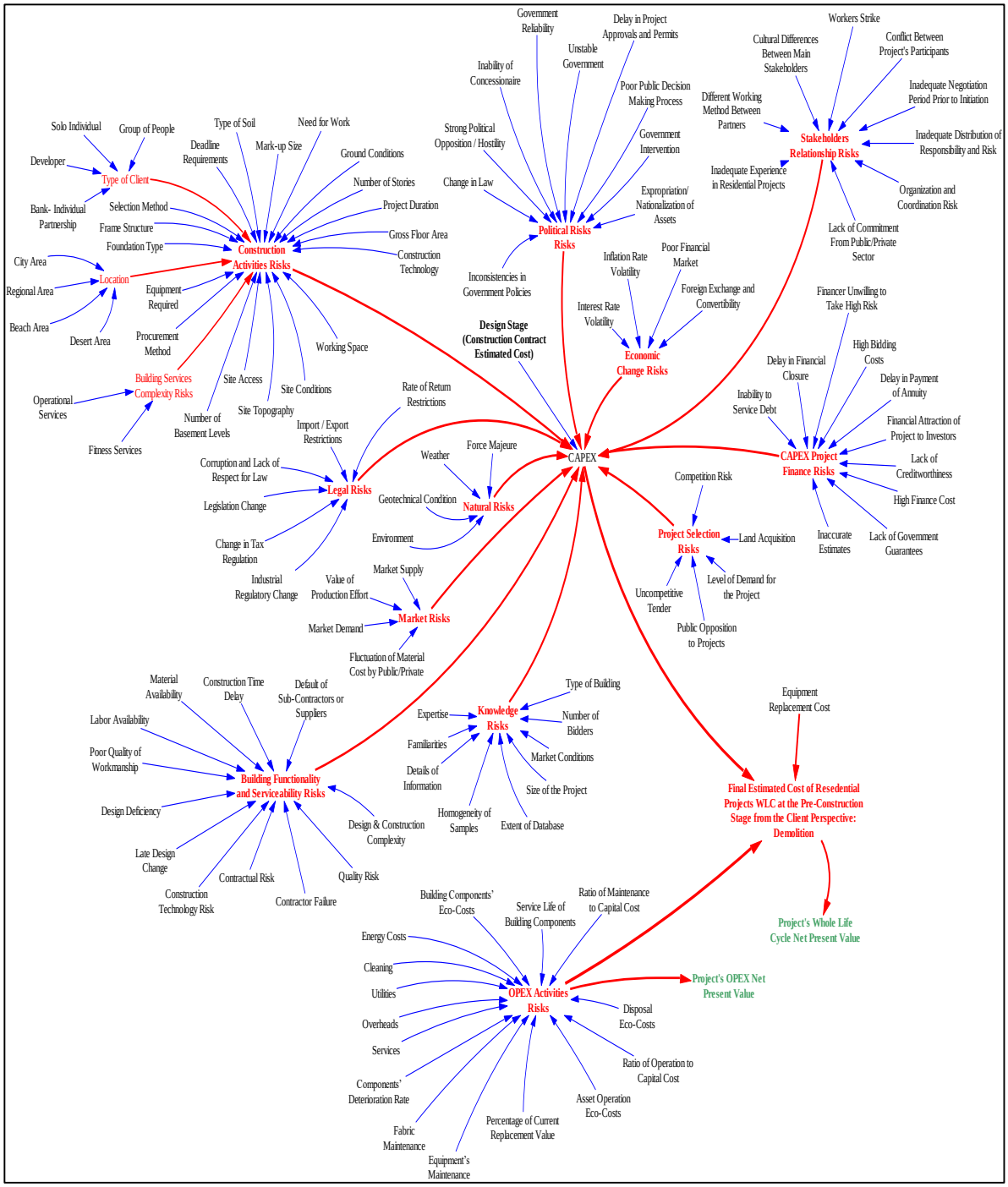


Figure 3-15: Final cost estimation model mapping including both CAPEX and OPEX Risks from design to demolition, showing their interaction with each other in the proposed project whole life cycle cost estimation model.

Chapter 4
RESEARCH METHODOLOGY

"*Research is formalized curiosity. It is poking and prying with a purpose*".

(Boncz et al. 2017, p.8)

4.0 Introduction

In the research methodology chapter, the research method will consider all aspects, factors, and procedures for conducting this research from start to end. This is done by verifying and explaining why the selected approach (i.e., quantitative) is the most optimum to satisfy this research requirement. Therefore, each approach will be presented in this chapter. It will include using each approach in research and selecting/discarding each of them concerning this research study. Justification and references will clarify doubts and provide a solid understanding of these research process and outcomes. However, the selected approach (i.e., quantitative) will be detailed to include each research stage application's methodology. Data collection and validation methodology will be detailed. Then, cost estimating system dynamics modelling, and simulation methodology will be detailed. Finally, the system dynamics model validation and discussion methodology will be detailed. The summary of this chapter will explain how this research study answers its research questions. The research questions are:

1- What are the risks' values of UAE residential project's whole life cycle cost estimation?

2- How to model mathematically and graphically map all identified and verified risks?

3- How to approach modelling cost estimation dynamics through time, including cash flow, for UAE residential building projects' whole life cycle?

4.1 Quantitative Research Approach

Research quantitative approach aims to extract the values in a statistical numerical shape, rather than informational and descriptive data (Golafshani 2003; Meredith 1998; Hancock 1998; Whetten 1989; Eisenhardt 1991). It is valuable for researchers interested in testing hypothetical generalization (Golafshani 2003; Jick 1979). Logical positivism

researchers use quantitative approaches to optimize their outcomes (Golafshani 2003). A quantitative research approach is desirable if the conducted research requires variable causal relationship analysis (Golafshani 2003). It is used to develop mathematical models and/or develop measurement analysis models (Meredith 1998; Hancock 1998; Whetten 1989; Eisenhardt 1991). However, it can be used for any proposes related to experiments testing, pure mathematical/statistical testing/sampling, obtaining the yield point, and other hypothetical objectives dealing with variables (Meredith 1998; Hancock 1998; Whetten 1989; Eisenhardt 1991; Mindrila & Balentyne 2014; Ruppert et al. 2016).

Quantitative research results reliability is based on three main types. First, the statistical significance test of quantitative results is deciding the repeatability or replicability of these results during a particular period; second, measurement stability is an important type for testing quantitative results reliability (Golafshani 2003). This means that stable measurements over time are more reliable than unstable measurements (Golafshani 2003; Rungtusanatham et al. 2003; Sauro & Lewis 2012; Mohd et al. 2015). Stability (i.e., strength) can be defined as the correlation between 2 separate readings of the same subject (Vanderwal et al. 2021; Francis 1991). Third, the similarity type of reliability can be defined as the average correlation of readings within a given condition (Vanderwal et al., 2021; Francis, 1991). Correlation is defined as the measurement of a specific pattern of association (Wild 2014). However, the association occurs when a scatterplot takes a pattern between two numerical variables (Wild 2014). Figure 4-1 shows that association examples are represented to clarify strong, weak, positive, and negative patterns (Wild 2014). Also, in Figures 4-1 and 4-2, correlation measures examples provide a better understanding of this research data reliability approach (Wild 2014). Correlation values range between +1 and -1 (Ratner 2009; Wild 2014; DeSoto & Roediger 2014).

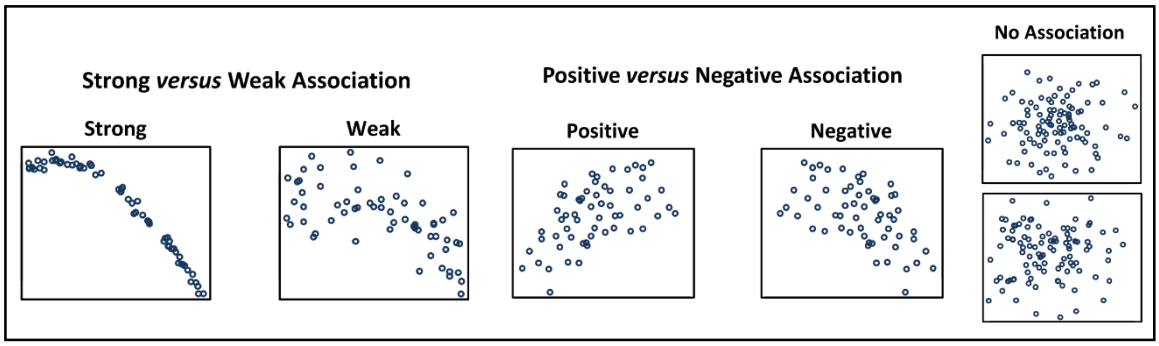


Figure 4-1: Association clarifying examples (Wild 2014).

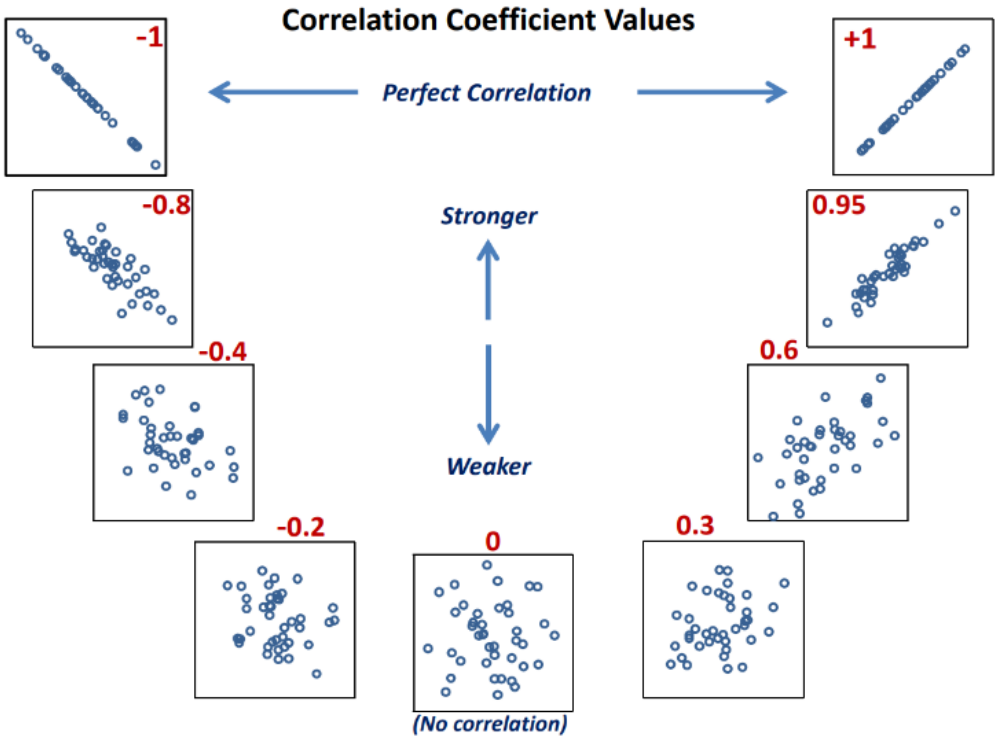


Figure 4-2: Correlation clarifying examples (Wild 2014).

The validity of quantitative research is based on the final useability and accuracy (Golafshani 2003; Almquist, Ashir & Brännström 2014). According to positivists, validity can be quantified based on testing the mathematical and measurement models to check if the research outputs can measure what it is intended to measure (Golafshani 2003). Moreover, to check if the research results accuracy is truthful and able to provide close results to actual true values (Golafshani 2003).

Therefore, this research methodology is designed to be based solely on a quantitative approach. There are several reasons for this choice, which will be presented and detailed for better understanding. First, this study aims to model the project's whole life cycle costs from the design to demolish, including its cash flow and its estimated values at each time step. This requires having exact numbers and values. Second, this research objective is to develop the first system dynamics cost estimation model using VENSIM software. This model is based on simulating linear and nonlinear mathematical modelling concerning the researcher's time steps. The simulation will provide accurate numerical results of the project's cost at each defined time step across its whole life cycle. Third, the research questions require pure numerical answers to deliver the objective's outputs.

4.2 Qualitative Research Approach

The qualitative research approach is based on non-numerical information systems that usually develop a theory with practices or systematically describe observations for better understanding (Golafshani 2003; Eisenhardt 2002; Qu & Dumay 2011; Cassell & Symon 2004; Nastasi & Schensul 2005; Binder & Edwards 2010; Santos et al. 2017; Kvale 2005; Avison et al. 1999; Eisenhardt 1989). It is used to study behaviour observation, descriptive information, case studies, phenomenon, and non-numerical real-world settings (Golafshani 2003; Eisenhardt 2002; Qu & Dumay 2011; Cassell & Symon 2004; Nastasi & Schensul 2005; Binder & Edwards 2010; Santos et al. 2017; Kvale 2005; Stuart 2002; Avison et al. 1999; Eisenhardt 1989). The qualitative approach aims to provide the naturalist interpretive paradigm (Golafshani 2003; Walsham 1995; Nastasi & Schensul 2005; Ostlund et al. 2011; Osigweh 1989; Bacharach 1989). The qualitative most effective techniques used in gathering data and collecting valid information from the audience are questionnaires and interviews (DiCicco-

Bloom & Crabtree 2006; Dillman, Sinclair & Clark 1993; Ireland, Clough & Day 2017; Hammersley 2003). Thus, those collecting data tools are necessary for getting information about a specific topic or subject (Banihashemi et al. 2017; Kvale 1983). It can be classified or grouped based on homogeneity or heterogeneity of data nature, objectives aims, or other classification criteria such as change/success factors (Banihashemi et al. 2017; Kvale 1983). In this research, the qualitative approach of data collection shall be adopted. This is due to the requirement of having mathematical-statistical modelling based on information classifications and understanding to build the final system dynamics cost estimation model successfully. However, many researchers found that qualitative research's reliability and validity are essential (Golafshani 2003). There is no difference between reliability and validity testing in qualitative research (Golafshani 2003). It is not like quantitative research in this regards. The reliability and validity testing in qualitative research is based on the researcher's effort and ability to defend the qualitative outputs (Golafshani 2003). It has been agreed that qualitative research outputs are reliable and valid if it is defendable against opposite debates (Golafshani 2003). In qualitative research, there is no validity without reliability (Golafshani 2003). The researcher's successful defence to validate a qualitative research output is giving trustworthiness, and creditable results toward the specific subject area defended (Golafshani 2003). If more generalization is required, the researcher should provide more defending ability and effort against all required validation subject areas (Golafshani 2003). Nevertheless, previous research declared and proved that the research would be no more qualitative if any measurement is used for testing qualitative research reliability or validity (Golafshani 2003). Therefore, this research study is purely quantitative and cannot be a mixed research method, even after using questionnaires and interviews to collect the required data. This is due to the measurable numerical approach of testing data reliability and validity in this research study.

4.3 Research Method

Modelling is the research methodology in this study. It is designed and detailed based on a quantitative research approach as justified previously. Several required design stages in this research methodology will deliver reliable and valid modelling outputs (Scandura & Williams 2000). The research strategy, data collection, analysis, and validation methods will be detailed to clarify this research procedure and expected outputs.

There are two strategies to answer these research question numerically. First, collecting and analysing numerical data quantitatively. Second, converting all qualitative (i.e., informative and descriptive) data to numerical values representing its meaning and weightage to use quantitative analysis approaches. Therefore, the following details will explain how these research questions have been answered quantitively:

1- The answer for the first research question, (What are the risks' values of UAE residential project's whole life cycle cost estimation?), is accomplished following the second strategy. The first part in answering this research first question is based on identifying risks and gather informative and descriptive data from published literature and government reports as presented in chapter 3. It is essential to start with this step to shaping a clear understanding of each identified risk before any graphical relationship mapping. Risks descriptive information is used in this research as a manual of risks' understanding when collecting their values from professional experts. Hence, it is ensured that all experts provided their suggested values for each risk have the same understanding. Finally, accurately collected risk values are validated statistically using the SPSS software programme.

2- The answer for the second research question, (How to model mathematically and graphically map all identified and verified risks?) is accomplished following the first

strategy. The numerical data collection stage will be ready after answering the first question. The values for each identified risk are expected to be within a specific range because experts providing these data will have a common understanding of each identified risk. Therefore, extreme values (i.e., outliers) can be identified and eliminated accordingly to avoid a negative impact on data accuracy. However, a graphical mapping relationship is representing the mathematical relationships between risks/factors within the model. It will be found that variables and arrows represent the inputs and outputs of system dynamics mathematical interactions. Using mathematical equations modelling for each risk group and utilize the verified risks as inputs of each equation will deliver an output value from each mapped group. Calculated output values can be used as inputs of another equation concerning arrows connections sequentially until it reaches the final model's aim and provides a detailed cash flow and final cost estimation of the project's whole life cycle.

3- The answer for the third research question, (How to approach modelling cost estimation dynamics through time, including cash flow, for UAE residential building projects' whole life cycle?), is accomplished following the first strategy. The mathematical relationships change over time between the model's variables. Over time, active and inactive relationships will trigger the equation change demand at certain timesteps through the project's model lifespan. Therefore, this research study selected system dynamics VENSIM Software programme. VENSIM software's ability to present modelling inputs and outputs graphically and control time-based equations implementation made it the most optimum modelling tool for this research study. For example, CAPEX risk impact is active only during the construction stage. Also, OPEX risk impact is active starting from the construction stage until demolition. Each CAPEX

accumulative risk's impact is based on a declining S-curve over time from 100% impact at the start of construction until 0% impact at the second of construction completion. CAPEX cost will follow an increasing S-curve pattern during the construction stage from 0% impact at the beginning of construction until 100% after construction. On the other hand, each OPEX accumulating risk's impact follows an increasing linear relationship over time starting from 0% at the end of construction until the last day of the project's whole life cycle (i.e., demolition). OPEX increasing accumulating costs follow a linear relationship from the end of construction until the project's demolition. During the project's operational stage, there will be pulse cost impacts of equipment replacement at specific time steps. Therefore, the project's whole life cycle costs and risks calculation need a mathematical mechanism to activate and deactivate their impact concerning time to end with accurate cost estimation results. The third research question will be satisfactorily answered by utilising time-based mathematical modelling using VENSIM software. This will consider all cost risk inputs over time to provide accurate values and graphical chart outputs for modelled project's whole lifecycle. However, the following parts will detail the methods used in this research, including data collection, data analysis, and model validation.

4.3.1 Writing a Literature Review

A literature review is an essential practice of providing a coherent and comprehensive introduction in qualitative and quantitative research (Steward 2004). Literature review for research contribution and publication is the review made to criticise what has been completed and achieved by other researchers (Steward 2004). It is including the review of information, analysis, and conclusions of previous research (Steward 2004). Literature reviews have three

types if used for journals publications and knowledge contribution empirical research (Steward 2004). First, the systematic literature review type aims to create a new database for analysis and provide proof before drawing any conclusion (Steward 2004). Quantitative research uses it to collect evidence and summarize them using statistical approaches before analysis (Steward 2004). Researchers argued many literature reviews approaches (Kucan 2011; Steward 2004). However, they agreed that it creates research justification, describes research methodology, and explains research contribution (Kucan 2011; Steward 2004). This research study conducted a systematic literature review to collect evidence related to support and prove the research topic's validity, collected variables, and modelling approach. In chapter 2 of this thesis, a systematic literature review is done to criticise all collected evidence from previous research to validate the missing gaps and support the chosen research topic. The systematic literature review is also done to create a database of cost modelling approaches and cost modelling variables used in previously published research. The second type is Literature reviews as secondary data analysis research projects. This type is used to review secondary data other than the published literature (Steward 2004). For example, the second type is including reviewing thesis, dissertations, internal reports, conference papers, and formal unpublished documents (Steward 2004). It may include formal trusted documents/reports such as government and authorized licensed organizations reports (Steward 2004). This type of review is called an extended literature review (Steward 2004). This research study used this type of review to draw valid guidelines for collecting cost estimation modelling variables. For example, the trusted government published reports and trusted licensed research organizations documents are used to extract the minimum risks required to estimate project costs. The third type is Literature reviews as part of primary research projects (Steward 2004). It is used to map the study's broad context and explain the reasons for selecting the research questions (Steward 2004). From

previous research, it is mandatory to use this type of literature as a study introduction and as a base before results and dissections (Steward 2004).

Empirical research (i.e., PhD research) overall literature review should be selective instead of exhaustive (Kucan 2011). Furthermore, it should be conceptual, not pure systematic (Kucan 2011). A conceptual literature review is an approach used to collect implications to design, analyse, and interpret successful conclusions (Kucan 2011). The systematic literature review should evolve conceptual literature reviews to conduct a successful study interpretation and generate new contributions (Kucan 2011). Therefore, this research conceptually reviewed the literature to end with an accurate adding value conclusion.

A good literature review aims to provide the reader with a clear overview of evidence, debates, and themes used to justify the research questions and support interpretation (Steward 2004). According to previous research, this research followed five steps to write a successful literature review (Rewhorn 2017). First, a researcher should survey literature by checking the introduction and conclusion to ensure its relevance to the chosen research topic (Rewhorn 2017). Second, researchers should ask themselves questions about their initially collected literature (Rewhorn 2017). Those questions are intended to clarify what knowledge has been collected and must be collected to proceed with the review (Rewhorn 2017). Third, researchers should read the selected literature to identify their arguments and introduce the next readings (Rewhorn 2017). Fourth, it is essential to recall articles more than once to ensure accurate understanding and evaluate the differences, similarities, and relevance of collected articles and the research topic (Rewhorn 2017). Finally, researchers should review selected literature in their own words to highlight how these articles support the research topic and questions (Rewhorn 2017).

However, eight attributes should be in good literature reviews, as shown in table 4-1 (Steward 2004; Kucan 2011; Rewhorn 2018). Table 4-1 is summarizing how this research study adapted these attributes.

SN	Good literature review attributes	Adaptation and implementation approach in this research study
1	"Comprehensive, collating evidence from all relevant disciplines".	In chapter 2, relevant literature is covered to collect evidence supporting ideas and justify the research questions; relevant literature support gaps and knowledge contribution.
2	"Fully referenced, offering reliable access routes to the evidence".	All used references are provided at the end of this research and included through the thesis as in-text citations. The referencing in this research is following Harvard Style.
3	"Selective, using appropriate inclusion and exclusion criteria to identify key evidence".	The selection of the literature review in this research study is based on four main areas to answer all research questions: 1- Project Cost and Information Modelling. 2- Project Cost, Economics & Profitability Modelling. 3- Project Cost and Risk Interaction Modelling. 4- Project Cost Estimation and Modelling. 5- Research Methodologies. 6- Quantitative Research.
4	"Relevant, focusing on data pertinent to the research question".	This study conducts a relevant and focussing literature review, including all its types, based on the chosen area field of research. Therefore, literature should be related to the following focuses on satisfying this research topic requirement: 1- Cost Estimation. 2- Buildings and Construction Modelling. 3- Projects Whole life cycle Modelling. 4- Construction Risks and Costs. 5- Operational Expenditure Cost and Risks. 6- Mathematical Modelling. 7- System Dynamics. 8- VENSIM and SPSS Software Programmes. 9- Research Methodology. 10- Quantitative Analysis. Chosen literature will support this research interpretation, data collection, analysis, and discussion to successfully answer all research questions.
5	"A synthesis of ideas and key themes".	The ideas handled in this research are based on providing a solid supporting background of the research area. Provide the latest research outputs and contributions to the body of knowledge. Identify all critical contribution and optimum solutions which can be used in this research study. Finally, generate more specific ideas and key themes to add significance and value to this research output and contributions.
6	"Balanced, offering a comparative account of differing theories and practices".	This research conducted a literature comparison of all relevant contributions. However, the selection of a method or an approach is made after providing supported justification. Drawing conclusions are based on accurate literature review evaluation.

7	"Critical, evaluating the rigour of evidence or argument in the data".	All selected cost risks are chosen based on a critical evaluation of literature, as shown in chapter 3. This is before collecting numerical data from experts and before conducting any analysis. Arguments of mapping those risks have been critically evaluated prior final decision.
8	"Analytical, developing new understandings from the available evidence".	After analysing selective literature and understand all evidence accurately, this research concluded the research topic. It is based on interpreting evidence with future research demand. So, approaching system dynamics utilizing statistical, mathematical, and graphical modelling will develop a new topic worth further investigation to contribute to the project management body of knowledge.

Table 4-1: Collected good literature review attributes from published articles and how it is adapted in this research study (Steward 2004, p.496; Kucan 2011; Rewhorn 2018).

Nevertheless, writing an educational research literature review, such as doctoral students' research, require great efforts and many requirements (Kucan 2011). This is because of the need for original contribution to bodies of knowledge (Kucan 2011). Unlike professional writing, it requires significant evaluation during writing an educational research dissertation (Kucan 2011). Therefore, researchers agreed on several steps to ensure good, supportive, and significant literature review in educational research papers (Pautasso 2013; Maier 2013). This study follows these steps to ensure accurate research processes and outputs. However, the first step is to define the topic area and targeted audience (Pautasso 2013). Second, keep searching for relevant literature from deferent valid sources (Pautasso 2013). This is important to cover several angles, justify previous contributions and verify available gaps (Pautasso 2013). Third, reading and take notes to open the chances of interpreting and comparing articles with the targeted research topic (Pautasso 2013). Fourth, choosing the type of review and create a reviewing strategy (Pautasso 2013). There are several types of reviews discussed earlier. Researchers propose a conceptual diagram in Figure 4-3 to balance between reviewing types. The top-right quarter of Figure 4-3 is required to consider the literature review good and successful (Pautasso 2013).

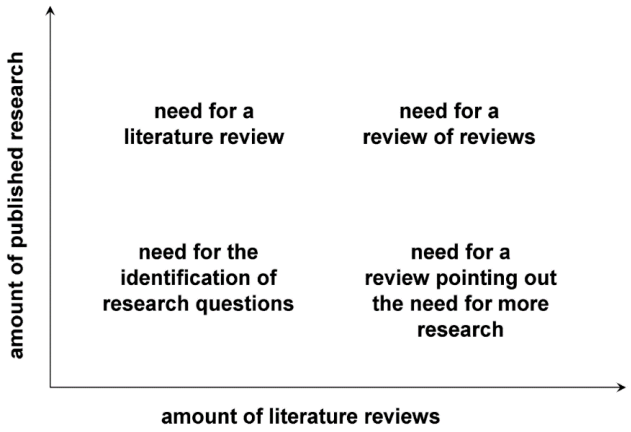


Figure 4-3: Literature review conceptual diagram for choosing reviewing type (Pautasso 2013).

Fifth, ensure keeping all selected literature focused and related to the comprehensive interest (Pautasso 2013). The sixth and the seventh steps are significantly essential to ensure that conducted reviews must be critical and follow a consistent logical structure (Pautasso 2013). Steps 5 to 7 will help in identifying knowledge gaps in the problem domain following "Swiss Cheese" and "Inverted Pyramid" literature review conceptual models as shown in Figure 4-4 (Maier 2013, p.4; Pautasso 2013).

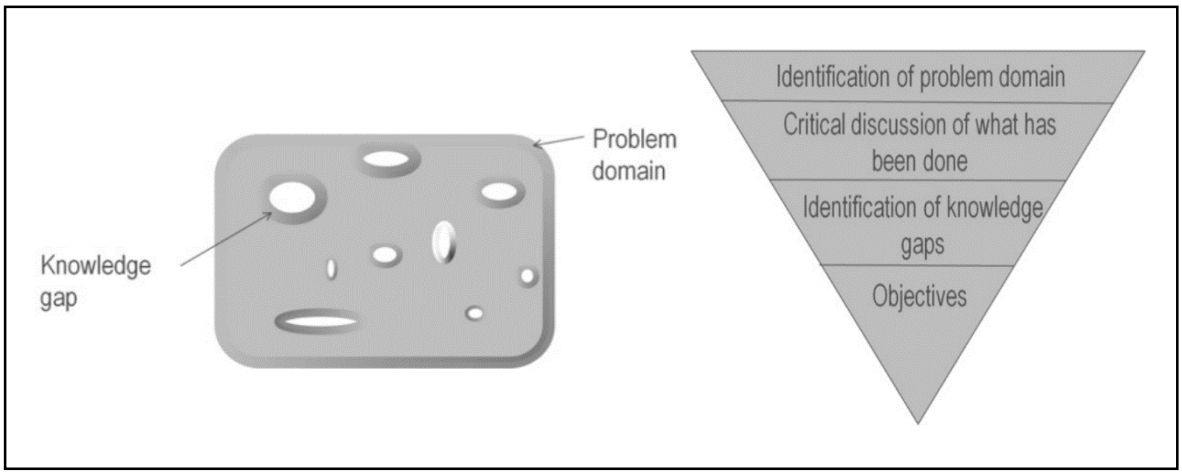


Figure 4-4: Literature review "Swiss Cheese" and "Inverted Pyramid" conceptual models (Maier 2013, p.4).

The eighth and ninth steps in conducting doctoral educational research are using feedback and researching the researcher objectively (Pautasso 2013). Finally, the tenth step is to ensure that the dissertation research literature review is up to date without forgetting old literature (Pautasso 2013). It is required to describe how research evolved through time up to date and how the researcher's outputs will contribute to drawing more developed conclusions in the body of knowledge (Pautasso 2013). Steps 8 to 10 are significantly essential to drive doctoral educational research to have its original contribution to the body of knowledge, as shown in Figure 4-5 (Steward 2004; Pautasso 2013; Maier 2013; Kucan 2001; Webster & Watson 2002; Rewhorn 2018; Asmussen & Moller 2019). This Figure is clarifying of this research study implemented a literature review to answer its research questions successfully.

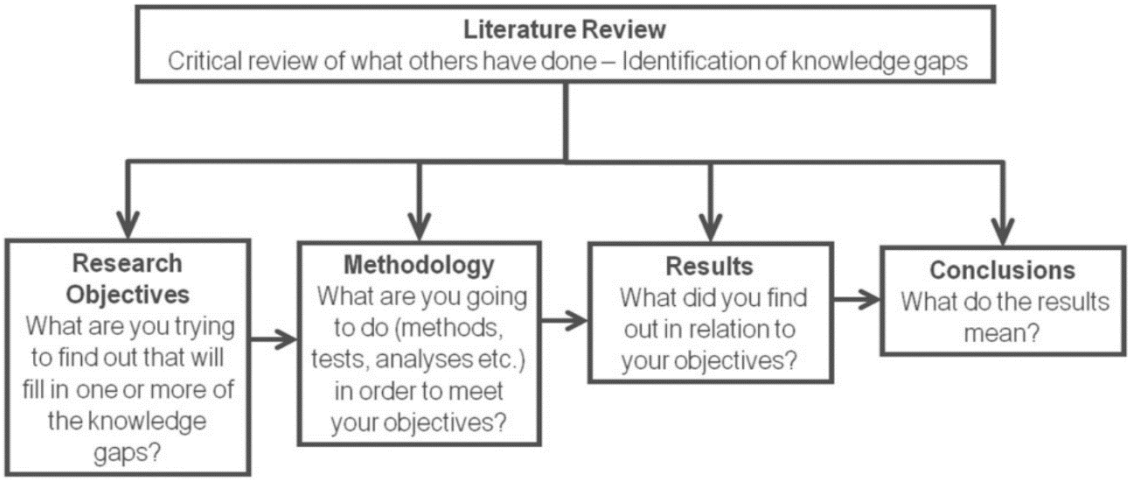


Figure 4-5: Literature review structure in educational doctoral research from topic identification to conclusion (Maier 2013; Steward 2004; Pautasso 2013; Kucan 2001; Webster & Watson 2002; Rewhorn 2018; Asmussen & Moller 2019).

4.3.2 Mapping Cost's Risks

Mapping in quantitative Modelling research methodology is an essential requirement for all cause-effect dynamical research studies (Tokede et al. 2014; Sydor et al. 2014; Williams 2003; Agyapong-Kodua et al. 2012; Chapman 1998; Yuan et al. 2011; Naderpajouh & Hastak

2014; Hoffma et al. 2017; Agyapong-Kodua & 2011; Boateng 2014; Alzahrani 2015; Ahiaga-Daghui 2014; Jang 2011). It is required to decide the reasons behind mapping variables (Boateng 2014; Alzahrani 2015; Ahiaga-Daghui 2014; Jang 2011). Mapping should be based on justified reasons supporting the validity of modelling processes (Boateng 2014; Alzahrani 2015; Ahiaga-Daghui 2014; Jang 2011). In this research study, mapping is done based on proved cause and effect relationships in literature and empirical studies, as shown in chapter 3. Mapping in dynamical systems represents mathematical relationships numerically or graphically (Boateng 2014; Alzahrani 2015; Ahiaga-Daghui 2014; Jang 2011). In this research study, mapping is controlled by the intended mathematical modelling equations to satisfy its inputs and outputs criteria.

Previous research proved that systems dynamics is the most accurate and useful approach to model variables and change across time (Tokede et al. 2014; Sydor et al. 2014; Williams 2003; Agyapong-Kodua et al. 2012; Chapman 1998; Yuan et al. 2011; Naderpajouh & Hastak 2014; Hoffma et al. 2017; Agyapong-Kodua & 2011; Boateng 2014; Alzahrani 2015; Jang 2011). Therefore, system dynamics is the most optimum approach in this research study. The aim is to model the project's full lifecycle costs based on costs' risks. Researchers agreed that there are two types of system dynamics diagrams; besides, they agreed on VENSIM Software to be the most accurate program for modelling and studying variables over time (Tokede et al. 2014; Sydor et al. 2014; Williams 2003; Agyapong-Kodua et al. 2012; Chapman 1998; Yuan et al. 2011; Naderpajouh & Hastak 2014; Hoffma et al. 2017; Agyapong-Kodua & 2011; Boateng 2014; Alzahrani 2015; Jang 2011). There are two main analysis diagrams in VENSIM system dynamics software reflecting variables relationships and interactions overtime (Tokede et al. 2014; Sydor et al. 2014; Williams 2003; Agyapong-Kodua et al. 2012; Chapman 1998; Yuan et al. 2011; Naderpajouh & Hastak 2014; Hoffma et al. 2017; Agyapong-

Kodua & 2011; Boateng 2014; Alzahrani 2015; Jang 2011). First, the stock-flow diagram represents the forward stock variables relationships without having variables closed-loop impacting/changing the rates of stock's inflow and outflow (Kang et al. 2020). In Figure 4-6, the VENSIM system dynamics stock-flow diagram is explained, showing its components (Kang et al. 2020).

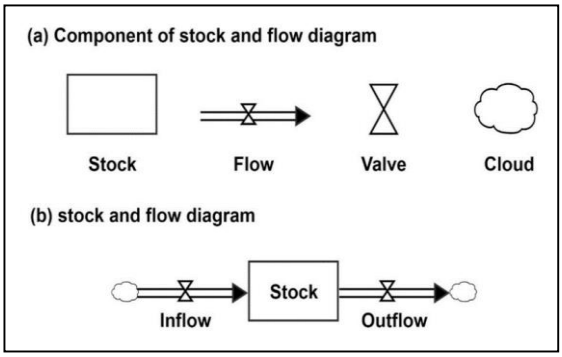


Figure 4-6: VENSIM system dynamics stock-flow diagram (Kang et al. 2020).

Second, the causal loops diagram represents a close loop between variables impacting each other's continuously (Boateng 2014). It means that variable 1 is an input for variable 2 and variable 2 is input for variable 1 simultaneously (Boateng 2014). In Figure 4-7, VENSIM causal loops diagram is explained, showing its components (Boateng 2014).

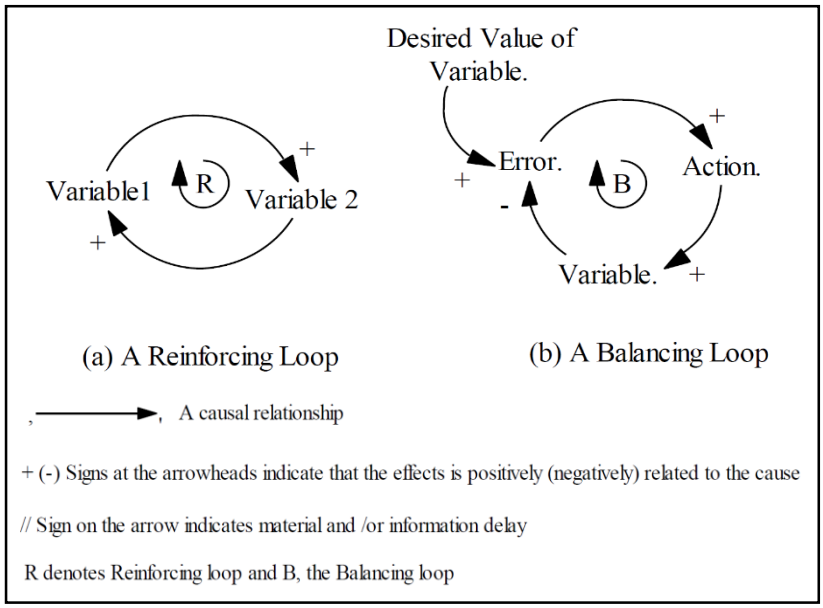


Figure 4-7: VENSIM system dynamics causal loop diagram (Boateng 2014).

In this research study, risk data values (i.e., risks, impacts, and probability) will be collected quantitatively to represent its weightage over the project's whole life cycle. Mathematical relationship equations will control the distribution over time. The aimed model is not targeting automated updates of risk variables and rates through time-steps simulation. Adjustments should be made manually in case if any change is required for a variable or rate. Therefore, using the stock and flow diagram to map the final project's whole lifecycle system dynamics cost model. All mathematical inputs and expected outputs are representing by the conducted mapping in chapter 3. This research used many literature, reports, and empirical studies to justify and validate variables mapping before any simulation analysis.

4.3.3 Data Collection Strategy

This research data collection strategy is based on the identified and mapped risks done in chapter 3. Required data is including the value risks, impact, and probability. This chapter explains that it is crucial to approach data collection using accurate approaches before conducting any measurement or analysis. Researchers agree that data collection strategy is a significant research output reliability and validity (DiCicco-Bloom & Crabtree 2006; Soltanian, Borzouei & Afkhami-Ardekan 2016; Eisenhardt 2002; Onwuegbuzie 2007; Crouch & McKenzie 2006; Leonard-Barton 1990; Scudder & Hill 1998). It is essential to justify this research choice because four ways can provide the required data. First, collecting data from case studies provides a large amount of data about its topic (McCutcheon & Meredith 1993; Ende & Marrewijk 2014; Stuart et al. 2002). However, it is related to the case type and condition, so it cannot be used in any case scenario (McCutcheon & Meredith 1993; Ende & Marrewijk 2014; Stuart et al. 2002). Therefore, this research does not use case studies to collect data because the final aimed model will represent all residential buildings' whole lifecycle in

UAE. This research data collection will need a sample-size equal to at least 29 (i.e., $N \geq 29$) to consider normality assumptions in quantitative data validity and reliability (Bujang & Baharum 2016; Delice 2010; Shen, Nguyen & Ojiako 2013; Aliverdi, Naeni & Salehipour 2013). Case studies will require to cover at least 29 samples for each risk (i.e., a total of 117) to consider data normality. The second data collection approach extracts data from historical projects (Doloi 2011; Reichelt & Lyneis 1999). It is having a magnificent amount of information. During this research study, it has been found that it is impossible to collect data using case studies or historical data for several reasons. Reason 1, it is impossible to collect 29 cases covering 29 sample-size for each of the 117 cost's risks. Reason 2, all collected cases should be within a narrow timeframe, or the validity of data will be lost. Risks are changing over time, as proved by researchers earlier in this research paper. Therefore, case studies accumulated data cannot have a sample size equal to at least 29 for each risk covering different big windows of time (i.e., years) because the validity of collected data will be questioned, and the model accuracy will not be considered. Reason 3, covering large amounts of cases within a defined small window of time to include the minimum sample size for each identified risk, is impossible for the project's whole life cycle in UAE because of projects' accessibility challenges. The third way of collecting data is by using interview techniques (Blair & Conrad 2011). The good advantage in interviews is extracting the required data as demanded by the researcher (Filippini & Voss 1997; Sondik et al. 2004). It can be done by researchers or by approved professional interviewers on behalf of researchers (Filippini & Voss 1997; Sondik et al. 2004). However, the interview design must be made, audited, and reviewed by the researcher (Filippini & Voss 1997; Sondik et al. 2004). The fourth approach of collecting data is by conducting questioners and surveys; however, researchers intensively use surveys to collect their research data because of its significant positive impact on statistical analysis accuracy and because of its ability to

extract the required information from the targeted population (Wytykowska et al. 2017; Linderman & Chandrasekaran 2010; Aiyetan, Smallwood & Shakantu 2012; Jafary, Mele & Fiondella 2020; Harms, Jackel & Montag 2017; Carter, Sanders & Dong 2008; Makienko & Bernard 2012; Metzler & Davis 1998).

After that, previous research proved that it is possible to combine more than one collecting data approach (Tsang 2014; Leonard-Barton 1990). It is crucial to justify the reason for merging more than one method (Tsang 2014; Leonard-Barton 1990). Therefore, this research will combine questioner surveys with interviews to extract the most accurate data from experts in the field. In order to justify this choice, it is required to conduct a survey questioner in this research to collect and record required data, including all details (Mason 2010). However, the required data values in the designed survey can vary based on experts' understanding. It is also mandatory to ensure that contributors are experienced in the topic field (Tam et al. 2017). Therefore, it was required to ensure that all experts understand each variable and use their experience and knowledge to set a value for each risk. Researchers agreed that combining survey questioner with an interview forming face-to-face surveys is significantly effective and supporting data reliability (Cottrell et al. 2015; Galesic & Bosnjak 2009; Burns et al. 2018; Szolnokin & Hoffmann 2013; Leeuw, Mellenbergh & Hox 1996; Chen et al. 2015; Fernández et al. 2012). The following part will explain how the data collection approach has been designed to end with accurate and valid data.

4.3.4 Design Data Collection

To collect the required data, it is mandatory to ensure appropriate design of how to complete this process successfully (Krzywinski & Altman 2013; Fanning 2005; Wang 2010; Testa & Simonson 2009; Huang et al. 2015). This will ensure proceeding with appropriate

analysis and reach a valid logical conclusion. This research paper will include in this part seven main stages to successfully design data collection. This will include (1) interview type, (2) interview questioner design, (3) sample size, (4) pilot study, (5) interview invitation and response, and (6) Data Statistical Significance, Reliability, and Validity.

4.3.4.1 Interview Type

There are two approaches to each interview type for collecting research data. The five types of interviews include face-to-face interviews, telephone interviews, e-mail interviews, video-stimulated-recall interviews, and online-chat interview (Barratt 2012; Fernández et al. 2012; Harmeyer 2010; Lee et al. 2011). First, face-to-face interviews are proved by researchers to be the most effective, accurate, and having higher responding applicants; and it is considered as the first choice by most researchers using interviews for data collection (Forza 2002; Filippini 1997; Dillman et al. 2009; Trier-Bieniek 2012; Barratt 2012; Fernández et al. 2012; Harmeyer 2010; Chen et al. 2015). This method's data can be recorded by video, voice, or survey approaches as desired (Forza 2002; Filippini 1997; Dillman et al. 2009; Trier-Bieniek 2012; Barratt 2012; Fernández et al. 2012; Harmeyer 2010; Chen et al. 2015). In recently published research, it is also found that video interviews are considered a technology to conduct face-to-face interviews (Rowe 2009; Henry & Fetters 2012; Cottereau 2014; Nguyen et al. 2013). It is a recommended tool and common during force-majeure events preventing face-to-face meetings such as the COVID-19 pandemic. Therefore, this research's data collection has been conducted using face-to-face interviews before COVID-19 starts and because most interviewees preferred the traditional approach such as paper questionnaires and physical face-to-face interviews. Second, phone-call interviews are often used as face-to-face alternative ways to complete interviews because challenges appeared in conducting face-to-face meetings

(Forza 2002; Filippini 1997; Dillman et al. 2009; Trier-Bieniek 2012; Barratt 2012; Fernández et al. 2012; Mahesh 1995; Lee et al. 2011). This research would consider this interview method if the study covers a large geographical area such as several countries. However, this research is done only in the UAE, and it was facilitated to conduct physical meetings with all interviewees. Third, e-mail interviews are usually done whenever the researcher has a big window of time to collect data or extend a conducted interview with more questions (Lee et al. 2011). This scenario was not experienced during this research study, and an e-mail interview method was not recommended. Fourth, the video-stimulated-recall interview type is an artificial intelligence approach used in qualitative research to study interviewees' deferent responses against the same set of questions (Rowe 2009; Nguyen 2013). This type includes certain responses that the system can recall against interviewees' behaviours or responses (Rowe 2009; Nguyen 2013). Although found that video-stimulated-recall interview type is growing, it is not recommended in this research study because data collection in this paper is purely quantitative and is based on ensuring that all experts (i.e., interviewees) have the same understanding (Rowe 2009; Nguyen 2013). Finally, the fifth interview type is online-chat interviews. This type is based on having all questions asked using a live online-chat portal and receive the answers in the same way (Harmeyer 2009; Barratt 2012). This type of interview is used with audiences who have speaking issues such as deaf-mutism or used with audiences with the issue in their confidence behaviour such as “young drug users” (Harmeyer 2009; Barratt 2012, p.571). Therefore, this research study does not face such challenges while collecting the required data, and online-chat interviews have been avoided.

However, researchers found that interviews can be approached willingly without cost because interviewees choose to do it (Chen et al. 2015). Furthermore, interviews can be approached by offering a benefit or profit to contributing applicants (i.e., interviewees) (Chen

et al. 2015). The approach of using incentive cash to increase the responding sample size was made in other research with retired old interviewees (Chen et al. 2015). The targeted audience in this research study is considered highly skilled professionals with high pay rates. Offering cash-intensive will push them to abort the interview because they feel humiliated or push them to ask for a significantly high amount of cash to consider it intensive. Therefore, all interviews in this research study are following the non-cash willingly approach face-to-face survey interviews.

4.3.4.2 Interview Questionnaire Design

After proofing that this research requires a face-to-face interview questionnaire and justifying the reason behind choosing face-to-face interviews, it is compulsory to justify using questionnaire surveys and optimising its design. Surveys are an extremely useful and powerful tool to obtain information (Glasow 2005). It is essential to design the survey format to optimize information extraction from respondents (Glasow 2005; Fanning 2005). This targets a smooth questionnaire with less confusion and an acceptable length (Herzog & Bachman 1981). First, it is essential to know the required type of surveys. There are two types of surveys, including paper questionnaires and web questionnaires (Fanning 2005; Fan & Yan 2010; Huang 2006; Herzog & Bachman 1981). This research study chooses to use paper-based survey questionnaires due to the importance of completing the questionnaire in a face-to-face interview. Paper questionnaires have several advantages, such as (1) the ability to ensure that the desired audience fills the questionnaire, (2) the ability to write notes on papers back, and (3) the ability to conduct the task in any place without technologies constraints and requirements. The disadvantages of paper questionnaires are including the additional costs to cover a wide geographical area and the sustainability impact (Yusof et al. 2016). However, this

research study uses recyclable papers to cover collecting information and data from the United Arab Emirates, only with no additional costs. So, the disadvantages of paper questionnaires have no negative impact on this research study. The second type of survey questionnaires is web-based questionnaires (Fan & Yan 2010; Huang 2006). There are many free and subscribed online-survey tools such as SurveyMonkey, HubSpot, Survey Anyplace, Nicereply, Advocately, MySurveyLab, Centiment, Delighted, YesInsights, Startquestion, Google Forms, Birdeye, HotJar, Arbit, Typeform, Qualaroo, and Smart Survey. The advantages of this survey type are (1) the ability to reach anywhere in the world without distance limits, (2) the ability to collect data without negative environmental impact (i.e., paper waste), and (3) the ability to collect data without social bias impacts (Huang 2006; Yusof et al. 2016; Fanning 2005). The disadvantages of web-based surveys are including (1) the inability to ensure that respondents are meeting the required criteria, (2) the inability to secure respondent's data (i.e., electronic hacks), and (3) the inability to ensure positive respondent's confidence about the research intentions which can impact data accuracy. However, this research study avoids the online-questionnaires type of surveys, although it is a globally growing data collection method (Huang 2006).

The survey questioner design in this research study has followed the optimum design requirements and format according to researchers' recommendations to maximize the smoothness of data collection without fail or difficulties as the following (Fanning 2005; Glasow 2005; Herzog & Bachman 1981; Hoddinott & Bass 1986; Bosnjak 2009; Reza, Borzouei & Afkhami-Ardekan 2016; Fogsgaarda et al. 2016; Huanga et al. 2015; Huang 2006).

- The cover page includes the study intentions and questions answering directions.
- The questionnaire is provided with an invitation to the interviewee, giving sufficient time before the interview.

- Figures and charts have been used to facilitate answering all questions within a short time. This research study gives interviewees the ability to answer three questions by providing one answer (i.e., risk, probability, and impact matrix).
- The factor grouping method is used for better understanding to avoid respondents' confusion and to answer questions accurately.
- The questionnaire presented all risks in a table to facilitate shifting between questions without getting lost.
- The respondents designed the questionnaire to answer each question with one number chosen from the provided risk matrix. This will significantly reduce the required time for answering all questions (i.e., 117 cost risks/variables).

Next, this research uses the Project Management Institute (PMI) to have the right weight for each risk probability and its impact. PMI is involved in project management research and development. In Figure 4-8, the original PMI risk matrix is divided into two impacts (i.e., Threats and Opportunities). This can create confusion for the data providers (i.e., experts).

Probability and Impact Matrix

Probability	Threats					Opportunities				
0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04
0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03
0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02
0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01
	0.05	0.10	0.20	0.40	0.80	0.80	0.40	0.20	0.10	0.05

Impact (numerical scale) on an objective (e.g., cost, time, scope or quality)

Each risk is rated on its probability of occurring and impact on an objective if it does occur. The organization's thresholds for low, moderate or high risks are shown in the matrix and determine whether the risk is scored as high, moderate or low for that objective.

Figure 4-8: Project Management Institute (PMI) Risk Matrix: Probability X Threats/Opportunities impacts (PMBOK Guide 2004).

Therefore, the required PMI original risk matrix's required adjustment is made, as shown in Figure 4-9. The adjustment is based on having threats and opportunities in one impact matrix instead of two. This will make it easier to put the absolute risk value based on its impact and probability without thinking about its negative or positive sign. The final modelling process will classify threats and opportunities based on mathematical modelling outputs signs (i.e., positive and negative).

Project Management Institute (PMI) Risk Matrix: Probability X Impact						
Probability	90%	5%	9%	18%	36%	72%
	70%	4%	7%	14%	28%	56%
	50%	3%	5%	10%	20%	40%
	30%	2%	3%	6%	12%	24%
	10%	1%	1%	2%	4%	8%
		5%	10%	20%	40%	80%
		Impact				

Figure 4-9: Adjusted coloured Project Management Institute (PMI) Risk Matrix: Probability and Impact multiplication is showing risks values including low (green), medium (yellow) and high (red) risks.

Finally, the used matrix in the face-to-face interview questionnaires needed experts to focus only on the probability and impact numbers of each risk factor. Colour can be a source of distraction and/or a second approach to provide answers. Therefore, this research questionnaire decided to remove the colours from the final used questionnaire, as shown in Figure 4-10.

Probability	90%	5%	9%	18%	36%	72%
	70%	4%	7%	14%	28%	56%
	50%	3%	5%	10%	20%	40%
	30%	2%	3%	6%	12%	24%
	10%	1%	1%	2%	4%	8%
		5%	10%	20%	40%	80%
		Impact				

Figure 4-10: Final Adjusted Project Management Institute (PMI) Risk Matrix: Probability and Impact Matrix.

4.3.4.3 Questions Type

There are two types of questionnaire questions mentioned in literature and empirical studies; however, the first type is open-ended questions, and the second type is closed-ended questions (Reja et al. 2003; Qu & Dumay 2011; Soltanian, Borzouei & Afkhami-Ardekan 2016; Makienko & Bernard 2012; Nastasi & Schensul 2005; Trier-Bieniek 2012; Jarkas 2016; Modell 2005). Open-ended questions are usually used for collecting suggestions and possible solutions (Reja et al. 2003). It can be used to study individuals' response behaviour against a specific event (Reja et al. 2003; Modell 2005). Open-ended questions are often used in mixed research methodologies (i.e., mixed qualitative-quantitative method) to develop the framework used for closed-end questions (Makienko & Bernard 2012). Table 4-2 shows how this research study satisfied researchers developed questionnaire questions analysis guidelines (Makienko & Bernard 2012, p.143).

SN	Questionnaire Questions Analysis Criteria	This research Study Questions Design
1	"Based on the survey questions, what is its main goal?"	To collect the required data used to build projects' whole lifecycle final system dynamics cost model.
2	What main construct (dependent variable) this study is trying to measure?	This study is trying to measure the cost risk value in the United Arab Emirates.
3	"What other constructs is the survey trying to measure"?	This study is trying to measure cost risks impact and occurrence probability in the UAE.
4	"Do scales capture all domains of the main construct (main dependent variable)?"	Yes, the given scale is based on the Project Management Institute PMBOK guideline
5	"How many open-ended vs close-ended questions are in the survey? Are there too many open-ended questions?"	All questions are closed—no open questions.
6	"Are there any duplicate/unnecessary questions?"	No.
7	"Are questions clear and easy to understand?"	Very Clear, and the researcher will be available as an interviewer to clear any doubts.
8	"Are there any sensitive questions?"	No. All sensitive questions are considered optional after the pilot study.

9	"Is the survey too long or too short?"	It is considered long (i.e., 45 min). However, after the pilot study, it can be completed in more than one session.
10	"Does the survey use the best format/layout?"	Yes, following researchers' optimum guidelines.
11	Does the survey use the appropriate letter size?	Yes, (Time New Roman) Font 12. No negative feedback was found about font during the pilot study.
12	What research questions can be answered by analysing this survey?	It will answer directly research question 1, and it is mandatory to answer research questions 2 and 3.
13	What types of statistical analyses can be run based on available independent and dependent variables?	Correlation and regression statistical analysis.

Table 4-2: Adapted Questionnaire Questions Analysis Criteria against this research study Questions Design (Makienko & Bernard 2012, p.143).

Therefore, in this research study, the structured interview is based on collecting specific data related to listed factors and variables (Reja et al. 2003). It is optimum to control collected answers with close-ended questions (Reja et al. 2003). In this research study, each question offers to select from a range of multiple choices (Reja et al. 2003). This is to ensure extracting accurate information after utilizing experts' experience to serve this study.

4.3.4.4 Sample Size

Determining the sample size in the research data collection stage is mandatory and critical for statistical analysis (Cai & Hames 2011). Having an adequate sample size is based on many factors (Cai & Hames 2011). For instance, the required data size will differ based on probability models and the type of applied statistical analysis (i.e., one-tailed or two-tailed) (Cai & Hames 2011). The one-tailed statistical analysis will require a smaller sample size (Cai & Hames 2011). Researchers found that the significance criterion is strongly impacting the required sample size (Ajay & Micah 2014). As the significance P-Value decreases, the sample size will increase (Ajay & Micah 2014). Therefore, it is crucial to set a known significance P-Value; however, the significance value is two-tailed 5% in this research. This chapter's reason for choosing this value is detailed in data significance, reliability, and validity section. There

are several sampling methods found in previous research, as shown in Figure 4-11 (Omair 2014; Bhardwaj 2019; McCombes 2019).

Probability sampling methods	Nonprobability sampling methods
Simple random sampling	Convenience sampling
Systematic random sampling	Consecutive sampling
Stratified random sampling	Quota sampling
Cluster sampling	Judgmental/purposive sampling
Multistage sampling	Snowball sampling

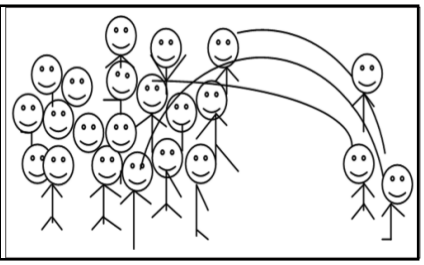


Figure 4-11: Probability & Non-Probability Sampling methods (Omair 2014; Bhardwaj 2019).

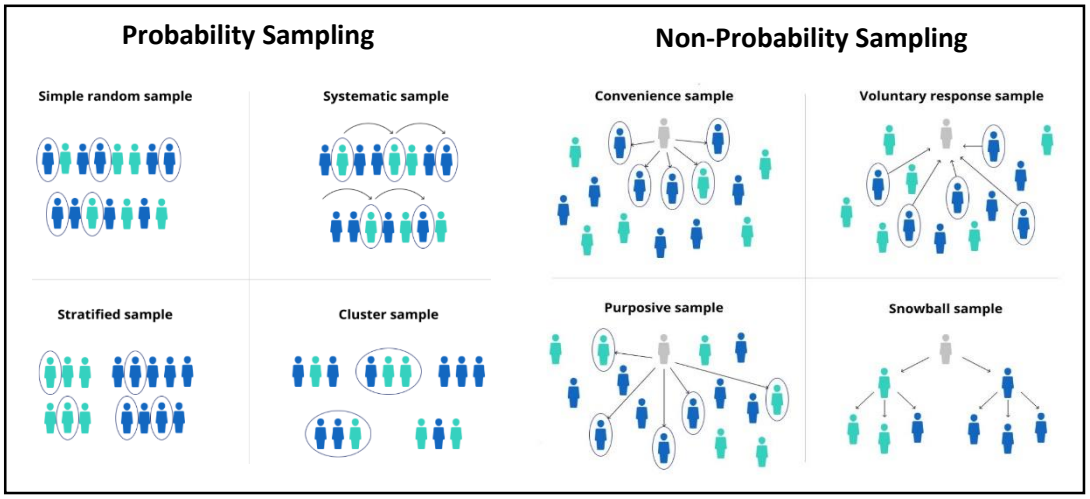


Figure 4-12: Probability and Non-Probability Sampling methods (McCombes 2019).

Probability sampling is usually used for quantitative research (Omair 2014). It is including four main sampling methods, as explained in Figure 4-12 (McCombes 2019). Researchers agreed on simple-random-sampling, systematic-sampling, stratified-sampling, and cluster-sampling (Omair 2014; Bhardwaj 2019). First, the simple random sampling method is the type that all population units have the same probability of selecting (Bhardwaj 2019). This research study defined its population to be construction and facilities management engineering professional experts. Then, simple-random sampling was conducted based on sending invitations to randomly selected engineers to collect data. Second, systematic sampling is the type that uses a systematic selection rule (Bhardwaj 2019). For instance, the rule can be

skipping two units after each selected sample (McCombes 2019). This research study did not assign any selection rules during the sampling process. Third, stratified sampling is the type that puts the population into groups called "strata" and selects randomly from each group (Bhardwaj 2019, p.159). This research did not create any strata for its data sampling. Fourth, cluster sampling is the type that creates sub-groups from the population and selects randomly between groups (Bhardwaj 2019). All members of selected clusters are included in the sample (Bhardwaj 2019). However, some researchers divide cluster sampling into the cluster and multistage sampling, as shown in Figure 4-11 (Omair 2014; Bhardwaj 2019; McCombes 2019). This research study did not create clusters or apply any multistage (i.e., complex cluster) sampling.

Non-probability sampling is usually used for qualitative research (Omair 2014; Bhardwaj 2019). It includes four main sampling methods shown in Figure 4-12 (Bhardwaj 2019; McCombes 2019). Researchers agreed on convenience-sampling, voluntary-sampling, snowball sampling, and purposive-sampling (Omair 2014; Bhardwaj 2019). Convenience sampling is based on using the most accessible samples to researchers (Omair 2014; Bhardwaj 2019). Voluntary sampling is based on sample individuals willing to accept being in the sample (i.e., volunteer) (Omair 2014; Bhardwaj 2019). Snowball sampling is based on respondents included in the sample who identify and recommend other respondents (Omair 2014; Bhardwaj 2019). The purposive sampling type is based on the study purpose from researchers' perspectives (Bhardwaj 2019). It is called by several names based on researchers' perceptions such as "deliberate-sampling", "judgemental-sampling", "consecutive-sampling", and "quota-sampling" (Omair 2014, p.145; Bhardwaj 2019, pp.158-162). Finally, the mixed method sample size approach combines both probability and non-probability methods; however, it is

not used in this research study and the following chart sampling as shown in Figure 4-13 (Onwuegbuzie 2007).

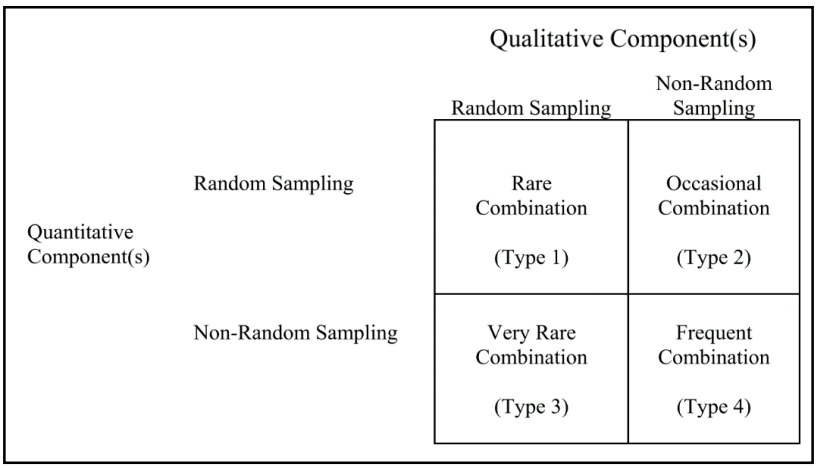


Figure 4-13: mixed method sample size approach (Onwuegbuzie 2007).

However, this research study did not include any non-probability sampling method. It is recommended for future research, based on updating cost risks of this research study, to use purposive sampling for better results. To sum up, this research study has used a simple random sampling probability method considering its population as construction and facilities management engineering professional experts.

Next, it is essential to ensure having an adequate sample size (Singh & Masuku 2014). Three criteria points need to be satisfied in a collected sample to consider its size good and appropriate (Singh & Masuku 2014). First, Data Level of Precision (i.e., sampling error) is a significant criterion and should be satisfied (Singh & Masuku 2014). Previous research considered ±5%, and researchers will consider their data precision fall within a range of 5 per cent up and down from their actual data representation value (Singh & Masuku 2014; Ahiaga-Dagbui 2014; Jang 2011; Seo & Park 2017). In this research study, the data precision level is considered ±5%; however, its calculation is done using equation 4-1 (Ahiaga-Dagbui 2014; Jang 2011).

$$\text{Data Level of Precision} = 100 \times \frac{(Actual - Estimated)}{Estimated}\% \qquad \text{Equation 4-1}$$

Second, data confidence level value determination is essential before assuming that collected data have the right sample size (Singh & Masuku 2014). It is based on the "Central Limit Theorem" (Singh & Masuku 2014, p.9). This theory considers that a defined population's true value is equal to the means' average of all collected samples from the same defined population (Singh & Masuku 2014). The data confidence is assumed 95% if all collected samples from the same population have a distribution risk error equal to 5% for means' average value as shown in 4-14 (Singh & Masuku 2014; Szyk, Mah & Pal 2020).

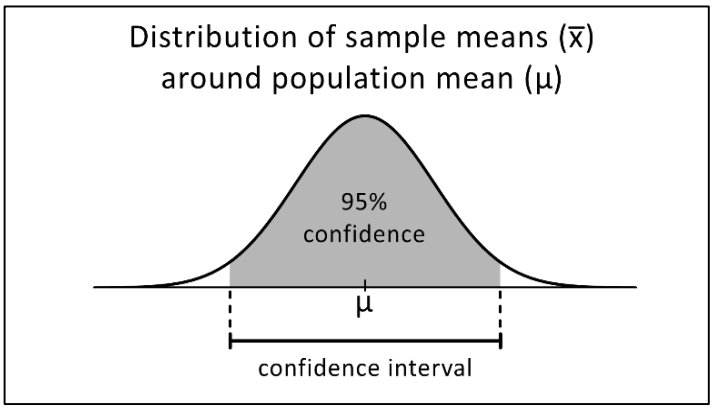


Figure 4-14: 95% confidence level chart (Szyk, Mah & Pal 2020).

Although there is no clear specific justification of setting a fixed certain significance level (i.e., precision level) other than what is followed in statistical traditions according to researchers and published articles (Trafimow et al. 2018; Brunnström & Barkowsky 2018; Pérez & Pericchi 2014). The most common significance levels in the quantitative statistical research approach are usually 95% (Trafimow et al. 2018; Brunnström & Barkowsky 2018; Pérez & Pericchi 2014). This research study is going to set the significance level as 95% (i.e., 1- α = 1- 0.05 = 0.95). This decision's validity will be clearer after knowing that previous research and publications proved that changing α from 0.05 to 0.005 makes no difference in the discussion and conclusion of any binary numerical system study (Trafimow et al. 2018;

Brunnström & Barkowsky 2018; Pérez & Pericchi 2014). The conclusion may change with increasing the significance level change up to 95% (Trafimow et al. 2018; Brunnström & Barkowsky 2018; Pérez & Pericchi 2014). It does not reflect conclusion decisions if it increased more than 95% (Trafimow et al. 2018; Brunnström & Barkowsky 2018; Pérez & Pericchi 2014). However, the sample size increases as α decreases, and it may create unnecessary challenges during conducted studies (Trafimow et al. 2018; Brunnström & Barkowsky 2018; Pérez & Pericchi 2014). The research design, assumptions auxiliary, and independent application studies' implication must be carefully considered to end up with acceptable conclusions (Trafimow et al. 2018; Brunnström & Barkowsky 2018; Pérez & Pericchi 2014). Therefore, this study is cautiously designed the research, justified all assumptions, and thoughtfully consider other independent application studies. Each cost risk data set in this research will have an R^2 value to measure how much it represents from the defined population, as shown in Equation 4-4 (i.e., included in mathematical modelling).

The actual representation of dependent Data (Y) based on collected independent data (X) is calculated in this research study using statistical approach R^2 (Alzahrani 2015; Jang 2011; Boateng 2014; Cui 2005).

Finally, the third mandatory criterion of the right sample size is the degree of variability (Singh & Masuku 2014). The sample degree of variability is based on population attributes distribution; in other words, the sample size will increase with a heterogeneous population and decrease with a homogeneous population (Singh & Masuku 2014). Having a degree of variability above or below 50% means a larger majority toward aside; therefore, the highest degree of variability is 50% (Singh & Masuku 2014; Omair 2014). This research considers the worst scenario recommended by researchers in published literature and will assign the degree

of variability to 50% (Singh & Masuku 2014; Omair 2014). This will guarantee a good sample size if the assumed degree of variability found not accurate.

After that, there are three approaches to determine good sample size in research studies (Singh & Masuku 2014). First, using the entire small population's survey is a good approach to ensure an appropriate sample size (Singh & Masuku 2014). However, the population should be small, and researchers recommended this method to sample the entire population if it is between 50 to 200 (Singh & Masuku 2014). Although it has several advantages, such as eliminating samples error, it is impossible to use this research paper approach due to the larger population size. Second, using published tables that include the sample size based on precision levels, confidence levels, and population size is recommended by researchers as an excellent approach to select an acceptable sample size (Singh & Masuku 2014; Darby 2010). The issue of this research paper, being in the United Arab Emirates, is that construction/engineering professionals' populations change over time, and it is unknown to the researcher. Therefore, this approach (using published tables) is not appropriate in this research study. Finally, the third approach utilizes a sample size of a similar research study (Singh & Masuku 2014). This is the most optimum approach to select the right sample size for this research study. There are three criteria bases for finding relevant research studies to determine the appropriate sample size. The first criterion is having at least 29 samples to satisfy the statistical normality requirements and consider a high correlation test between 2 variables; however, some researchers recommended at least 30 to ensure avoiding any statistical analysis issues (Bujang & Baharum 2016; Delice 2010; Shen, Nguyen & Ojiako 2013; Ruiz et al. 2017; Aliverdi, Naeni & Salehipour 2013). The second criterion is the required sample size of the data collection approach (i.e., interview questionnaires). After reviewing the literature, it has been found that 29 previous research included samples size ranging from 2 to 132 interviews (Blair & Conrad

2011; Mason 2010; Onwuegbuzie 2007; Tongco 2007). Their analysis used qualitative approaches (Tongco 2007). Also, nine previous research approaches quantitative survey questionnaires included samples size ranging from 32 to 223 and analysed them using percentages (Tongco 2007). Therefore, it is acceptable to determine an acceptable research sample size using percentage techniques. From reviewing literature having similar research methodologies (i.e., interview questionnaires), it is found that the used data sample has a size equal to 14, 40, and 83; however, samples were analyzed by percentages and other statistical calculations to determine its acceptability (Tongco 2007). The last criterion is to find out the acceptable percentage to consider a good sample for this research study. The required percentage can be extracted from published literature similar to this research study in the data type (i.e., risks and factors) and population type (i.e., construction cost and engineering professionals). Previously published research studying construction factors and risks used 200 invitation sample size (Vidogah & Ndekugri 1998). The valid responding percentage from all invited 200 experts was 27% (Vidogah & Ndekugri 1998). Researchers also found that after inviting 218 listed cost experts Royal Institute of Chartered Surveyors (RICS), the valid response rate increased to 31% (Elhag, Boussabaine & Ballal 2005). On the other hand, the valid response rate was found equal to 30.5% of 285 invited construction experts in other similar studies of this research (Aziz & Abdel-Hakam 2016). Moreover, in other construction factors literature, the higher invited sample is not necessarily increasing the responding rate percentage; for example, it was found that only 28.3 % responded after inviting 300 contractors' top management (i.e., experts) to answer questionnaires related to construction factors (Shash 1993). Published literature declared that most construction research studies invited 200 experts from the industry to answer their questionnaire and received back 20-30% of their 200 invitations (Akintoye & Fitzgerald 2000). These researches considered this

percentage range a valid criterion to accept the collected data in similar research studies (Akintoye & Fitzgerald 2000).

This research study concludes after reviewing literature that similar studies used experts to collect their valid data. Also, similar researches have agreed to consider responding rate percentages as the measuring criteria of accepting sample size. According to a researcher working in the same field (i.e., construction), the agreed acceptable invitation-sample size found between 200 to 300 invitations sent to experts. However, it is proved by previous research that increasing invitation-sample size, to include more than 200, has no considerable impact on responding rate percentages (i.e., acceptance criterion). The agreed acceptable responding rate percentage has been found between 20% to 31% of sent invitation quantities. Therefore, this research study sent invitations to 200 experts randomly. So, the acceptable sample size is expected to be between 40 (i.e., 20% of 200) to 62 (31% of 200) random samples. It will be covering the minimum requirements of quantitative statistical analysis (i.e., at least 29). This research has completed 55 face-to-face interview questionnaires with experts. The resulting responding percentage has been found 27.5%, almost within the top 90% of other similar studies' acceptable percentages. Therefore, this research study is approved, and the valid sample size is 55 face-to-face experts' interview questionnaires.

4.3.4.5 Pilot Study

A pilot study is essential in any research data collection to identify a good sample size (Ruiz et al. 2017; Toor & Ogunlana 2009; Aziz & Abdel-Hakam 2016; Viechtbauer et al. 2015). It is also essential to identify possible challenges and improvements (Ruiz et al. 2017; Toor & Ogunlana 2009; Aziz & Abdel-Hakam 2016; Viechtbauer et al. 2015). There are three approaches to determine research pilot study sample size (Kraemer et al. 2006; Cocks &

Torgerson 2013; Ruiz et al. 2017; Toor & Ogunlana 2009; Aziz & Abdel-Hakam 2016; Viechtbauer et al. 2015). The first approach is determining the pilot study sample size without having any idea about the main sample size; however, it has two methods (Kraemer et al. 2006; Cocks & Torgerson 2013). The first method is using the "role of thumb" (Cocks & Torgerson 2013, p.199). It can be followed to initially start with 30 pilot samples (Cocks & Torgerson 2013). The main sample size will be identified later based on initial analysis outputs (Cocks & Torgerson 2013). The second method calculates the pilot sample using mathematical equations based on statistical properties and assumptions (Kraemer et al. 2006). This research study does not follow the first approach because the main sample range has been identified as justified earlier. The second approach of identifying pilot study sample size based on knowing the main sample size range (Viechtbauer et al. 2015; Kraemer et al. 2006). These range boundaries can be extracted from similar studies or mathematical calculation limits (Viechtbauer et al. 2015; Kraemer et al. 2006). However, this research study is not following this approach. It is because that the largest main sample size is equal to 62 samples, as justified earlier. Therefore, this highest expected value is considered the base of calculating this research pilot study sample size. The third approach determines the pilot study sample size based on precisely the primary sample size using two methods. The first method of knowing the primary sample size is by extracting it from published tables based on the estimated population, as explained earlier. The second method is by considering the higher limit of the main sample range to guarantees that the pilot study sample is valid in covering the targeted main sample size. However, unidentified challenges may appear during data collection processes, and pilot study may be questioned if the primary sample exceeded the higher limit using the second method (Kraemer et al. 2006; Cocks & Torgerson 2013; Ruiz et al. 2017; Toor & Ogunlana 2009; Aziz & Abdel-Hakam 2016; Viechtbauer et al. 2015). Based on the researchers' recommendations, the pilot study

sample size has been decided to equal 5% (i.e., 1 pilot sample of each desired 20 main samples) to optimize the results (Viechtbauer et al. 2015). Therefore, the pilot study has been decided to be 3 (i.e., between 1.5≈2 and 3.1≈3 pilot samples) based on the chosen main sample size (i.e., 40 to 62). To ensure a valid pilot sample size, further literature has been reviewed to support the chosen pilot sample. For example, similar research selected six samples for a pilot study representing 117 main sample sizes, including interviews and questionnaires (Aziz & Abdel-Hakam 2016). This is equal to about 5% (i.e., 6/117=5.1%); however, the sample range was between 87 and 118 (i.e., 20% to 31% respond rate). Therefore, it is acceptable. Another similar study selected 6 pilot samples to represent the expected 115 main sample size (Toor & Ogunlana 2009). However, the research ended with having six pilot samples representing 111 main sample sizes, including interviews and questionnaires (Toor & Ogunlana 2009). This pilot percentage has shifted from 5.2% (i.e., 6/115) to 5.4% (i.e., 6/111), which is approximately 5%, and the actual main sample did not exceed the range higher limit. Other quantitative research selected 12 pilot samples to represent 230 main validation samples (Ruiz et al., 2017). This result was found equal to 5.2% ≈ 5%. Therefore, it is acceptable to consider this research study piloting sample equal to 3 (i.e., 5%); however, the main sample size did not exceed the higher limit (i.e., 55 < 62), and the pilot study resulted in the following comments to optimize this research questionnaire's design:

- Questions quantities (i.e., 117 cost risks) were too long and required ample time to think about the information and required numerical data (i.e., 2 hrs.). This is solved by putting the key words only instead of the full question. The interviewer will provide any required clarification.
- Questions descriptions were causing different understanding, and the interviewer had to explain it anyhow. This has been solved by having the interviewer introducing each

group, as explained in chapter 3 of this research study, considering interviewees' background, profession, and previous experience.

- Interviewees found a challenge in using risk, impact, and probability matrix. This is solved by introducing the PMBOK risk matrix and how it is used to answer each question.

After improving the questionnaire and identifying all possible challenges, it is essential to consider this study's face-to-face interview questionnaire's final duration. The final validated questionnaire requires 45 minutes to be completed. To validate this duration, it is mandatory to review previous research literature. So, researchers declared an interview could take 30 minutes up to several hours (DiCicco-Bloom & Crabtree 2006). The United States Census Bureau concluded that each in-person interview questionnaire takes between 25 and 75 minutes (Bogen 1994). Nevertheless, other researchers proved that most questionnaires have a duration of 10, 15, 20, and 30 minutes (Galesic & Bosnjak 2009; Barnes 2001). This is significant in maintaining the quality of collected data and maintaining a higher responding rate (Galesic & Bosnjak 2009; Barnes 2001). Therefore, this research study has an acceptable face-to-face interview questionnaire duration (i.e., 45 minutes). It maintains the quality of data collection and responding rate by offering an optional choice to complete the questionnaire in more than one session. This will ensure that all collected data in one session is not rushed and by interviewees choice. Moreover, it will ensure that busy interviewees' data collection quality (i.e., construction industry experts) is maintained as required.

4.3.5 Mathematical Modelling

Previous research proved that quantitative empirical studies require justified and logical application mathematical modelling (Todorov 2014; Reina et al. 2016; Winter 2016; Blair & Conrad 2011; Meyer et al. 2013). Real-world problems should be simplified and translated into mathematical inputs; however, these inputs are used in equations system to form a mathematical model (Todorov 2014; Reina et al. 2016; Winter 2016; Blair & Conrad 2011; Meyer et al. 2013). There are six main classification frameworks of mathematical modelling (Abanda, Tah & Cheung 2013). First, mathematical models are dynamic if they are based on time, including deferential or partial differential equations (Abanda, Tah & Cheung 2013). However, it is considered static if the mathematical process is based on algebra and it is made and solved for certain conditions at a given time (Abanda, Tah & Cheung 2013). Therefore, this research study is dynamic because it is based on time, and the VENSIM simulation is based on differential equations. Second, mathematical modelling is deterministic if it has an exact solution (Abanda, Tah & Cheung 2013). This research study includes a deterministic equation system because it is based on modelling the exact value of the project's entire life cycle cost. Third, mathematical modelling is mechanistic if its equations are created and derived from hypotheses or theoretical fundamentals of a system (Abanda, Tah & Cheung 2013). This research study includes a mechanistic mathematical equations system because it derives CAPEX and OPEX costs equations from the system theoretical framework. Furthermore, because it is deriving equipment replacement costs equations and from previous research hypothesis results. Fourth, mathematical modelling is stochastic if its equations system is based on probability (Abanda, Tah & Cheung 2013; Ketokivi & Choi 2014; Sher & Punglia 2014). This research is including stochastic mathematical sub-systems such as Monte Carlo and data analysis approaches. Fifth, mathematical modelling is empirical if it uses real data (i.e., existing

data) to describe the comparison and relationship between two variables (Abanda, Tah & Cheung 2013). Real projects existing data will be used at the validation stage of this research study to compare the estimated value with the actual value. Therefore, this research study is including an empirical mathematical sub-system. However, researchers proved that mathematical systems are complex if they include internal sub-systems (Scheufele et al. 2018). Therefore, this mathematical research modelling is considered complex because it comprises several sub-systems, including more than one classification. Sixth, mathematical models can be continuous or discrete (Abanda, Tah & Cheung 2013). This research study will deal with this type of subjectively. For example, it will consider cost continuous whenever its analysis is based on curve equations. However, the model's cost will be considered discrete if its analysis is based on discrete-time intervals.

4.3.5.1 Data Statistical Significance, Reliability and Validity

Data significance, reliability, and validity are mechanistic mathematical modelling. There are two reliability types require to be included in this research as justified earlier. First, the reliability stability (i.e., strength) of collected data in this research will be the correlations between values of risks against their impacts and values of risks against their occurrence probabilities. However, the following hypotheses are used to complete stability analysis as the following:

Let, ρ represent the Correlation of Pearson Population, then

HO: $\rho = 0$, (i.e., No Correlation between variables),

H1: $\rho \neq 0$, (i.e., Correlation is available between variables)

This research is using the SPSS software program to conduct statistical analysis. Therefore, it is crucial to represent the mathematical equations used in this study to understand data verification mathematical modelling better. The following equations from 4-2 to 4-5 are used in this statistical, mathematical modelling.

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

Equation 4-2

r = correlation coefficient
x_i = values of the x-variable in a sample
$\bar{x}$ = mean of the values of the x-variable
y_i = values of the y-variable in a sample
$\bar{y}$ = mean of the values of the y-variable

$$e_t = \rho e_{t-1} + \nu_t$$

Equation 4-3

ν_t = nonzero eigenvalues
ρ = Durbin -Watson statistic hypothesis
e_t = the residual error
e_{t-1} = the previous residual error

$$d = \frac{\sum_{t=2}^{T} (e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^2}$$

Equation 4-4

d = Durbin -Watson statistic
t = Time
T = total number of observations

$$R^2 = 1 - \frac{\text{sum squared regression (SSR)}}{\text{total sum of squares (SST)}},$$
$$= 1 - \frac{\sum (y_i - \hat{y}_i)^2}{\sum (y_i - \bar{y})^2}.$$

Equation 4-5

R^2 = ariance proportion in dependent variables explained by independent variables
y_i = actual Observation
$\hat{y}_i$ = predicted Observation
$\bar{y}$ = mean of Actual value

This research study's reliability similarity correlation is to ensure that all outliers are eliminated and ensure no autocorrelation. After checking each risk's stability (i.e., a correlation exists between each risk's value against its impact/probability), the mean of error analysis and Durbin–Watson analysis will be conducted to ensure each risk's collected data is falling within the acceptable range of values. The acceptable range of values to consider reliability similarity is the range that excludes the impact of outliers and autocorrelation (Kadiyala 1970; Nazif et al. 2016; Jafarzadeh et al. 2015). This means that regression analysis assumptions are satisfied (Kadiyala, 1970; Nazif et al. 2016; Jafarzadeh et al. 2015). In other words, linear-relationship, normality, independence, and homoscedasticity assumptions are satisfied (Kadiyala 1970; Nazif et al. 2016; Jafarzadeh et al. 2015). After ensuring that data stability correlation exists, these assumptions can be satisfied by having normally distributed independent standardized residuals scattered along the zero-horizontal line without identifying or detecting any pattern (Kadiyala 1970; Nazif et al. 2016; Jafarzadeh et al. 2015). Table 4-3 summarizes Regression Mandatory Error Assumptions.

SN	Regression Mandatory Error Assumptions Validation Requirements
1	The error's probability distribution of the regression should be normally distributed (i.e., Bell-shaped).
2	The error's population mean value (μ_ε) must equal to zero.
3	The error's variance (δ^2) must be constant for all independent X values.
4	The errors must be independent for all dependent Y values.

Table 4-3: Regression Mandatory Error Assumptions Validation Requirements (Kadiyala 1970; Nazif et al. 2016; Jafarzadeh et al. 2015).

Next, the stability-similarity relationship is conducted based on P-Value's significance between the dependent variable with each of its independent variables (Vanderwal et al. 2021; Golafshani 2003). This research is approaching stability-similarity relationship by ensuring the

significance between risks and their impacts/probabilities. Linear regression analysis will be conducted for each risk variable. This will include the risk's value as a dependent variable, while the independent variables will impact its probability values. Linear regression will model each cost risk's mathematical equation to adapt any change happening in the future related to risks' impact or probability as shown in equations 4-6 and 4-7 (Nazif et al. 2016).

$$Y_i = f(X_i, \beta) + e_i$$ Equation 4-6

Y_i = dependent variable
f = function
X_i = independent variable
β = unknown parameters
e_i = error terms

$$\mathbf{Y = \beta_0 + \beta_{prob}\, X_{prob} + \beta_{imp}\, X_{imp} + \xi}$$ Equation 4-7

Y = the Risk dependent Variable of each factor.
$\mathbf{X_{prob}}$ and $\mathbf{X_{imp}}$ = the probability and impact independent Variable of each factor.
$\boldsymbol{\beta_{prob}}$ and $\boldsymbol{\beta_{imp}}$, = the Linear Regression Coefficients for X_{prob} and X_{imp}, respectively of each factor.
$\boldsymbol{\xi}$, = the Error (Considered Zero because this regression is not time-based).

However, the degree of measurements' repeatability to fall within a given range under high significance value proves that the results are reliable for analysis and discussion (Golafshani 2003). This research ensures data reliability by satisfying all reliability criteria types after collecting it quantitively before any analysis or discussion. This will provide the possible accurate cost estimation and cash flow modelling results.

4.3.5.2 Cost Risks Minimum-Maximum Limits

Cost risk range identification, including minimum and maximum limits, is an essential mathematical process before moving to Monte Carlo simulation. It is done after validating all collected data (i.e., risks, impact, and probability). Each validated cost risk has a mean and standard deviation value. This research is using experts' data to simulate actual costs in the future. It will require a minimum sample size equal to 385 for unknown populations using Equation 4-8 (Sathian et al. 2010). Alternatively, a sample size equal to 400 from published quantitative sample-size tables (Singh & Masuku 2014).

$$n_0 = \frac{Z^2 pq}{e^2}$$ Equation 4-8

$\boldsymbol{n_0}$= Sample Size
$\boldsymbol{Z}$= Standard score
$\boldsymbol{p}$ = the (estimated) proportion of the population (variability)
$\boldsymbol{q}$ = 1 – p
$\boldsymbol{e}$ = Desired level of precision (i.e., 0.05 for 95% confidence level)

Therefore, the following quantitative minimum required sample calculation of unknown population, using equation 4-8, is including Z= 1.96 (Sathian et al. 2010). It is assuming the population error of confidence level 95% as e (i.e., 1 - 0.95 = 0.05) and it is assuming maximum variability as justified earlier (i.e., P = 0.5).

$$Sample\ Size = \frac{1.96^2 * 0.5 * 0.5}{0.05^2} = 384.16 \approx 385$$

Alternatively, it is possible to use the Monte Carlo simulation to cover the smaller sample size gaps. This research study is justified in how the acceptable sample size is equal to 55 face-to-face survey interviews. Therefore, this research study does not follow the published table or sample size mathematical calculations, as mentioned in Equation 4-8. However, it is

still required to include accurate mathematical modelling to deliver an accurate final cost estimation model. Monte Carlo simulation can guaranty the high precision of each modelled variable (Heijungs 2020). It requires upper and lower limits to ensure precise accuracy (Heijungs 2020). These limits need to be around the actual population's mean using standard deviation (Heijungs 2020). Therefore, valid sample size and data collection methods ensure accurate means and standard deviations as justified earlier. These data will successfully represent the population's mean and standard deviation, as proved earlier. Therefore, in this research study, Monte Carlo variables' modelling limits are extracted from the validated experts' face-to-face survey interviews to ensure accuracy. Figure 4-15 clarifies the difference between accuracy and precision (Heijungs 2020). Valid data will ensure accuracy, and Monte Carlo simulation will ensure the precision of each variable.

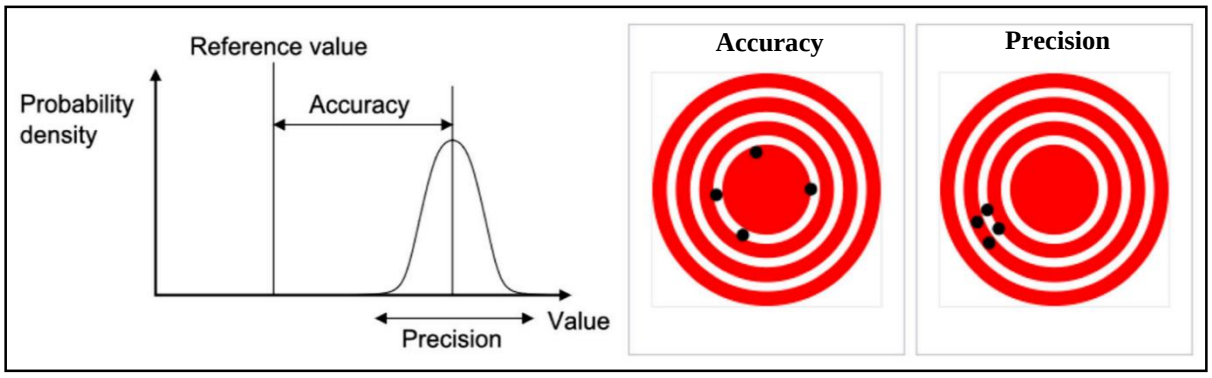


Figure 4-15: the difference between accuracy and precision (Heijungs 2020).

Finally, equation 4-9 is used to define the Monte Carlo upper and lower limits. The following part will detail how Monte Carlo simulation is accomplished in this research study.

$$\boldsymbol{Monte\ Carlo\ Upper\ and\ Lower\ Limits} = \boldsymbol{Cost\ Risk\ Mean} \pm \boldsymbol{Standard\ Deviation} \qquad \text{Equation 4-9}$$

4.3.5.3 Monte Carlo Simulation

This part will explain how Monte Carlo modelling is validated in this research study. Monte Carlo modelling is the stochastic mathematical estimation modelling of this research study (Bukaçi et al. 2016). This method is used to maximize the likelihood of functions representing actual results at absent data incidence (Caffo, Jank & Jones 2005). It is also used in previous research to maximize linear equations' likelihood to represent actual data (Lai & Lin 2011). Also, researchers proved that it is valuable for conducting unbiased simulations (Thompson & McLeod, 2009). However, it is found in previous research that Monte Carlo simulation requires a minimum number of iterations (i.e., random values) to validate functions' likelihood of actual representation (Heijungs 2020; Bukaçi 2016; Caffo, Jank & Jones 2005; Nowak et al. 2016; Thompson & McLeod 2009). It is found that previous research used a wide range of valid Monte Carlo iterations, including 100, 1,000, 10,000, $1x10^5$, and $1x10^7$ (Heijungs 2020; Nowak et al. 2016; Thompson & McLeod 2009). It is also extracted from the literature that Monte Carlo required the number of iterations based on the research type (Heijungs 2020; Bukaçi 2016; Caffo, Jank & Jones 2005; Nowak et al. 2016; Thompson & McLeod 2009). It is unnecessary to have more accurate outputs by adding more iterations; in other words, previous research proved that using $1x10^5$ iterations is more accurate than using $1x10^7$ iterations for the same study (Thompson & McLeod 2009). It is essential to identify the minimum required valid iteration number in this research. Moreover, in literature, similar life cycle assessment studies declared that it is common to use ≥10,000 iterations for Monte Carlo modelling and recommended this minimum valid number (i.e., 10,000) for life cycle assessment studies (Heijungs 2020). Therefore, this research study uses 10,000 iterations for each cost risk Monte Carlo simulation without increasing iterations to prove its validity.

The mathematical modelling equations of this research Monte Carlo simulation require several assumptions to validate it from a client perspective at the pre-construction stage. These assumptions are listed based on what is explained earlier as the following:

- Constructions and projects industry experts provide all survey risks.
- All weighted risks have an appropriate risk management system set by contractors with values equal to what is provided by industry experts. These risk values are identified and assessed successfully by contractors throughout the projects' whole life cycle.
- All risks identified by industry experts have been considered by contractors and included in the contract value cost. Therefore, the contract bill of quantity pricing is done by contractors and is including all identified risks by industry experts.
- The Monte-Carlo simulation will be used to calculate the error in the project's risk management system and find the adjustment value for each risk factor. It is required because the project's actual costs are not matching pre-construction estimated costs as justified earlier. Therefore, this is evidence of having errors in experts identified risk values. Moreover, it will be corrected through this research Monte Carlo method.
- The adjustment values are errors of mean risks, minimum risks, and maximum Risks. It will be used in the final system dynamics model to ensure that the estimated cost includes all its possible impacting risks. This will be including the known risks' weightage identified by experts (i.e., known-known and known-unknown risks). Moreover, it will include the unknown risk error (i.e., unknown-unknown risks) by conducting Monte-Carlo Simulation for each cost risk variable.
- Based on the justified reasons behind considering the error of experts' judgment when estimating costs at the pre-construction stage from a client perspective, the final

model’s minimum, mean, and maximum risks are the error of minimum, mean, and maximum risks.

The adjusted mean is the sample mean after implementing Monte Carlo outputs. This research assumes that the population mean equal to the adjusted mean after finding out each risk variable's error and embracing it in the variable's sample mean. This declaration is to recommend further research periodically to measure risks error and update it continuously. However, as of this research time, all risks are considered accurate and reflect the population's actual data.

From Figure 4-15, it is clear why using Monte Carlo simulation is essential. However, shifting data means should be done based on moving the full distribution to avoid discrediting experts' data. The mean only shall be moved toward the believed actual population means μ without changing each risk's standard deviation. Figure 4-16 clarifies how this research intends to conduct the required shift successfully.

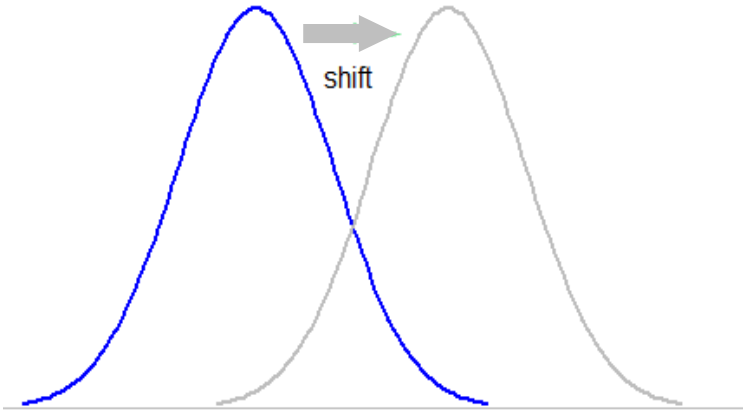


Figure 4-16: Shifting data mean without discredit distribution reliability should be without changing the standard deviation.

The reason behind fixing each variable’s standard deviation is to maintain experts’ data reliability and validity. Figure 4-17 shows how standard deviation change impacts data distribution significantly and withdraws data credibility. However, the normal back

distribution has the largest standard deviation. The red-normal distribution has a smaller standard deviation than the black one, but it is larger than the normal green distribution standard deviation. Finally, the green-normal distribution has the smallest standard deviation.

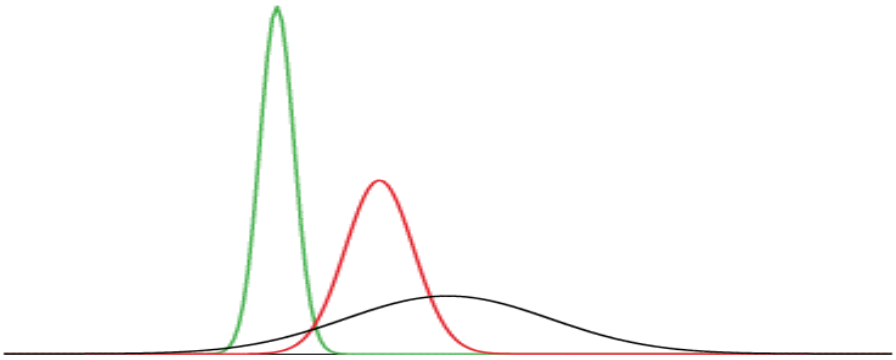


Figure 4-17: showing how shifting data mean while changing its standard deviation discredit the full data distribution and withdraw its reliability and validity.

Therefore, the adjusted mean value can be calculated for each risk variable using equations 4-10. Then, the adjustment mean value (i.e., error) can be calculated for each risk variable using Equation 4-11. This process is clarified in Figure 4-18 for better understanding.

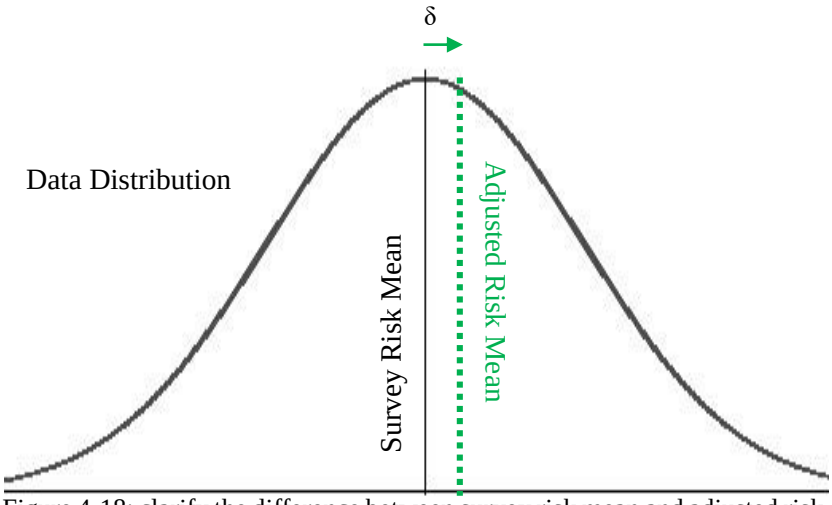


Figure 4-18: clarify the difference between survey risk mean and adjusted risk mean for the same data distribution of each variable.

Adjusted Mean Value = Min + [MC * (Max – Min)] Equation 4-10

Min = the Minimum Survey Risk Value

Max = the Maximum Survey Risk Value

MC = Monte Carlo average of 10,000 random values (between 0 to 1).

Adjustment Mean Value = $\delta = \left| \frac{v_A - v_E}{v_E} \right| \cdot 100\%$ Equation 4-11

δ = **Percent error**

v_A = **Believed actual value (i.e. Adjusted value)**

v_E = **Experts estimated value**

After implementing the Monte Carlo simulation method, final system dynamics data inputs can achieve the required accuracy and precision, as shown in Figure 4-19. This will improve the final cost estimation using the system dynamics approach.

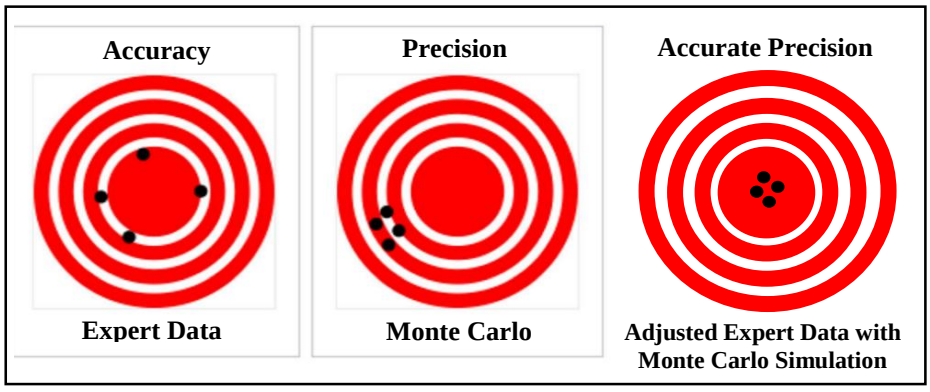


Figure 4-19: Experts data and Monte Carlo modelling impact on final outputs' accuracy and precision.

However, it is found that Adjusted Mean Risk, Adjusted Maximum Risk, and Adjusted Minimum Risk have the same mathematical relationship between Survey Mean Risk, Survey Maximum Risk, and Survey Minimum Risk. This is justified and proved in equations 4-12 to 4-19. These equations clarify how the adjusted minimum and adjusted maximum values are mathematically calculated.

Based on 95% Confidence:

Max Risk $= \bar{X} + 2\sigma$ Equation 4-12

Min Risk $= \bar{X} - 2\sigma$ Equation 4-13

$\boldsymbol{\sigma}$ is the risk standard deviation

$\bar{X}$ is the survey sample mean risk

Max Risk is the Normal Distribution Upper Limit

Min Risk is the Normal Distribution Lower Limit

From equations 4-12 and 4-13

$2\sigma = Max\ Risk - \bar{X} = \bar{X} - Min\ Risk$ Equation 4-14

$2\,\bar{X} = Min\ Risk + Max\ Risk$ Equation 4-15

From equation 4-11:

Adjustment Mean Value (error) $= \dfrac{Adjusted\ Mean - \bar{X}}{\bar{X}}$ Equation 4-16

By feeding equation 4-16 into equation 4-15 and by using mathematical multiplication and division properties:

$$2\,\bar{X} * \frac{Adjusted\ Mean - \bar{X}}{\bar{X}} = (Min\ Risk + Max\ Risk) * \frac{Adjusted\ Mean - \bar{X}}{\bar{X}}$$

$$2\,\bar{X} * Adjustment\ Mean = (Min\ Risk + Max\ Risk) * Adjustment\ Mean$$

$$2\ Adjustment\ Mean = \left(\frac{Min\ Risk}{\bar{X}} + \frac{Max\ Risk}{\bar{X}}\right) * Adjustment\ Mean$$ Equation 4-17

Therefore, equations 4-15 and 4.16 can be concluded from equations 4-13 and 4-14.

Adjustment minimum risk value $= \dfrac{Min\ Risk}{\bar{X}} * Adjustment\ Mean$ Equation 4-18

Adjustment maximum risk value $= \dfrac{Max\ Risk}{\bar{X}} * Adjustment\ Mean$ Equation 4-19

4.3.5.4 Construction Cash Flow S-Curve

This mathematical modelling is deterministic because its answer has exact values. Previous research outputs and equations were studied intensively, using a cash flow s-curve to ensure accurate cost estimation (Cristóbal 2017). However, researchers such as Gates and Scarpa (1979), Peer (1982), Kenley and Wilson (1986), Tuker (1988), Miskawi (1989), Khosrowshahi (1991), Navon (1996), Skitmore (1998), Kaka (1999), Kaka (1993), Chao and Chien (2010), and Brandewinder (2017) are referenced in several literature to validated construction cost s-curve equation (Cristóbal 2017; Odeyinka, Lowe & Kaka 2013; Abanda, Tah & Cheung 2013; Ahiaga-Daghui 2014). Therefore, this research study will use the same validated s-curve equation, as shown in equation 4-20 to 4-21. It is found that equation 4-21 has a better performance in modelling results, as shown in Figure 4-20.

$$f(x) = \frac{1}{1 + e^{-x}}$$ Equation 4-20

X = the time point on S-Curve chart

e = exponential constant

$$f(x) = \frac{1}{1 + e^{-\propto(t-T_0)}}$$ Equation 4-21a

T_0 = the maximum slop adjusting parameter.

The maximum slop increases as it increase.

t = the time step of f(x) cash flow point.

α = is the stepness of the curve $\begin{cases} \propto (t_1 - T_0) = \ln\left(\frac{1}{f_1} - 1\right) \\ \propto (t_2 - T_0) = \ln\left(\frac{1}{f_2} - 1\right) \end{cases}$

$f(X)$ = *Cost* S-Curve = $\frac{1}{1+e^{-1.22(t-1.88)}}$ (From similar literature) Equation 4-21b

$f(X)$ = *Cost* S-Curve = $\frac{1}{1+e^{-2.7(t-1.4)}}$ (Adapted from similar literature) Equation 4-21

In this research study, system dynamics model validation will use real project data. However, as requested by projects' data providers, it is mandatory to avoid showing the actual payments of each used cash flow. In the United Arab Emirates construction industry, the cash flow payments curve is divided into 12 months. Therefore, this research used eight time-steps per year instead of 12 to avoid showing actual payments in this study. The number of time-steps has been reduced from 12 to 8 per year with the projects' data providers' approval. As a result, the final model can be validated using real project data while satisfying its requested confidentiality.

Year Time Step	Cost Cash Flow Increasing S-Curve
0	0.022
0.125	0.031
0.25	0.043
0.375	0.059
0.5	0.081
0.625	0.110
0.75	0.147
0.875	0.195
1	0.254
1.125	0.322
1.25	0.400
1.375	0.483
1.5	0.567
1.625	0.647
1.75	0.720
1.875	0.783
2	0.835
2.125	0.876
2.25	0.908
2.375	0.933
2.5	0.951
2.625	0.965
2.75	0.975
2.875	0.982
3	1.000

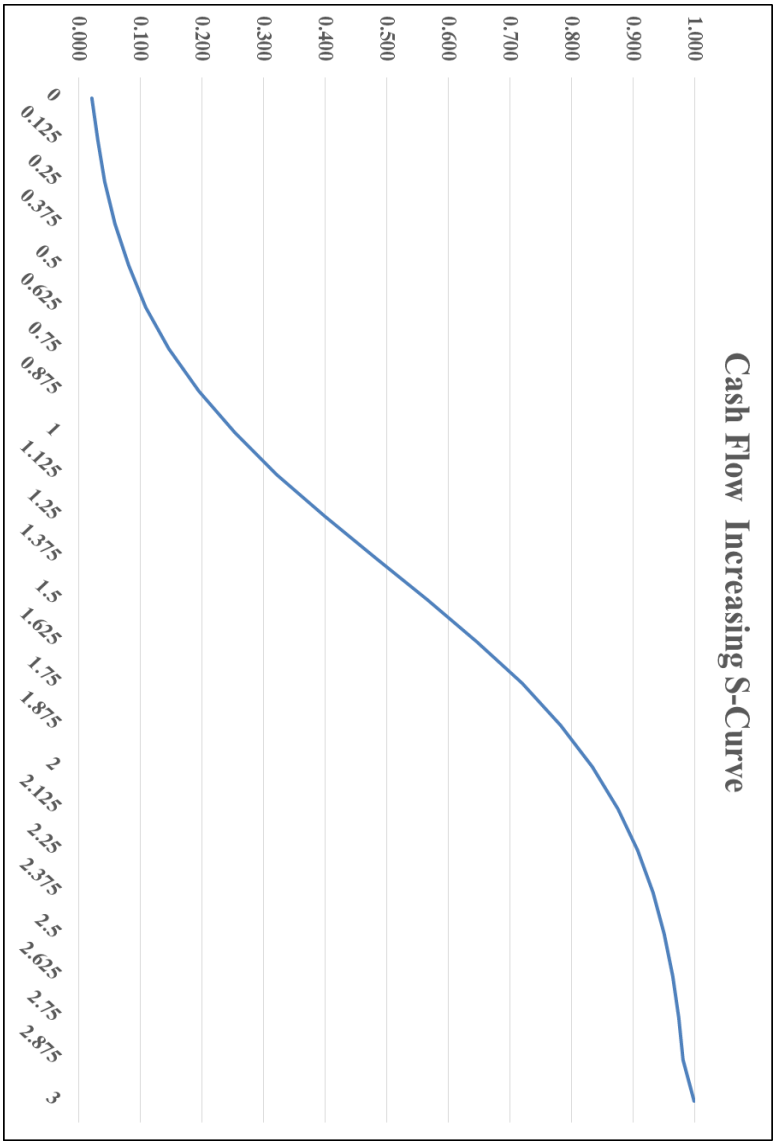


Figure 4-20: The final S-Curve used in this research construction system dynamics cost modelling.

4.3.5.5 Construction Risk S-Curve

According to Oxford Advanced Learner's Dictionary (1995), risk definition is the possibility of suffering harm or loss; or facing danger or failure (Baloi & Price 2003). Therefore, it is challenging to generalise its measurement or its behaviour throughout projects. This mathematical modelling is deterministic because its answer has exact values. However, risks can be used for the study as long its definition can be met and satisfied through the assigned measurement or behaviour criteria (Baloi & Price 2003). Several facts need to be considered in order to finalize the construction risk equation. First, construction risk is taking an exponential function for costs and financial situations (Dowd & Cotter 2007). Second, construction (i.e., buildings) risk behaviour is based on a decreasing S-Curve (Pajares & López-Paredes 2011). Third, to satisfy the risk definition, the probability of facing danger during construction will be in the remaining time, and the amount of cash paid. These are the required risk behaviour considerations in this research system dynamics cost estimation model. The conditional probability intersection relationship between two events is mathematically represented by multiplication (Techet 2005). There are two calculation parts of construction cost risks. The cash flow s-curve is based on time and costs ratio/percentage (i.e., X and Y). First, the probability of facing danger in time at each time step is the weightage of remaining time concerning total construction time. It will equal the ratio of time remaining to total construction time, as shown in equation 4-22. Second, the probability of facing danger in costs at each time step is the weightage of remaining costs concerning total construction cost. It will equal the ratio of remaining unpaid value to total construction cost. This can be extracted from Figure 4-20 and equations 4-23 and 4-24. In equation 4-23, limits function are important to show the exact calculations of C_S as risk time step value (i.e., T_S) approaches cash flow s-curve time step value (i.e., t). Construction risks are active from just before the first cash flow

payment until the last cash flow payment. In other words, construction risks are 100% just before starting and 0% at the finishing time. Thus, the construction risk curve will equal the probability of facing risk in the remaining time multiply by the probability of facing danger in the remaining cash flow amount will equal to this research risk decreasing s-curve as shown in equations 4-25 and 4-26 (Pajares & López-Paredes 2010; Techet 2005; Dowd & Cotter 2007). Therefore, this research risk s-curve will equal to Figure 4-21 chart values. Furthermore, it will be used in the final VENSIM system dynamics cost modelling.

$$P_T = \frac{T_E - T_S}{T_E} = \textbf{Time Risk}$$ Equation 4-22

P_T = the probability of time danger

$\mathbf{T_E}$ = the total execution time

$\mathbf{T_S}$ = the risk time step value

$$C_S = \lim_{T_S \to t} \left(\frac{1}{1 + e^{-1.22(t-1.88)}} \right)$$ Equation 4-23

$\mathbf{C_S}$ = the cost S curve value at each time step (from 0 to 1).

t = the time step of f(x) cash flow point.

$$P_C = [1 - C_S]$$ Equation 4-24

P_C = the probability of cost danger

$$P\,(Time\ Risk \cap Cost\ Risk) = P_T * P_C$$ Equation 4-25

$$\textbf{Risk S-Curve} = \frac{T_E - T_S}{T_E} * \left(1 - \lim_{T_S \to t} \left(\frac{1}{1 + e^{-1.22(t-1.88)}} \right)\right)$$ Equation 4-26

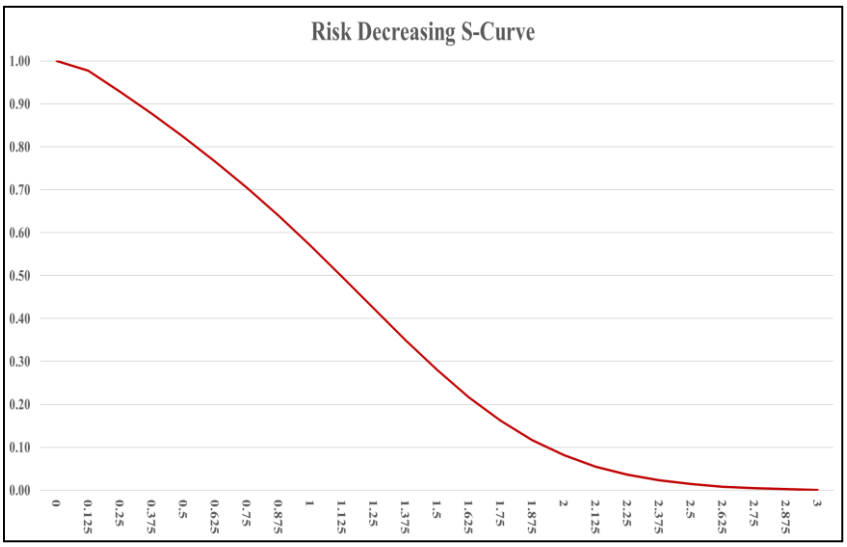


Figure 4-21: Tending the construction Risk S-Curve which will be used in final system dynamics model.

4.3.5.6 Capital Expenditure

This mathematical modelling is deterministic because its answer has exact values. There are several calculation steps to calculate total capital expenditures. First, it must calculate each construction risk-group cost, as shown in equations 4-27 to 4-29. Then, construction activities' risks cost mathematical calculation will use equations 4-30 to 4-32 to include all risks-groups costs concerning construction risk s-curve. Finally, CAPEX total costs will use equation 4-33 to 4-36 to calculate the value used for OPEX calculations in the following stages. Therefore, this research CAPEX mathematical modelling is detailed, as shown in equations 4-27 to 4-36. Finally, the design stage construction contract value is considered the initial stage of this research model cost modelling. This study will adjust the construction contract value provided by contractors at the pre-construction stage by investigating its change under cost risks impact.

$$C_{RGmean} = \sum_{t=0}^{3} \sum_{i=1} \left(\frac{Adjusted\ Mean - \bar{X}}{\bar{X}} \right)$$ Equation 4-27

C_{RGmean} = the mean cost risks of each CAPEX risk group.

t = system dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 3).

i = the risk number in each group (i = 1, 2, 3, …, etc.).

$$C_{RGmin} = \sum_{t=0}^{3} \sum_{i=1} \left(\frac{Min\ Risk}{\bar{X}} * Adjustment\ Mean \right)$$ Equation 4-28

C_{RGmin} = the minimum cost risks of each CAPEX risk group.

t = system dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 3).

i = the risk number in each group (i = 1, 2, 3, …, etc.).

$$C_{RGmax} = \sum_{t=0}^{3} \sum_{i=1} \left(\frac{Max\ Risk}{\bar{X}} * Adjustment\ Mean \right)$$ Equation 4-29

C_{RGmax} = the maximum cost risks of each CAPEX risk group.

t = system dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 3).

i = the risk number in each group (i = 1, 2, 3, …, etc.).

$$C_{RCmean} = 1 + \left(\sum_{t=0}^{3} \sum_{n=1} (C_{RGmean} * \text{Cost S Curve value}) \right)$$ Equation 4-30

C_{RCmean} = CAPEX Risks Cost (mean risk).

t = system dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 3).

n = the group number in CAPEX risks (i = 1, 2, 3, …, etc.).

$$C_{RCmin} = 1 + \left(\sum_{t=0}^{3} \sum_{n=1} (C_{RGmin} * \text{Cost S Curve value}) \right)$$ Equation 4-31

C_{RCmin} = CAPEX Risks Cost (min risk).

t = system dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 3).

n = the group number in CAPEX risks (i = 1, 2, 3, …, etc.).

$$C_{RCmax} = 1 + \left(\sum_{t=0}^{3} \sum_{n=1} (C_{RGmax} * \text{Cost S Curve value}) \right)$$ Equation 4-32

C_{RCmax} = CAPEX Risks Cost (max risk).

t = system dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 3).

n = the group number in CAPEX risks (i = 1, 2, 3, …, etc.).

$$C_D = (D_T * \text{Cost S Curve value})$$ Equation 4-33

C_D = initial construction contract cost at each time steps (t = 0, 0.125, 0.25, …, 3).

D_T = the initial construction contract cost at pre-construction design stage

$$\boldsymbol{CAPEX\ Total\ Cost\ (mean\ risks)} = \sum_{t=0}^{3} (C_D * C_{RCmean} * \text{Risk S Curve value})$$ Equation 4-34

C_{RCmean} = CAPEX Risks Cost (mean risk).

t = system dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 3).

C_D = initial construction contract cost at each time steps (t = 0, 0.125, 0.25, …, 3).

$$\boldsymbol{CAPEX\ Total\ Cost\ (min\ risks)} = \sum_{t=0}^{3} (C_D * C_{RCmin} * \text{Risk S Curve value})$$ Equation 4-35

C_{RCmin} = CAPEX Risks Cost (min risk).

t = system dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 3).

C_D = initial construction contract cost at each time steps (t = 0, 0.125, 0.25, …, 3).

$$\boldsymbol{CAPEX\ Total\ Cost\ (max\ risks)} = \sum_{t=0}^{3} (C_D * C_{RCmax} * \text{Risk S Curve value})$$ Equation 4-36

C_{RCmin} = CAPEX Risks Cost (min risk).

t = system dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 3).

C_D = initial construction contract cost at each time steps (t = 0, 0.125, 0.25, …, 3).

4.3.5.7 Equipment Replacement

This mathematical modelling is empirical because it is based on real data. The published literature shows that MEP cost has a percentage of the total building cost (Riley et al. 2005). However, Figure 4-22 summarizes MEP cost percentage based on building type (Riley et al. 2005). Also, researchers studied MEP replacement over its life cycle to measure its cost (Wu & Clements-Croome 2007). These researches proved that the equipment life span is equal to 25 years (Wu & Clements-Croome 2007). Therefore, this research study assigns equipment replacement intervals every 25 years using equation 4-37.

Facility type	MEP cost classification		
	High	Medium	Low
	MEP cost as percent of total building cost		
Semiconductor plants	60	50	40
Biotechnology plants	65	55	45
Heavy industrial plants	60	50	40
Multiresidential complexes	25	20	15
Commercial buildings	40	30	15
Research laboratories	50	40	30
Hospitals	50	40	30

Figure 4-22: This figure is adapted by "Riley et al., 2005" for "Tao et al., 2001" table showing the percentage of MEP costs compared to the total building costs including residential building projects (Riley et al., 2005).

$$\boldsymbol{Equipment\ Replacement} = \sum_{t=28}^{53} (D_T * E_C) \qquad \text{Equation 4-37}$$

t = system dynamics time of pulse impact (t = 28, 53). Every 25 years after CAPEX.

D_T = the initial construction contract cost at pre-construction design stage

E_C = equipment replacement cost as a ratio of total building cost ($E_C = 0.15$)

4.3.5.8 Operational Expenditure

This mathematical modelling is deterministic because its answer has exact values. Unlike capital expenditures (i.e., CAPEX), projects' operational expenditures (i.e., OPEX) are following linear relation with risks and time (Kirkwood et al. 2016). In projects' forecasting, researchers concluded that it is important to start activating OPEX calculations just after deactivating CAPEX calculation impact, without overlapping, to end with accurate estimation results (Cambini, Congiu & Soroush 2020). Operational expenditure includes all facilities' operation-and-maintenance costs (i.e., O & M), spare parts costs, and energy costs (Sharma, Najafi & Qasim 2013). Previous research found that buildings operation and maintenance have

an average equal to 9% of the buildings MEP initial investment costs (i.e., 15% of construction total costs) over 25 years, as shown in Figures 4-22 and 4-23 (Wu & Clements-Croome 2007). Thus, operation and maintenance cost equal to 0.09 multiply by CAPEX total cost multiply by 0.15.

Ratios	Median	Mean	Standard deviation	Skewness	Kurtosis
Maintenance costs over initial costs	0.63	0.69	0.31	2.74	7.95
Operating and maintenance costs over initial costs	7.77	9	5.17	3.29	12.33

Figure 4-23: This figure is adapted by Wu and Clements-Croome (2007) for Schaufelberger and Jacobson (2000) and Fuller (2005) table showing the percentage of operations and maintenance costs compared to the total building costs including residential buildings projects (Riley et al. 2005).

However, it excludes equipment replacement costs because CAPEX is considered in some research and OPEX in other research (Sharma, Najafi & Qasim 2013; Ioannou, Angus & Brennan 2017). However, this research study will include equipment replacement separately, as CAPEX adjustments, in the final project's whole life cycle cost model. OPEX mathematical modelling equation is based on CAPEX value, as shown in equations 4-38 to 4-46.

$$O_{RGmean} = \sum_{i=1} \left(\frac{Adjusted\ Mean - \bar{x}}{\bar{x}} \right)$$ Equation 4-38

O_{RGmean} = the mean cost risks of OPEX risk group.

i = the risk number in OPEX group (i = 1, 2, 3, …, etc.).

$$O_{RGmin} = \sum_{i=1} \left(\frac{Min\ Risk}{\bar{x}} * Adjustment\ Mean \right)$$ Equation 4-39

O_{RGmin} = the minimum cost risks of OPEX risk group.

i = the risk number in OPEX group (i = 1, 2, 3, …, etc.).

$$O_{RGmax} = \sum_{i=1} \left(\frac{Max\ Risk}{\bar{x}} * Adjustment\ Mean \right)$$ Equation 4-40

C_{RGmax} = the maximum cost risks of OPEX risk group.

i = the risk number in OPEX group (i = 1, 2, 3, …, etc.).

$$\boldsymbol{O_{RCmean} = OPEX\ Risks\ Cost\ (mean\ risk) = 1 + \sum_{t=3}^{60} \left(\frac{O_{RGmean} * O_M * E_C}{Y_{TS}}\right)}$$

Equation 4-41

$\mathbf{Y_{TS}}$ = the number of time steps per year (Y_{TS} = 8).

t = system dynamics time steps (t = 3, 3.125, 3.25, 3.375, 3.5, …, 60).

$\boldsymbol{O_M}$ = the ratio of operation and maintenance to initial capital investment ($\boldsymbol{O_M}$ = 0.09/25).

$\boldsymbol{E_C}$ = the equipment to initial capital investment ratio ($\boldsymbol{E_C}$ = 0.15).

$$\boldsymbol{O_{RCmin} = OPEX\ Risks\ Cost\ (min\ risk) = 1 + \sum_{t=3}^{60} \left(\frac{O_{RGmin} * O_M * E_C}{Y_{TS}}\right)}$$

Equation 4-42

$\mathbf{Y_{TS}}$ = the number of time steps per year (Y_{TS} = 8).

t = system dynamics time steps (t = 3, 3.125, 3.25, 3.375, 3.5, …, 60).

$\boldsymbol{O_M}$ = the ratio of operation and maintenance to initial capital investment ($\boldsymbol{O_M}$ = 0.09/25).

$\boldsymbol{E_C}$ = the equipment to initial capital investment ratio ($\boldsymbol{E_C}$ = 0.15).

$$\boldsymbol{O_{RCmax} = OPEX\ Risks\ Cost\ (max\ risk) = 1 + \sum_{t=3}^{60} \left(\frac{O_{RGmax} * O_M * E_C}{Y_{TS}}\right)}$$

Equation 4-43

$\mathbf{Y_{TS}}$ = the number of time steps per year (Y_{TS} = 8).

t = system dynamics time steps (t = 3, 3.125, 3.25, 3.375, 3.5, …, 60).

$\boldsymbol{O_M}$ = the ratio of operation and maintenance to initial capital investment ($\boldsymbol{O_M}$ = 0.09/25).

$\boldsymbol{E_C}$ = the equipment to initial capital investment ratio ($\boldsymbol{E_C}$ = 0.15).

$$\boldsymbol{OPEX\ Total\ Cost\ (mean\ risk) = \sum_{t=3}^{60} (D_T * O_{RCmean})}$$

Equation 4-44

t = system dynamics time steps (t = 3, 3.125, 3.25, 3.375, 3.5, …, 60).

D_T = the initial construction contract cost at pre-construction design stage.

O_{RCmean} = OPEX risks cost (mean risk).

$$\boldsymbol{OPEX\ Total\ Cost\ (min\ risk) = \sum_{t=3}^{60} (D_T * O_{RCmin})}$$

Equation 4-45

t = system dynamics time steps (t = 3, 3.125, 3.25, 3.375, 3.5, …, 60).

D_T = the initial construction contract cost at pre-construction design stage.

O_{RCmin} = OPEX risks cost (min risk).

$$\boldsymbol{OPEX\ Total\ Cost\ (max\ risk)} = \sum_{\boldsymbol{t=3}}^{\mathbf{60}} (D_T * O_{RCmax}) \qquad \text{Equation 4-46}$$

t = system dynamics time steps (t = 3, 3.125, 3.25, 3.375, 3.5, …, 60).

D_T = the initial construction contract cost at pre-construction design stage.

O_{RCmax} = OPEX risks cost (max risk).

4.3.5.9 Project's Whole Life Cycle Total Expenditure

Total expenditure (i.e., TOTEX) mathematical modelling is the last step, before NPV, in forming this research system dynamics, final cost model. Regulators use TOTEX to address projects' cost problems and make investment decisions (Cambini, Congiu & Soroush 2020). Previous research proved that the TOTEX approach has great efficiency in assessing large investment projects (Cambini, Congiu & Soroush 2020). Therefore, this research study is including the project's whole life cycle total cost (i.e., TOTEX) in its cost estimation final model. TOTEX will be calculated for each risk level (i.e., minimum, mean, and maximum risks). The mathematical calculation will equal the summation of CAPEX total costs, OPEX total costs, and equipment costs in each step of the project cycle. Finally, this mathematical model is considered deterministic because it will provide exact values for each time step output. It will also create the combined cost chart from the first time-step to the last time-step of residential projects' whole life cycle (i.e., 60 years). Equations 4-47 to 4-49 will present TOTEX mathematical equations.

$$\text{TOTEX}_{\text{mean}} = \sum_{t=0}^{60} \begin{pmatrix} OPEX\ Total\ Cost\ (mean\ risk) \\ +CAPEX\ Total\ Cost\ (mean\ risk) \\ +Equipment\ Replacement \end{pmatrix}$$ Equation 4-47

t = System dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 60).

$\text{TOTEX}_{\text{mean}}$ = Total expenditure under mean risk impact.

$$\text{TOTEX}_{\text{min}} = \sum_{t=0}^{60} \begin{pmatrix} OPEX\ Total\ Cost\ (min\ risk) \\ +CAPEX\ Total\ Cost\ (min\ risk) \\ +Equipment\ Replacement \end{pmatrix}$$ Equation 4-48

t = System dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 60).

$\text{TOTEX}_{\text{min}}$ = Total expenditure under minimum risk impact.

$$\text{TOTEX}_{\text{max}} = \sum_{t=0}^{60} \begin{pmatrix} OPEX\ Total\ Cost\ (max\ risk) \\ +CAPEX\ Total\ Cost\ (max\ risk) \\ +Equipment\ Replacement \end{pmatrix}$$ Equation 4-49

t = System dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 60).

$\text{TOTEX}_{\text{max}}$ = Total expenditure under maximum risk impact.

4.3.5.10 Net Present Value

Previous research proved that a project's whole lifecycle cost estimation requires net present value (i.e., NPV) calculations (Akter, Mahmud & Oo 2017). This is essential for investment return appropriate decisions (Akter, Mahmud & Oo 2017). The discount rate of calculating NPV can be extracted from local government financial institutions (Florio, Forte & Sirtori 2016). Previous research agreed that operational expenditure NPV is mandatory for future investment cost models (Akter, Mahmud & Oo 2017; Florio, Forte & Sirtori 2016). Thus, this research study will consider net present value calculation for each OPEX and project the whole life cycle using equations 4-50 to 4-52 and UAE discount rate in Figure 4-23 (Jang 2011). However, construction capital initial investment does not require separate NPV (McLean & McGovern 2017; Nguyen, Ogunlana & Lan 2004; Abdelsalam & Gad 2009). The return on investment in CAPEX is measured based on criteria other than NPV, such as the

performance, quality, and cost (McLean & McGovern 2017; Nguyen, Ogunlana & Lan 2004; Abdelsalam & Gad 2009). It is the most accurate way to ensure that the operational project stage will function without fail (McLean & McGovern 2017; Nguyen, Ogunlana & Lan 2004; Abdelsalam & Gad 2009). Therefore, this research study included CAPEX measurement criteria as justified earlier by considering all its related risks. There will be no separate NPV calculations for CAPEX. However, it can be extracted from the project's whole life cycle NPV chart.

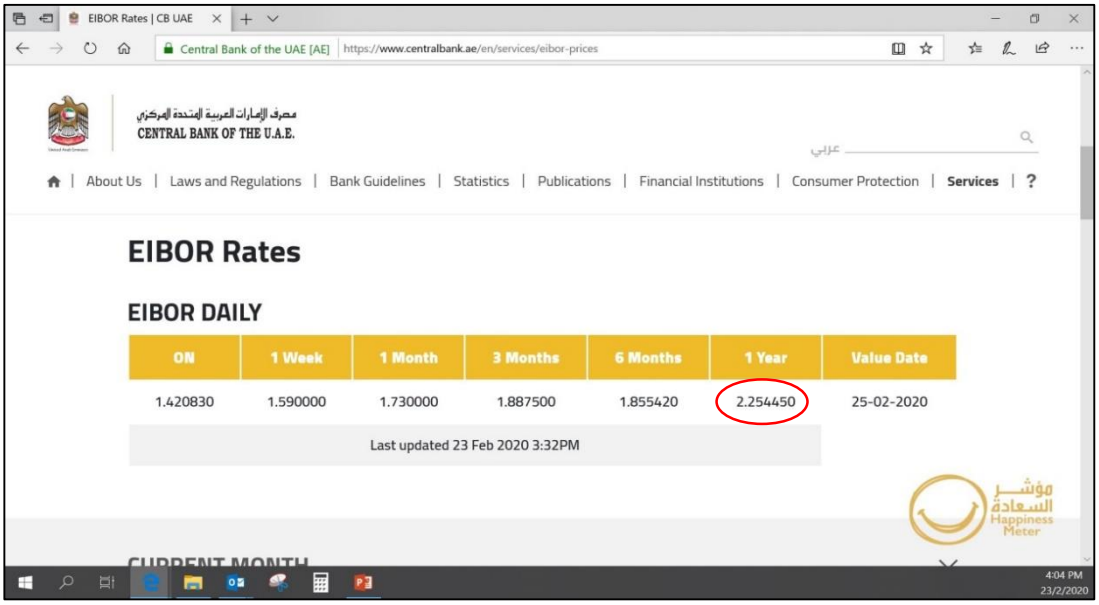


Figure 4-24: a screen shot of the official EIBOR rate value in the United Arab Emirates as of 23rd February 2020 which is used in calculating the net present value of the developed system dynamics model and its mathematical equation system.

$$NPV_{PWLCmean} = \sum_{t=0}^{60} \left(\frac{TOTEX_{mean}}{\left(1 + \frac{EIBOR}{100}\right)^{t}} \right) \qquad \text{Equation 4-50}$$

$NPV_{PWLCmean}$ = Net Present Value of project's whole life cycle under mean risk impact

t = System dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 60).

EIBOR = The discount rate provided by the Central Bank of UAE in percentage.

$TOTEX_{mean}$ = Total expenditure under mean risk impact.

$$NPV_{PWLCmin} = \sum_{t=0}^{60} \left(\frac{TOTEX_{min}}{\left(1 + \frac{EIBOR}{100}\right)^{t}} \right)$$ Equation 4-51

$NPV_{PWLCmin}$ = Net Present Value of project's whole life cycle under minimum risk impact

t = System dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 60).

EIBOR = The discount rate provided by the Central Bank of UAE in percentage.

$TOTEX_{min}$ = Total expenditure under minimum risk impact.

$$NPV_{PWLCmax} = \sum_{t=0}^{60} \left(\frac{TOTEX_{max}}{\left(1 + \frac{EIBOR}{100}\right)^{t}} \right)$$ Equation 4-52

$NPV_{PWLCmax}$ = Net Present Value of project's whole life cycle under maximum risk impact

t = System dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 60).

EIBOR = The discount rate provided be Central Bank of UAE in percentage.

$TOTEX_{max}$ = Total expenditure under maximum risk impact.

4.3.5.11 Project's Whole Lifecycle System Dynamics

System dynamics can be defined as a set of variables and components interacting with each other through different relationships (Yuan et al. 2011; Marzouk & Azab 2014; Sterman 2003; Choopojcharoen & Magzari 2012). Modelling is essential to understanding the skeleton's problem and how decisions will impact its outputs (Choopojcharoen & Magzari 2012). The beauty of system dynamics modelling is that it can clarify variables movements through time using linear and non-linear mathematical modelling (Yuan et al. 2011; Marzouk & Azab 2014; Sterman 2003; Choopojcharoen & Magzari 2012). It will allow us to see graphically (i.e., charts and diagrams) and numerically all events and changes within a modelled system. This mathematical modelling classification is under dynamical mathematics. This is because the VENSIM software programme is based on differential equations and time-based analysis

(Yuan et al. 2011; Marzouk & Azab 2014; Sterman 2003; Choopojcharoen & Magzari 2012). First, the used approach in this research is based on stock and flow dynamics as justified earlier. However, equations 4-53 to 4-55 clarify how VENSIM uses the previous mathematical models in stock and flow dynamical system as shown in Figure 4-25 (Yuan et al. 2011; Marzouk & Azab 2014; Sterman 2003; Choopojcharoen & Magzari 2012).

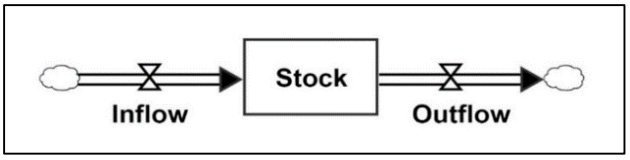


Figure 4-25: System Dynamics stock and flow diagram.

$$\frac{d(Stock)}{dt} = Inflow(t) - Outflow(t) \qquad \text{Equation 4-53}$$

$$Stock(t) = \int_0^t [flows_{total}(s)]\, ds \qquad \text{Equation 4-54}$$

$$Stock(t) = \int_0^t [Inflow(s) - Outflow(s)]\, ds + Stock(0) \qquad \text{Equation 4-55}$$

t = System dynamics time steps (t = 0, 0.125, 0.25, 0.375, 0.5, …, 60).

The two types of system dynamics diagrams are open flow diagrams and causal loop diagrams (Yuan et al. 2011; Marzouk & Azab 2014; Sterman 2003; Choopojcharoen & Magzari 2012). Causal loops are not used in this research cost modelling. However, it has been introduced earlier in this study. On the other hand, open flow diagrams are used through the stock and flow dynamical systems. The previous researcher explained the approach of solving open flow problems based on identifying the problem's goals and situation (Sterman 2003). Then analyze it to have a decision (Sterman 2003). Then, implement the solution/decision to obtain desired results (Sterman 2003). Figure 4-26 is explaining how to open flow problems should be handled (Sterman 2003). Therefore, this research study identified the goal of building

a cost estimation model using a system dynamics approach to solve the problem of having issues in projects' cost estimation as justified in chapter 2. Finally, the results will be discussed in the following chapters to obtain this research investigation answers.

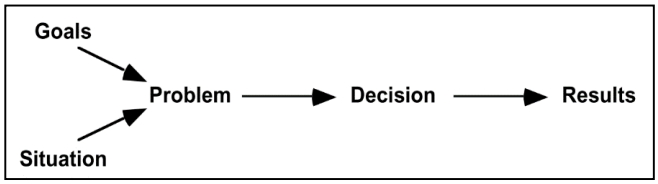


Figure 4-26: problem solving approach based on open flow system (Sterman 2003).

According to researchers, stock and flow systems are like water inflow and outflow from a basin, as shown in Figure 4-27 (Sterman 2003). It is because of the differences between inflow and outflow rates (Sterman 2003). The inflow and outflow can change to adapt linear and nonlinear mathematical models (Yuan et al. 2011; Marzouk & Azab 2014; Sterman 2003; Choopojcharoen & Magzari 2012). However, the stock results from inflows and outflows in an open flow system (Yuan et al. 2011; Marzouk & Azab 2014; Sterman 2003; Choopojcharoen & Magzari 2012). In this research study, cost cash-flow and rate over time are considered the system inflow and outflow. On the other hand, total costs until any time step point are considered the stock of this research system. The overall main stocks are CAPEX, OPEX, and TOTEX. Mathematical equations are considered the valves of this research inflow and outflows.

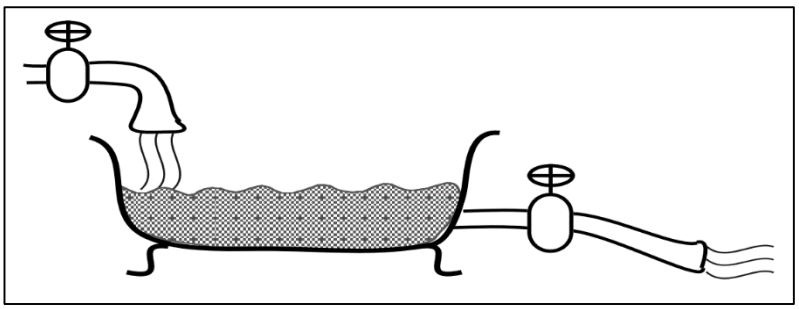


Figure 4-27: System Dynamics stock and flow conceptual framework (Sterman 2003).

Next, the basic mathematics used in VENSIM system dynamics modelling and simulation are presented in equations 4-56 to 4-634. It is extracted from the online official VENSIM software tutorial reference manual. In equations 4-56 and 4-57, the time base function is required to ensure that time steps as variables of previously defined mathematical modelling equations are not experiencing any evolution through time. Equation 4-58 is representing function evolution over time. Equation 4-59 represents the rates computations of evolution determinations. Equation 4-60 is representing the functions required to compute the rates. Equation 4-61 is representing the system initialization function. These functions are connected using a graphical representation of each mathematical relationship shown in Figure 4-28. $Levels_t$, $Aaux_t$, $data_t$, and $const_t$ are various types that VENSIM can adapt.

$$\boldsymbol{TIME\ BASE}\left(\boldsymbol{newtime}, \frac{\boldsymbol{newtime}}{\boldsymbol{time}}\right)$$ Equation 4-56

Time Base = the function of defining time as a variable to use in equations.
newtime = the simulation starting time step of time steps series (newtime = 0).
Time = the defined time steps and whole life cycle length in sittings.
$\frac{\text{newtime}}{\text{time}}$ = the dynamical movement slope (TIME BASE Slop = 1).
$TIME\ BASE(0,1)$ is used in this research study to enforce calculating time variable as per the defined time steps. (t = (0,0), (0.125,0.125) …, (time-step t_n, time-step t_n))

$$\boldsymbol{TIME\ BASE}\ (\boldsymbol{START}\ +\ \boldsymbol{Time} * \boldsymbol{SLOPE})$$ Equation 4-57

Time Base = the function of defining time as a variable to use in equations.
(START+Time*SLOPE) = the dynamical simulation movement of Time Base function.

$$levels_t = \int_0^T rates_t dt \quad \text{or} \quad \frac{d}{dt} levels_t = rates_t$$ Equation 4-58

$$rates_t = g(levels_t, aux_t, data_t, const)$$ Equation 4-59

$$aux_t = f(levels_t, aux_t, data_t, const_t) = 0$$ Equation 4-60

$levels_0 = h(levels_0, aux_0, data_0, const)$	Equation 4-61
`LOOKUP NAME(X1, X2, X3,....Xn, Y1, Y2, Y3,....Yn)`	Equation 4-62
`LOOKUP NAME ([(Xmin, Ymin)-(Xmax, Ymax),(Xref1,Yref1), (Xref2,Yref2),...(Xrefn,Yrefn)] (X1,Y1),(X2,Y2),...(Xn, Yn))`	Equation 4-63

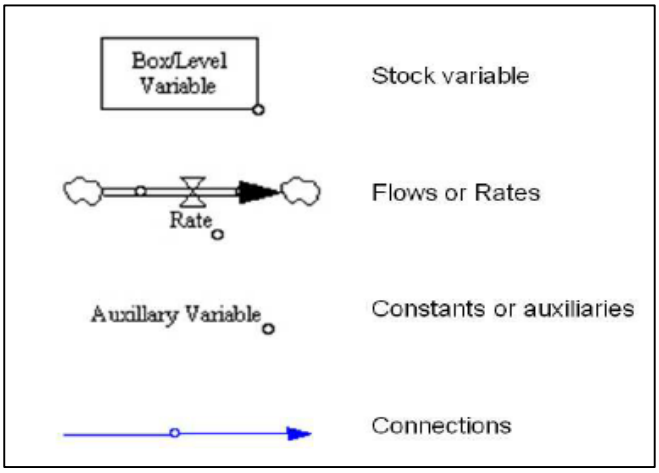


Figure 4-28: System Dynamics mathematics relationships graphical representation in VENSIM Software.

In equations 4-62 and 4-63, the LOOKUP Table function ensures that each of the VENSIM system dynamics simulations does not violate the mathematical modelling function. Figure 4-29 is an example of how to set a LOOKUP Table in VENSIM software.

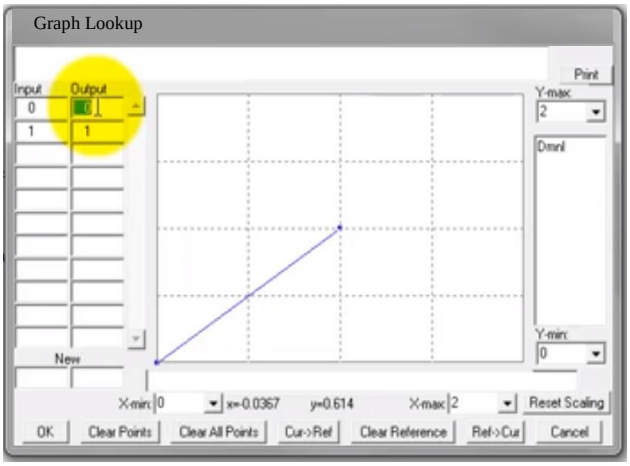


Figure 4-29: System Dynamics Lookup Table Graph conceptual framework from VENSIM Software.

4.3.5.12 Forecasting Accuracy Error

Calculating and measuring accuracy error is essential for any forecasting or modelling study; however, this is because it is required to know how much forecasting results reflect the actual value (Koo, Hong & Hyun 2010; Xu & Moon 2013; Shahandashti & Ashuri 2013; Odeyinka, Lowe & Kaka 2013; Huang et al. 2015; Hyari, Al-Daraiseh & El-Mashaleh 2016; Murillo-Hoyos, Volovski & Labi 2016). Measuring accuracy error is commonly used in quantitative and modelling research after validating the created forecasting system using real data (Koo, Hong & Hyun 2010; Xu & Moon 2013; Shahandashti & Ashuri 2013; Odeyinka, Lowe & Kaka 2013; Huang et al. 2015; Hyari, Al-Daraiseh & El-Mashaleh 2016; Murillo-Hoyos, Volovski & Labi 2016).

$$Error = A_t - F_t \quad \text{Equation 4-64}$$

$$MAD = \frac{\sum_{n=0}^{t} |A_t - F_t|}{\mathrm{T}} \quad \text{Equation 4-65}$$

$$MSE = \frac{\sum_{n=0}^{t} (A_t - F_t)^2}{\mathrm{T}} \quad \text{Equation 4-66}$$

$$MAPE = \frac{\sum_{n=0}^{t} [A_t - F_t]}{\mathrm{A_t}} * \mathrm{T} \quad \text{Equation 4-67}$$

MAD = Mean Absolute Deviation.

MSE = Mean Squared Error.

MAPE = Mean Absolute Percentage Error.

A_t = Actual Value at (t) time.

F_t = Forecast Value at (t) time.

T = The number of time periods.

From previous research, adapted equations have been assigned to measure the error of this research final cost estimation model using equations 4-64 to 4-67; nevertheless, using mean absolute deviation and mean square error have been proved very effective in calculating system dynamics and mathematical modelling error percentage (Koo, Hong & Hyun 2010; Xu & Moon 2013; Shahandashti & Ashuri 2013; Odeyinka, Lowe & Kaka 2013; Huang et al. 2015; Hyari, Al-Daraiseh & El-Mashaleh 2016; Murillo-Hoyos, Volovski & Labi 2016). Thus, this research study will use real project data to validate the final system dynamics cost model and apply the mean square error approach to measure its accuracy.

4.3.6 Final System Dynamics Model

System dynamics final model, in this study, is built in the last research stage. It is because of the need for prerequisite inputs preparation stages. Each input will be framed, analysed, and validated before using it in the system dynamics final model. First, cost risk inputs are the main components of this study. They need to be mapped, collected, and validated to ensure accurate modelling outputs. Second, mathematical modelling is the main driving engine of this modelling study. It is providing how and why modelling components interact with each other. Finally, VENSIM software algorithms are the main artificial intelligence brain binding all components together over time using the desired mathematical modelling approach.

Therefore, this research study's final system dynamics model will be the main original contribution to the body of project management knowledge. This significance is because of several reasons that resulted from this study as justified earlier. First, system dynamics cost estimation modelling provide accurate charts of cash flow curves under several risks impact. Second, it is allowing us to adapt directly to future changes in cost risk rates. This will create updated cash flow curves under minimum, mean, and maximum risks' impact in future

estimation using the same model. Third, this final research model presents detailed values for each time step, including the cash flow under the zero-risk impact, minimum-risk impact, mean-risk impact, and maximum-risk impact. Fourth, all provided data resulted from system dynamics modelling simulations can be exported out of the VENSIM software programme to be used in other software programmes for further analysis or reporting purposes. Finally, this research study delivers a model capable of presenting more than four simulations simultaneously, including all cash flow curves in one chart and including all simulations' exact values of each time step in one exportable table.

4.3.7 Demolition

The demolition stage of the project's whole life cycle cost estimation modelling is not included mathematically. Instead, it is included as a milestone event representing the end of the residential project's life cycle. There are several reasons for not including mathematical demolition calculation in modelling future costs over 60 years. These reasons have been discussed in chapter 3; however, as shown in Figure 3-14, demolition has an exceptionally low impact on the project's whole life cycle net present value. However, this research study will introduce the debates on demolishing costs and recommend further research in this regard.

There are three primary debates about demolition and deconstruction concept (Han, Srebric & Enache-Pommer 2014; Doan & Chinda 2016; Creba 2019; Marrero & Ramirez-De-Arellano 2010). First, researchers argued that project demolition costs are based on labours and equipment required to complete the task while satisfying the environmental and technical requirements (Han, Srebric & Enache-Pommer 2014; Creba 2019). They declared that it is a part of a project's whole life cycle and should be included in the cost modelling process (Han, Srebric & Enache-Pommer 2014). They located this activity in the last stage of the project's

whole life cycle and considered demolition to be the end of building and infrastructure projects (Han, Srebric & Enache-Pommer 2014). This is the worst scenario impacting the project's whole life cycle cost (i.e., causing additional costs). Therefore, as discussed in chapter 3 of this research study and as shown in Figure 3-14, it is not required to add any mathematical modelling to measure demolition cost risks in the final cost estimation model. Second, previous research classified demolition and deconstruction as a development transformation stage (Creba 2019). It is connected with architecture, modern movements, and urban designs to satisfy cultural and social requirements (Creba 2019). This direction is based on the capitalist economic system (Creba 2019). Nonetheless, there are demolition exceptions for government urban planning and development (Creba 2019). The main exclusion from building demolition and deconstruction is considering the building as a historical property (Creba 2019). The rule of thumb in considering historical properties is based on at least 50 years old (Williams & Crass 2020). However, according to the United States' Georgia department of natural resources under the historical preservation division, historical buildings must be registered in the government system (Williams & Crass 2020). This will require three mandatory attributes to consider buildings as historical properties (Williams & Crass 2020). First, the building's age should be at least 50 years old (Williams & Crass 2020). Building integrity (i.e., unchanged original status) should be met and maintained (Williams & Crass 2020). Finally, buildings' significance should be met and maintained by direct association with shaped history, physical, historical architecture characteristics, or the ability to generate information to understand the past (Williams & Crass 2020). To summarize the second debate of demolition costs, capitalist economics' approach is to convert projects with completed life cycle either to historical buildings or to reinvestment projects (Creba 2019; Williams & Crass 2020).

The third demolition debate considers buildings' demolition wastes like construction wastes (Marrero & Ramirez-De-Arellano 2010; Doan & Chinda 2016). This argument is based on applying a construction waste management system on demolishing wastes (Marrero & Ramirez-De-Arellano 2010; Doan & Chinda 2016). It will include material recycling and material disposal following the same authorities' requirements and regulations (Marrero & Ramirez-De-Arellano 2010; Doan & Chinda 2016). The reason behind this approach is due to having the demolition of an ended project in the same time window of the replacement project reconstruction (Marrero & Ramirez-De-Arellano 2010; Doan & Chinda 2016). In most cases, the demolition happened to accomplish a new development and treated during the reconstruction stage as using construction waste management approaches as shown in figures 4-30 and 4-31 (Marrero & Ramirez-De-Arellano 2010; Doan & Chinda 2016; Won & Cheng 2017; Saez et al. 2013). The second and third debates agree on merging the demolition stage with the construction stage and consider it a generated construction waste during reinvestment projects execution (Marrero & Ramirez-De-Arellano 2010; Doan & Chinda 2016; Won & Cheng 2017; Saez et al. 2013; Creba 2019; Williams & Crass 2020).

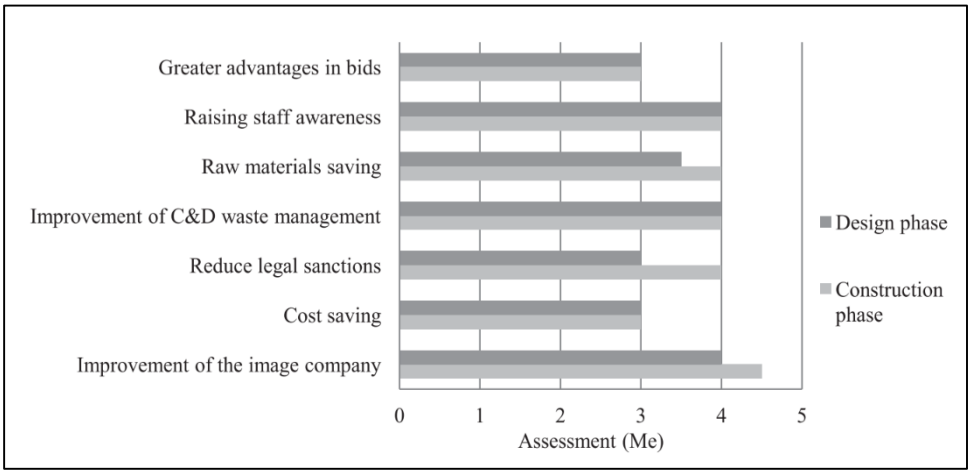


Figure 4-30: The best practices of handling construction and demolition (C & D) waste management costs during design and construction stages based on data median (Me) assessment (Won & Cheng 2017).

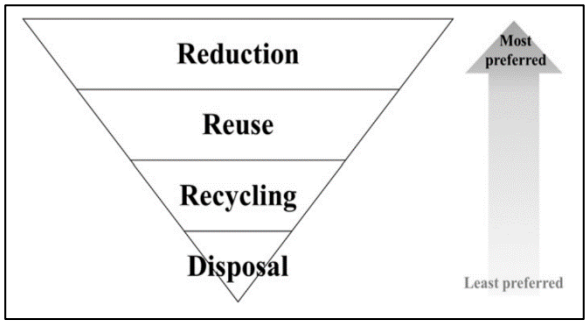


Figure 4-31: Construction and demolition waste management approach (Saez et al. 2013).

Therefore, this research study will not include demolition calculation in future cost estimation of large investments over a long-life span due to the low-cost impact of the first argument on NPV (i.e., investment measurement criteria). Furthermore, it is due to the unknown possibility of turning the project into a historical building or merge its demolition with the investments reconstruction stage. The CAPEX sub-model covers all construction waste management risks based on design stage construction contract value (i.e., including land preparation for construction). However, the second and third arguments are the best choice for a capitalist country like the United Arab Emirates, supporting the decision made by this research study.

4.4 Summary

To sum up, in chapter 4, this pure quantitative research methodology and design have discussed in detail all aspects of successfully answering its questions and meeting its objectives. This research study aims to approach system dynamics using VENSIM software programme to model the project's whole life cycle future costs, including its cashflow simulation under different scenarios. All choices and decisions in this study have been justified and clarified. All mathematical and statistical modelling has been framed and is ready to be used in further analysis. However, the key outputs of this research will be summarised in this

section. Moreover, it is recommended to refer to detailed discussions if any additional information is required.

The reasons for choosing this research approach as solely quantitative are detailed at the beginning of this chapter. However, the approach of collecting and analysing data reliability and validity is the main criterion of assigning quantitative research approach executively for this study. This chapter provided a brief about qualitative and mixed methods and justified, with evidence from literature, and their inability to fit this study.

In the beginning, it is mandatory to cover how these research questions have been answered. Therefore, the first research question, (What are the risks' values of UAE residential project's whole life cycle cost estimation?), has been answered through extracting data from experts and ensure its reliability, validity, accuracy, and precision. This is accomplished by conducting face to face survey interviews with experts using the designed questionnaire in appendix A. Then, verify its reliability and validity using correlation and statistical regression modelling as detailed in appendix B. Then, create the adapting linear equations using risk impacts and probabilities. Finally, the last step of answering the first research question is utilising Monte Carlo simulation to confirm its accuracy and precision to obtain the experts' risk error (i.e., risks from a client perspective).

After that, the second question, (How to model mathematically and graphically map all identified and verified risks?), has been set for the investigation to complete the journey of meeting this research aim and objectives. The mathematical equation system requires several steps before utilizing it in any software programmes analysis (i.e., SPSS and VENSIM). Data significance, reliability, and validity mathematical equations system have been provided to complete the first research question successfully. This means that answering the second research question will start before fully answering the first research question. Then, Monte

Carlo mathematical modelling has been detailed with justification evidence for each step. After that, the equations system used in system dynamics modelling includes construction cashflow and risks S-Curves. It is followed by capital expenditure (i.e., CAPEX), equipment replacement, and operational expenditure (i.e., OPEX) mathematical calculation system. Finally, the project's whole life cycle total expenditure (i.e., TOTEX) and net present values (i.e., NPVs) mathematical computing system have been detailed as a final step before answering the third research question. Nevertheless, there is another overlapping in answering the second research question with the third research question. It is because of the need to understand VENSIM software programme modelling basic mathematics. This will provide a clear understanding of how a system dynamics software use cost estimation equations system overtime to provide final accurate outputs.

Next, answering the third research question, (How to approach modelling cost estimation dynamics through time, including cashflow, for UAE residential building projects' whole life cycle?), is explained in this chapter by detailing the process of developing and validating VENSIM system dynamics simulation model for residential project's whole life cycle cost estimation in UAE. This task is achieved by using the collected and validated risks in the developed computing mathematical equations system. The development stage of the VENSIM model is based on accurately mapping all related risks in groups, as explained in chapter 3. It is then essential to define the project's whole life cycle criteria in VENSIM software platform settings. It is required to insert all risk rates and mathematical equations in the built dynamical system. Ensuring the model's function by running simulations and obtain outputs without system-errors based on the provided inputs. The VENSIM system dynamics final model's validation stage is achieved using real data of 3 completed residential projects in the United Arab Emirates. This is to investigate the developed model's cashflow of each time

step compared with the actual projects' cash flows at the same time steps. Finally, the validation process of this research's final model' outputs (i.e., aim and objectives) cannot be completed without measuring its accuracy. This is achieved using the mean square error approach (i.e., MSE), as explained and detailed in chapter 4.

In conclusion, it is essential to present key information points that resulted from this chapter discussions and arguments. First, the project's whole life cycle timespan is equal to 60 years. CAPEX timespan is equal to 3 years. OPEX timespan is equal to 57 years. Second, the acceptable collected data for each risk variable is equal to 55 samples. Monte Carlo simulation is using 10,000 iterations for each risk variable. Finally, the following chapters are the execution, outputs, and conclusion of this research methodology design.

Chapter 5
DATA COLLECTION AND VALIDATION

"*The challenge is to define the measures and to find them economically and swiftly*".

(Phillips & Stawarski 2013, p.118)

5.0 Introduction

The implementation of data collection and validation procedures will be detailed following the explained and justified research methodology design of this research. In this chapter, there are three main arguments related to data collection and analysis presented as the following:

1- Experts' competencies.

2- Data correlation analysis.

3- Data regression analysis.

Each argument will include a comprehensive discussion to highlight the key points and interpret data collection and validation approaches. This interpretation will be conducted through an intensive critique of what has been concluded in previously published literature reviews. Therefore, by completing chapter 5, the collected data will be scientifically validated and shaped for further modelling analysis. This will include Monte Carlo simulations and VENSIM system dynamics mathematical modelling equations.

5.1 Experts' Competencies

Data collection in this research methodology design is based on 200 residential building project's whole life cycle experts' invitations. From previous similar studies (i.e., real estate development and construction project management), experts who have a related knowledge base and who have similar projects experience were used to provide acceptable data for research studies, including cost and duration variables (Zimmermann & Eber 2017). Previous similar studies (i.e., buildings predictive maintenance criteria) accepted experts' evaluations to draw a valid scientific research conclusion (Zimmermann & Eber 2017). However, it is

important to define experts and ensure that data providers for this research are valid and are satisfying the designed research methodology. According to the literature, choosing data collection experts is to "excellence" level of requested outputs (Mieg 2009, p.92). Traditionally, researchers defined experts as people who can evaluate something better than anyone else because they know more than others in their specific knowledge (Zimmermann & Eber 2017). Also, experts' outputs are termed in literature as the "road to excellence" (Mieg 2009, p.92). Researchers stated that assessment excellence in scientific research is the output of true expertise (Mieg 2009). As a result, it is essential to understand the criteria of experts' considerations for scientific studies (Mieg 2009; Zimmermann & Eber 2017; Flores-Colen, Brito & Freitas 2010). This is significant to ensure experts' assessment excellence level (Mieg 2009). Commonly, experts' evaluation validity is justified by reputation (Zimmermann & Eber 2017). This reputation is called experience (Zimmermann & Eber 2017). The experience is defined as the satisfactory number of successful similar systems investigations to reach the ability to predict complex systems' behaviour and estimate variables' values within acceptable small margins (Zimmermann & Eber 2017). In this research study, it is required to be more specific in identifying experts. First, from reviewed literature, the "10-year rule" requirement stated that experts need to study the area of knowledge for 10,000 to 50,000 hours before considering their reputation (i.e., expertise) (Mieg 2009, p.93). This is equal between 3.5 to 17 years based on 8 hours per day to reach maters level (Mieg 2009). From another perspective, it is equal to 4.8 to 24 years of studying the knowledge based on 40 hours a week and 52 weeks a year. In similar studies (i.e., built environment), researchers conducted and accepted 30 expert survey questionnaires; however, the experts' selection approach included two main criteria (Mieg 2009). The first criterion is a higher education qualification (Mieg 2009). It required a minimum of 5-years of university degree qualification (Mieg 2009). The second criterion is the

number of years of specialized experience in addition to a university degree qualification (Mieg 2009). Researchers classified experts with 5-year degree qualification plus 2 to 7 years of related specialized experience as high experts (Mieg 2009). On the other hand, they classified experts who have only a 5-year degree qualification, with high sensitivity to the research topic, as medium experts (Mieg 2009). Therefore, this research study considers high experts as professionals with 5-year degree qualification and at least two years of related specialized experience. Moreover, considering medium experts as professionals with a 5-year degree qualification in engineering related to building environment knowledge (i.e., construction and operation) such as civil engineering, mechanical engineering, electrical engineering, construction engineering, and facilities engineering. Due to the large cultural and educational diversity in the United Arab Emirates, this research targeted only experts registered in built environment organizations (i.e., contractors, consultants, developers, and government). It is because the Ministry of Human Resources and Emiratization (i.e., Ministry of Labour) in the United Arab Emirates ensure the authenticity of degree certificates before issuing work permits and does not register engineers' contracts unless the licensing authorities approve them (i.e., Abu Dhabi Municipality and Society of Engineers) (Mohre 2020; Abu Dhabi Municipality 2020; Society of Engineers 2020). This will ensure selecting valid experts who satisfy the minimum acceptable conditions, including authentic equivalated 5-year engineering degree qualification and approved relevant specialized experience. This research study invited 200 experts following the previous justified criteria and completed 55 face-to-face survey interviews within acceptable response rate (i.e., 27.5%) as explained and justified in chapter 4. In table 5-1, experts' general information is presented to confirm their validity through the following analysis.

Survey Interview SN	Respondent's Position	Job Title	Organization Experience (Years)	Total Experience (Years)	Size of Projects (AED)
1	Public	Sr. FM Engineer	5 - 10	>10	< 500,000
2	Public	Sr. FM Engineer	5 - 10	>10	< 500,000
3	Public	Project Engineer	5 - 10	>10	> 5,000,000
4	Private	QA/QC Manager	>10	>10	> 5,000,000
5	Public	QA/QC Manager	5 - 10	>10	> 5,000,000
6	Private	Project Manager	>10	>10	> 5,000,000
7	Public	Project Manager	>10	>10	> 5,000,000
8	Public	QA/QC Manager	5 - 10	>10	> 5,000,000
9	Private	Mechanical Engineer	3 - 5	5 - 10	> 5,000,000
10	Public	Project Manager	>10	>10	> 5,000,000
11	Public	Sr. FM Engineer	5 -10	>10	> 5,000,000
12	Public	Sr. FM Engineer	5 - 10	>10	> 5,000,000
13	Public	FM Engineer	5 - 10	>10	> 5,000,000
14	Public	FM Engineer	5 - 10	>10	> 5,000,000
15	Public	FM Engineer	5 - 10	>10	> 5,000,000
16	Public	Sr. Procurement Engineer	5 - 10	>10	> 5,000,000
17	Public	FM Engineer	5 - 10	>10	> 5,000,000
18	Public	Sr. FM Engineer	5 - 10	>10	> 5,000,000
19	Public	FM Engineer	5 - 10	>10	> 5,000,000
20	Public	Project Manager	>10	>10	> 5,000,000
21	Public	Sr. Procurement Engineer	>10	>10	> 5,000,000
22	Public	Project Manager	5 - 10	5 - 10	> 5,000,000
23	Public	QA/QC Manager	< 3	>10	> 5,000,000
24	Public	Cost Engineer	>10	>10	> 5,000,000
25	Public	Cost Engineer	5 - 10	>10	> 5,000,000

Survey Interview SN	Respondent's Position	Job Title	Organization Experience (Years)	Total Experience (Years)	Size of Projects (AED)
26	Public	Sr. HSE Engineer	3 - 5	>10	> 5,000,000
27	Public	Projects Control Engineer	3 - 5	>10	> 5,000,000
28	Public	Section Head	< 3	>10	> 5,000,000
29	Public	Project Manager	5 - 10	5 - 10	> 5,000,000
30	Public	Project Manager	5 - 10	5 - 10	1,000,000-5,000,000
31	Public	Project Manager	5 - 10	5 - 10	> 5,000,000
32	Public	Projects Control Engineer	>10	>10	> 5,000,000
33	Public	Project Manager	5 - 10	>10	> 5,000,000
34	Public	Project Manager	5 - 10	>10	> 5,000,000
35	Public	QA/QC Manager	>10	>10	> 5,000,000
36	Private	Cost Engineer	>10	>10	> 5,000,000
37	Private	Internal Auditor	3 - 5	3 - 5	500,000-1,000,000
38	Private	Project Manager	>10	>10	> 5,000,000
39	Public	Planning Manager	5 - 10	5 - 10	> 5,000,000
40	Public	Cost Engineer	3 - 5	>10	> 5,000,000
41	Public	Sr. Planning Engineer	>10	>10	> 5,000,000
42	Public	Cost Engineer	3 - 5	>10	> 5,000,000
43	Public	Sr. Procurement Engineer	>10	>10	> 5,000,000
44	Public	Project Manager	< 3	< 3	> 5,000,000
45	Public	Sr. Planning Engineer	>10	>10	> 5,000,000
46	Public	Cost Engineer	5 - 10	5 - 10	> 5,000,000
47	Public	Project Manager	5 - 10	>10	> 5,000,000
48	Public	Project Engineer	>10	>10	> 5,000,000
49	Public	Project Engineer	>10	>10	> 5,000,000

Survey Interview SN	Respondent's Position	Job Title	Organization Experience (Years)	Total Experience (Years)	Size of Projects (AED)
50	Public	Project Engineer	>10	>10	< 500,000
51	Public	Project Engineer	5 - 10	>10	> 5,000,000
52	Public	Sr. Procurement Engineer	>10	>10	> 5,000,000
53	Public	FM Engineer	>10	>10	> 5,000,000
54	Private	QA/QC Manager	>10	>10	> 5,000,000
55	Private	HSE Engineer	>10	>10	> 5,000,000

Table 5-1: General information about interviewees who provided the required risk values based on its probability and impact weightage.

From table 5-1, this research study has followed previous research requirements of validating knowledge experts. First, the questionnaire cover page included all needed general information about interviewees. These information tips have been used to validate each expert and whether to consider using their provided data or not. Table 5-1 has five primary columns. The first column has the serial number of accepted valid experts (i.e., 55 valid experts' questionnaires). The second column is showing each respondent's position (i.e., public or private). It is used to ensure that interviewed experts are not freelancers and work in organizations under the Ministry of Human Resources and Emiratisation requirements. The third column is presenting the job title of each expert. However, this study's researcher does not need to verify any degree certificate or experience behind UAE authorities from the second and third columns. It is only required to have a look at the professional engineering license. Figure 5-1 provides the Abu Dhabi municipality practising engineer license template with all its detailed components. This approach follows previous similar studies conducted in the United Kingdom (Elhag, Boussabaine & Ballal 2005; Doloi 2011). These studies used the official records of the Royal Institute of Chartered Surveyors (RICS) to find valid experts (Elhag, Boussabaine & Ballal 2005; Doloi 2011).

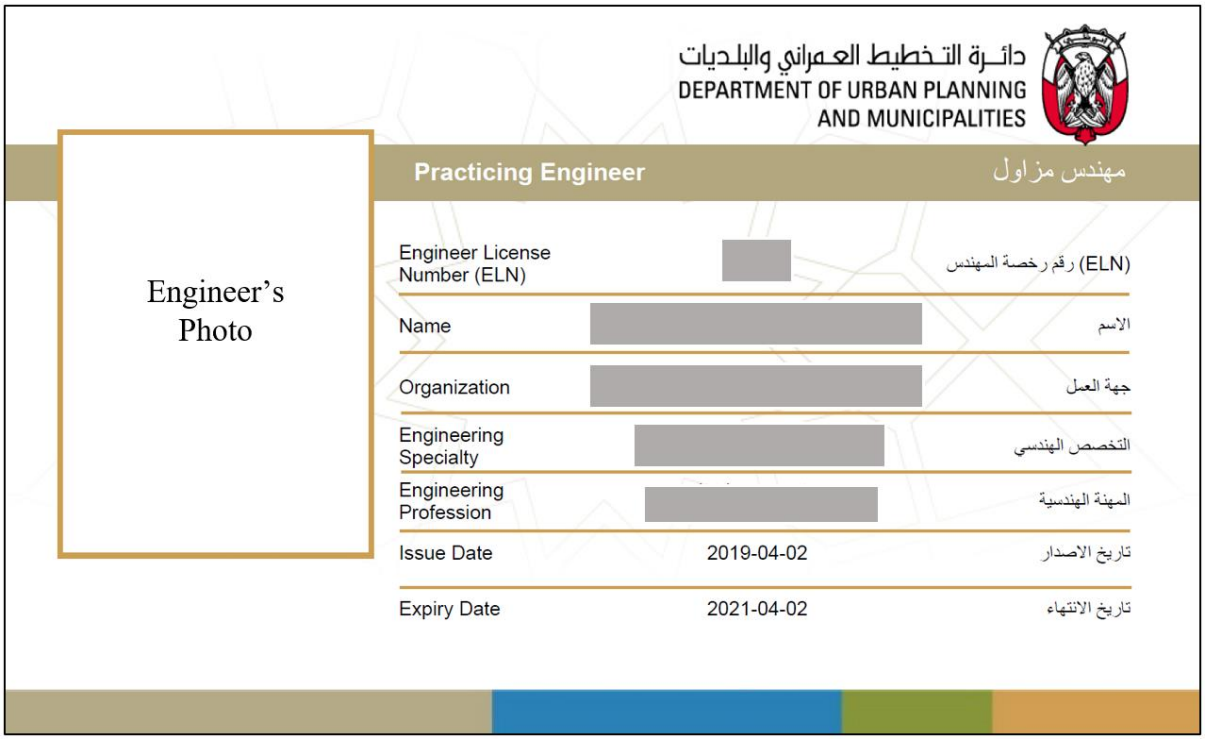


Figure 5-1: Abu Dhabi Municipality License Sample to show official provided information to validate experts.

Years of Experience Within the Organization	Number of Interviewees
< 3	3
3 - 5	6
5 - 10	25
> 10	21

Table 5-2: Interviewees years of experience within the current organization.

Total Years of Experience	Number of Interviewees
< 3	1
3 - 5	1
5 - 10	7
> 10	46

Table 5-3: Interviewees total years of experience

Experience Size of Projects (AED)	Number of Interviewees
< 500,000	3
500,000 - 1,000,000	1
1,000,000 - 5,000,000	1
> 5,000,000	50

Table 5-4: Interviewees experienced size of projects.

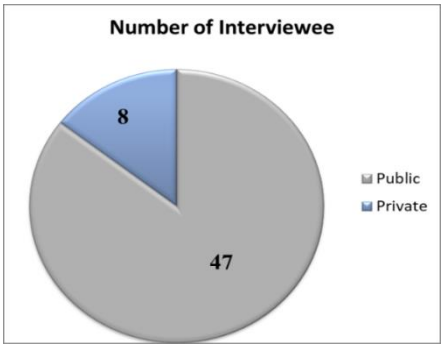


Figure 5-2: Interviewees working sector.

Table 5-1 shows that the number of interviewees, who are currently working in the private sector, is equal to 8, and the number of interviewees, who are working in the public sectors, is equal to 47, as shown in summary Figure 5 2. On the other hand, 46 interviewed experts have ≥10 years of experience (i.e., 25 + 21 = 46), as shown in table 5-2. They worked in the private and public sectors. Only one interviewee had between 2 to 3 years of experience plus a 5-year engineering degree qualification, as shown in table 5-3. It is still meeting experts' high level, as explained previously (Mieg 2009).

There are no criteria about the project's size experience to validate experts (Mieg 2009; Zimmermann & Eber 2017; Flores-Colen, Brito & Freitas 2010). However, this research investigated to ensure that the related experience (i.e., at least two years) is as accurate as possible. Therefore, the final system dynamics model will be validated using real residential housing project data. This will require ensuring to experts with similar specialized experience. Nevertheless, previously published literature declared clearly that it is challenging to define large construction based on common costs (Memon et al. 2010). Projects in Vietnam are considered large projects if their budget equal to or greater than 1 million USD dollars (i.e., 3.67 million dirhams) (Memon et al. 2010). On the other hand, Malaysia projects are considered large if their budget equal to or greater than 5 million Malaysian Ringgit (i.e., 4.55 million dirhams) (Memon et al. 2010). Other researchers considered projects as large project as long it is < 1 billion US dollars (i.e., 3.67 billion dirhams) (Zidane, Johansen & Ekambaram 2013). Based on Norwegian projects, it was considered large with a value of 985 million US dollars (Zidane, Johansen & Ekambaram 2013). From another perspective, the maintenance works are contracted on an annual basis; thus, based on Figure 4-23 in chapter 4, operation and maintenance cost have a mean equal to 9% and a standard deviation equal to 5.17% of MEP CAPEX cost (Wu & Clements-Croome 2007). MEP CAPEX is equal to 15% from Figure 4-

22 in chapter 4 (Riley et al. 2005). The biggest validating real project's value is about 4 billion dirhams (i.e., megaproject). Therefore, considering the OPEX medium, large, and mega projects should be based on the mean and standard deviation provided by literature. The medium OPEX project value will equal to 3.83% (i.e., 9% - 5.17% = 3.83%). The large OPEX project will equal 9%. And the mega OPEX project will equal to 14.17% (i.e., 9% + 5.17% = 14.17%). MEP CAPEX based on 4 billion dirhams will equal 600 million (i.e., 15% of total CAPEX). Most similar research discussed large projects instead of mega-projects based on different criteria a explained previously (Memon et al. 2010; Zidane, Johansen & Ekambaram 2013). Therefore, this research study will consider four criteria of experts' size of projects experience, as shown in table 5-5. First, OPEX normal-size projects value will be < 500,000 AED (i.e., Annual projects = 3.83%*15%*4 billion ÷ 57 years of operation = 403,158 AED). Second, OPEX large-size projects value will be from 500,000 to 1,000,000 AED (i.e., Annual projects = 9%*15%*4 billion ÷ 57 years of operation = 947,368 AED). Third, CAPEX normal-size projects value will be from 1,000,000 to 5,000,000 AED (i.e., including literature arguments about large projects cut-off value) (Memon et al. 2010; Zidane, Johansen & Ekambaram 2013). Finally, CAPEX large-size projects value will be > 5,000,000 AED (i.e., more than literature's large projects cut-off value arguments) (Memon et al. 2010; Zidane, Johansen & Ekambaram 2013). It is found that 50 out of 55 experts (i.e., 91%) have experience in large projects, as shown in table 5-5.

Criteria	Experience Size of Projects (AED)
OPEX Normal Projects	**< 500,000**
OPEX Large Projects	**500,000 - 1,000,000**
CAPEX Normal Projects	**1,000,000 - 5,000,000**
CAPEX Large Projects	**> 5,000,000**

Table 5-5: experience size of projects criteria.

Therefore, all interviewed experts are considered high-level experts, and the excellent level of provided data has been met in this research study (Mieg 2009; Zimmermann & Eber 2017).

5.2 Data Correlation Analysis

Correlation is defined as the measurement of a specific pattern of association (Wild 2014). However, the association occurs when a scatterplot takes a pattern between two numerical variables (Wild 2014). After validating data providers' ability to contribute to this research study, three types of essential reliability criteria need to be satisfied, as explained in the research methodology chapter. First, the statistical significance test of quantitative results is deciding the repeatability or replicability of these results during a particular period (Golafshani 2003). This is the indicator of data strength. In correlation analysis, P-Value is the significance of hypothesis consideration. Second, measurement stability is an important type for testing quantitative results reliability (Golafshani 2003). This means that stable measurements over time are more reliable than unstable measurements (Golafshani 2003; Rungtusanatham et al. 2003; Sauro & Lewis 2012; Mohd et al. 2015). Stability (i.e., strength) can be defined as the correlation between 2 separate readings of the same subject (Vanderwal et al. 2021; Francis 1991). Third, the similarity type of reliability can be defined as the average correlation of readings within a given condition (Vanderwal et al. 2021; Francis 1991). Correlation R-values range between +1 and -1 (Ratner 2009; Wild 2014; DeSoto & Roediger 2014). In correlation analysis, the r-value is the scatter strength and similarity indicator. The considered hypotheses for this research correlation analysis are listed as the following:

Let, **ρ** represent the Correlation of Pearson Population, then

H_O: $\rho = 0$, (i.e., No Correlation between variables),

H_I: $\rho \neq 0$, (i.e., Correlation is available between variables)

H_O is true if the significance does not exist (i.e., P-value > 0.05). H_I is true if correlation analysis showed significance P-value ≤ 0.05. The correlation analysis has been conducted for each risk factor and summarized in table 5-6. The table is including the key data analysis outputs, including the mean, standard deviation, p-value, r-value, and analysis description for each analysis (Linear Relationship Strength). Data correlation is completed for each risk 2 times to include both (Risk vs Probability) and (Risk vs Impact). Finally, this correlation indicates the linear relationship between the data sets of each risk factor (i.e., 117 risks). Although this research is conducting all statistical analysis using the SPSS software programme, it is mandatory to know that basic correlation mathematics uses chapter 4 (i.e., research methodology) mathematical modelling as shown in equations 4-2 and 4-3.

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

Equation 4-2

r = correlation coefficient
x_i = values of the x-variable in a sample
$\bar{x}$ = mean of the values of the x-variable
y_i = values of the y-variable in a sample
$\bar{y}$ = mean of the values of the y-variable

$$e_t = \rho e_{t-1} + \nu_t$$

Equation 4-3

ν_t = nonzero eigenvalues
ρ = Durbin -Watson statistic hypothesis
e_t = the residual error
e_{t-1} = the previous residual error

SN	Cost Risk Description	Mean	Standard Deviation	Correlation: Risk vs Probability			Correlation: Risk vs Impact		
				r - value	P - value	Linear Relationship Strength	r - value	P - value	Linear Relationship Strength
A	**Construction Activities' Risks**								
1	Selection Method	**31.93**	**22.386**	**0.760**	**0.000**	**Strong**	**0.919**	**0.000**	**Strong**
2	Type of Client: Solo Individual	**24.55**	**23.277**	**0.806**	**0.000**	**Strong**	**0.927**	**0.000**	**Strong**
3	Type of Client: Bank- Individual Partnership	**22.58**	**17.649**	**0.493**	**0.000**	**Weak**	**0.780**	**0.000**	**Strong**
4	Type of Client: Developer	**21.22**	**15.645**	**0.451**	**0.000**	**Weak**	**0.841**	**0.001**	**Strong**
5	Type of Client: Group of People	**26.08**	**15.807**	**0.400**	**0.000**	**Weak**	**0.789**	**0.004**	**Strong**
6	Location: City Area	**22.67**	**19.730**	**0.648**	**0.000**	**Moderate**	**0.943**	**0.000**	**Strong**
7	Location: Regional Area	**22.84**	**18.129**	**0.312**	**0.020**	**Weak**	**0.914**	**0.000**	**Strong**
8	Location: Beach Area	**23.55**	**16.722**	**0.737**	**0.000**	**Strong**	**0.841**	**0.000**	**Strong**
9	Location: Desert Area	**31.65**	**23.420**	**0.801**	**0.000**	**Strong**	**0.919**	**0.000**	**Strong**
10	Building Services Complexity: Operational Services	**26.82**	**17.132**	**0.467**	**0.000**	**Weak**	**0.723**	**0.000**	**Strong**
11	Building Services Complexity: Fitness Services	**24.15**	**15.401**	**0.343**	**0.000**	**Weak**	**0.936**	**0.000**	**Strong**
12	Number of Basement Levels	**22.56**	**18.953**	**0.709**	**0.000**	**Strong**	**0.828**	**0.000**	**Strong**
13	Procurement Method	**29.20**	**17.190**	**0.426**	**0.000**	**Weak**	**0.846**	**0.000**	**Strong**
14	Site Topography	**26.93**	**17.920**	**0.522**	**0.000**	**Moderate**	**0.856**	**0.000**	**Strong**
15	Site Conditions	**29.33**	**20.110**	**0.620**	**0.000**	**Moderate**	**0.908**	**0.000**	**Strong**
16	Working Space	**19.13**	**16.546**	**0.550**	**0.000**	**Moderate**	**0.880**	**0.000**	**Strong**
17	Site Access	**19.91**	**18.686**	**0.660**	**0.000**	**Moderate**	**0.925**	**0.000**	**Strong**
18	Frame Structure	**18.45**	**13.281**	**0.003**	**0.983**	**No relationship**	**0.884**	**0.000**	**Strong**
19	Foundation Type	**18.87**	**13.951**	**0.092**	**0.514**	**No relationship**	**0.941**	**0.000**	**Strong**
20	Ground Conditions	**30.31**	**17.055**	**0.247**	**0.069**	**No relationship**	**0.932**	**0.000**	**Strong**
21	Type of Soil	**28.27**	**18.006**	**0.434**	**0.001**	**Weak**	**0.830**	**0.000**	**Strong**
22	Mark-up Size	**17.85**	**16.672**	**0.630**	**0.000**	**Moderate**	**0.927**	**0.000**	**Strong**
23	Need for Work	**17.67**	**14.934**	**0.383**	**0.004**	**Weak**	**0.881**	**0.000**	**Strong**
24	Deadline Requirements	**36.71**	**20.623**	**0.659**	**0.000**	**Moderate**	**0.703**	**0.000**	**Strong**
25	Number of Stories	**22.02**	**15.841**	**0.601**	**0.000**	**Moderate**	**0.893**	**0.000**	**Strong**
26	Project Duration	**33.35**	**21.961**	**0.749**	**0.000**	**Strong**	**0.849**	**0.000**	**Strong**

SN	Cost Risk Description	Mean	Standard Deviation	Correlation: Risk vs Probability			Correlation: Risk vs Impact		
				r - value	P - value	Linear Relationship Strength	r - value	P - value	Linear Relationship Strength
27	Gross Floor Area	21.45	16.726	0.566	0.000	Moderate	0.769	0.000	Strong
28	Equipment Required	25.80	18.664	0.378	0.004	Weak	0.941	0.000	Strong
29	Construction Technology Availability	30.67	21.461	0.652	0.000	Moderate	0.891	0.000	Strong
B	**Political Risks**								
1	Change in Law	27.44	23.599	0.744	0.000	Strong	0.802	0.000	Strong
2	Delay in Project Approvals and Permits	41.41	20.110	0.598	0.000	Moderate	0.846	0.000	Strong
3	Poor Public Decision Making Process	31.54	17.959	0.547	0.000	Moderate	0.837	0.000	Strong
4	Government Intervention	30.57	19.296	0.633	0.000	Moderate	0.866	0.000	Strong
5	Unstable Government	36.65	25.307	0.850	0.000	Strong	0.713	0.000	Strong
6	Government Reliability	38.26	23.664	0.698	0.000	Moderate	0.848	0.000	Strong
7	Inconsistencies in Government Policies	29.35	22.868	0.834	0.000	Strong	0.806	0.000	Strong
8	Strong Political Opposition / Hostility	27.07	23.768	0.812	0.000	Strong	0.736	0.000	Strong
9	Expropriation/ Nationalization of Assets	26.44	22.576	0.775	0.000	Strong	0.687	0.000	Moderate
10	Inability of Concessionaire	22.56	19.908	0.160	0.247	No relationship	0.752	0.000	Strong
C	**Legal Risks**								
1	Change in Tax Regulation	30.47	22.963	0.915	0.000	Strong	0.920	0.000	Strong
2	Corruption and Lack of Respect for Law	30.96	22.622	0.796	0.000	Strong	0.746	0.000	Strong
3	Legislation Change	25.56	19.411	0.727	0.000	Strong	0.888	0.000	Strong
4	Import / Export Restrictions	22.83	19.872	0.731	0.000	Strong	0.865	0.000	Strong
5	Rate of Return Restrictions	18.61	19.755	0.779	0.000	Strong	0.898	0.000	Strong
6	Industrial Regulatory Change	24.98	20.551	0.818	0.000	Strong	0.889	0.000	Strong
D	**Economic Change Risks**								
1	Interest Rate Volatility	22.67	20.536	0.750	0.000	Strong	0.948	0.000	Strong
2	Inflation Rate Volatility	26.22	21.914	0.481	0.000	Weak	0.960	0.000	Strong
3	Foreign Exchange and Convert	20.63	17.709	0.707	0.000	Strong	0.807	0.000	Strong
4	Poor Financial Market	30.45	19.669	0.751	0.000	Strong	0.832	0.000	Strong

SN	Cost Risk Description	Mean	Standard Deviation	Correlation: Risk vs Probability			Correlation: Risk vs Impact		
				r - value	P - value	Linear Relationship Strength	r - value	P - value	Linear Relationship Strength
E	**Natural Risks**								
1	Force Majeure	**18.35**	**18.789**	**0.660**	**0.000**	**Moderate**	**0.673**	**0.000**	**Moderate**
2	Environment	**18.07**	**17.122**	**0.615**	**0.000**	**Moderate**	**0.874**	**0.000**	**Strong**
3	Weather	**17.44**	**16.317**	**0.513**	**0.000**	**Moderate**	**0.919**	**0.000**	**Strong**
4	Geotechnical Condition	**23.69**	**18.247**	**0.085**	**0.541**	**No relationship**	**0.923**	**0.000**	**Strong**
F	**Market Risks**								
1	Market Supply	**25.11**	**20.860**	**0.737**	**0.000**	**Strong**	**0.872**	**0.000**	**Strong**
2	Market Demand	**27.07**	**23.514**	**0.787**	**0.000**	**Strong**	**0.958**	**0.000**	**Strong**
3	Fluctuation of Material Cost by Public/Private	**24.81**	**20.746**	**0.721**	**0.000**	**Strong**	**0.889**	**0.000**	**Strong**
4	Value of Production Effort	**22.30**	**20.355**	**0.675**	**0.000**	**Moderate**	**0.886**	**0.000**	**Strong**
G	**Project Selection Risks**								
1	Public Opposition to Projects	**18.54**	**20.705**	**0.779**	**0.000**	**Strong**	**0.779**	**0.000**	**Strong**
2	Uncompetitive Tender	**25.50**	**20.831**	**0.689**	**0.000**	**Moderate**	**0.946**	**0.000**	**Strong**
3	Level of Demand for the Project	**24.19**	**19.179**	**0.726**	**0.000**	**Strong**	**0.761**	**0.000**	**Strong**
4	Land Acquisition	**25.00**	**18.473**	**0.706**	**0.000**	**Strong**	**0.826**	**0.000**	**Strong**
5	Competition Risk	**19.61**	**18.296**	**0.654**	**0.000**	**Moderate**	**0.930**	**0.000**	**Strong**
H	**Project Finance Risks**								
1	Inaccurate Estimates	**31.41**	**22.055**	**0.778**	**0.000**	**Strong**	**0.804**	**0.000**	**Strong**
2	High Finance Cost	**26.26**	**21.016**	**0.713**	**0.000**	**Strong**	**0.830**	**0.000**	**Strong**
3	High Bidding Costs	**26.85**	**20.754**	**0.733**	**0.000**	**Strong**	**0.814**	**0.000**	**Strong**
4	Delay in Payment of Annuity	**27.98**	**20.087**	**0.732**	**0.000**	**Strong**	**0.856**	**0.000**	**Strong**
5	Financial Attraction of Project to Investors	**23.89**	**17.372**	**0.647**	**0.000**	**Moderate**	**0.863**	**0.000**	**Strong**
6	Lack of Creditworthiness	**22.87**	**17.394**	**0.661**	**0.000**	**Moderate**	**0.855**	**0.000**	**Strong**
7	Delay in Financial Closure	**27.85**	**19.082**	**0.558**	**0.000**	**Moderate**	**0.745**	**0.000**	**Strong**
8	Inability to Service Debt	**26.41**	**17.615**	**0.509**	**0.000**	**Moderate**	**0.704**	**0.000**	**Strong**
9	Lack of Government Guarantees	**23.47**	**20.526**	**0.697**	**0.000**	**Moderate**	**0.911**	**0.000**	**Strong**
10	Financer Unwilling to Take High Risk	**28.09**	**20.574**	**0.559**	**0.000**	**Moderate**	**0.836**	**0.000**	**Strong**

SN	Cost Risk Description	Mean	Standard Deviation	Correlation: Risk vs Probability			Correlation: Risk vs Impact		
				r - value	P - value	Linear Relationship Strength	r - value	P - value	Linear Relationship Strength
I	**Building Functionality and Serviceability Risks**								
1	Construction Time Delay	33.24	23.063	0.563	0.000	Moderate	0.927	0.000	Strong
2	Material Availability	21.72	19.022	0.650	0.000	Moderate	0.962	0.000	Strong
3	Labour Availability	24.48	21.043	0.701	0.000	Strong	0.908	0.000	Strong
4	Poor Quality of Workmanship	27.72	22.443	0.805	0.000	Strong	0.935	0.000	Strong
5	Default of Sub-Contractors or Suppliers	27.26	22.192	0.690	0.000	Moderate	0.923	0.000	Strong
6	Design & Construction Complexity	28.86	20.276	0.702	0.000	Strong	0.912	0.000	Strong
7	Design Deficiency	34.37	21.935	0.831	0.000	Strong	0.803	0.000	Strong
8	Late Design Change	33.24	20.054	0.760	0.000	Strong	0.907	0.000	Strong
9	Construction Technology Complexity	24.09	17.485	0.434	0.001	Weak	0.877	0.000	Strong
10	Contractual Risk	24.61	16.973	0.588	0.000	Moderate	0.899	0.000	Strong
11	Contractor Failure	36.29	20.888	0.535	0.000	Moderate	0.748	0.000	Strong
12	Quality and Reliability	25.17	18.248	0.642	0.000	Moderate	0.867	0.000	Strong
J	**Stakeholders Relationship Risks**								
1	Different Working Method Between Partners	22.67	16.968	0.582	0.000	Moderate	0.916	0.000	Strong
2	Inadequate Experience in Residential Projects	25.85	18.700	0.501	0.000	Moderate	0.790	0.000	Strong
3	Lack of Commitment From Public/Private Sector	24.80	16.725	0.569	0.000	Moderate	0.818	0.000	Strong
4	Organization and Coordination Risk	17.83	15.720	0.536	0.000	Moderate	0.778	0.000	Strong
5	Inadequate Distribution of Responsibility & Risk	20.61	17.066	0.622	0.000	Moderate	0.889	0.000	Strong
6	Inadequate Negotiation Period Prior to Initiation	20.26	13.902	0.584	0.000	Moderate	0.769	0.000	Strong
7	Conflict Between Project's Participants	23.19	17.059	0.675	0.000	Moderate	0.785	0.000	Strong
8	Workers Strike	19.20	18.867	0.738	0.000	Strong	0.870	0.000	Strong
9	Cultural Differences Between Main Stakeholders	15.06	14.330	0.689	0.000	Moderate	0.835	0.000	Strong
K	**Knowledge Risks**								
1	Expertise	26.26	18.559	0.550	0.000	Moderate	0.827	0.000	Strong
2	Familiarities	21.17	15.358	0.534	0.000	Moderate	0.871	0.000	Strong
3	Number of Bidders	20.02	15.540	0.378	0.005	Weak	0.966	0.000	Strong

SN	Cost Risk Description	Mean	Standard Deviation	Correlation: Risk vs Probability			Correlation: Risk vs Impact		
				r - value	P - value	Linear Relationship Strength	r - value	P - value	Linear Relationship Strength
4	Market Conditions	25.70	20.870	0.728	0.000	Strong	0.922	0.000	Strong
5	Size of the Project	25.69	21.231	0.735	0.000	Strong	0.884	0.000	Strong
6	Type of Building	23.19	19.125	0.656	0.000	Moderate	0.931	0.000	Strong
7	Extent of Database	17.11	15.633	0.633	0.000	Moderate	0.839	0.000	Strong
8	Homogeneity of Samples	14.89	15.298	0.585	0.000	Moderate	0.958	0.000	Strong
9	Details of Information	21.74	19.511	0.662	0.000	Moderate	0.932	0.000	Strong
O	**OPEX Activities' Risks**								
1	Energy Costs	27.19	21.098	0.673	0.000	Moderate	0.829	0.000	Strong
2	Service Life of Building Components	23.00	18.703	0.585	0.000	Moderate	0.943	0.000	Strong
3	Building Components' Eco-Costs	17.31	15.076	0.605	0.000	Moderate	0.886	0.000	Strong
4	Asset Operation Eco-Costs	18.35	14.947	0.604	0.000	Moderate	0.918	0.000	Strong
5	Disposal Eco-Costs	16.09	15.966	0.653	0.000	Moderate	0.950	0.000	Strong
6	Components' Deterioration Rate	17.54	17.103	0.747	0.000	Strong	0.921	0.000	Strong
7	Fabric Maintenance	16.02	13.216	0.402	0.003	Weak	0.919	0.000	Strong
8	Services	21.93	15.286	0.461	0.000	Weak	0.930	0.000	Strong
9	Equipment's Maintenance	21.88	13.414	0.494	0.000	Weak	0.935	0.000	Strong
10	Overheads	20.56	17.649	0.308	0.000	Weak	0.918	0.000	Strong
11	Utilities	22.81	14.523	0.209	0.129	No relationship	0.933	0.000	Strong
12	Cleaning	15.09	12.363	0.408	0.002	Weak	0.802	0.000	Strong
13	Percentage of Current Replacement Value	17.76	14.762	0.396	0.000	Weak	0.915	0.000	Strong
14	Ratio of Maintenance to Capital Cost	19.19	15.857	0.547	0.000	Moderate	0.908	0.000	Strong
15	Ratio of Operation to Capital Cost	22.22	16.769	0.617	0.000	Moderate	0.894	0.000	Strong

Table 5-6: Show the detailed correlation analysis conducted for each variable including its Risk vs. Probability & its Risk vs. Impact. This is indicating whether the regression analysis will be successful or not. And will prove the linear relationship between each risk and its probability and impact including each value provided by survey interviewees.

Table 5-6, Linear Relationship Strength columns showed colour coding representing correlation analysis p-value and the r-value. The p-value significance has been discussed earlier in this chapter. However, it is important to understand the r-value representation. Although there is no specific rule for considering linear relationship classifications, this research has created the most appropriate based on reviewed literature. According to literature reviews, there is no linear relationship between data scatters if there is no significance (Ratner 2009; Schober, Boer & Schwarte 2018). However, a linear relationship exists if hypothesis H_I is true ($\rho \neq 0$) based on p-value ≤ 0.05 (Ratner 200 Ratner 2009; Schober, Boer & Schwarte 20189). H_I hypotheses will have a correlation analysis r-value between 0 and 1 for positive relationships and if correlation analysis r-value is between 0 and -1 for negative relationships (Ratner 2009; Schober, Boer & Schwarte 2018). It is weak if the r-value is between 0 to 0.3 and within (0) to (-0.3) (Ratner 2009). It is moderate if the r-value is within 0.3 to 0.7 and within (-0.3) to (-0.7) (Ratner 2009). Table 5-7 summarizes how Ratner (2009) classified linear data relationships based on Pearson's correlation coefficient r-value. It is strong if the r-value is within 0.7 to 1 and within (-0.7) to (-1) (Ratner 2009).

SN	Pearson's correlation coefficient r-value	Linear Relationship Classification
1	P-Value >0.05 No significance	No linear relationship
2	0 to 0.3 and 0 to -0.3	Weak linear relationship
3	0.3 to 0.7 and -0.3 to -0.7	Moderate linear relationship
4	0.7 to 1 and -0.7 to -1	Strong linear relationship

Table 5-7: summarize how Ratner (2009) classified data linear relationships based on “Pearson's correlation coefficient” r-value.

Other researchers have included more than 3 classifications, as shown in Figure 5-3 (Schober, Boer & Schwarte 2018). It is including 5 strength classifications of linear relationships (Schober, Boer & Schwarte 2018).

Table. Example of a Conventional Approach to Interpreting a Correlation Coefficient

Absolute Magnitude of the Observed Correlation Coefficient	Interpretation
0.00–0.10	Negligible correlation
0.10–0.39	Weak correlation
0.40–0.69	Moderate correlation
0.70–0.89	Strong correlation
0.90–1.00	Very strong correlation

Figure 5-3: summarize how Schober, Boer and Schwarte (2018) classified data linear relationships based on Pearson's correlation coefficient r-value.

Previous cash flow literatures divided correlation strength based on weak (i.e., 0% to 33%), average (i.e., 34% to 66%), strong (i.e., 67% to 90%), and very-strong (i.e., 91% to 100%) (Konior & Szóstak 2020). Therefore, this research study created its most suitable linear relationship strength classifications, including colour coding and justification remarks, based on the previously reviewed literature, as shown in table 5-8.

SN	Pearson's correlation coefficient r-value	Linear Relationship Classification / Colour coding	Remarks
1	**P-Value >0.05 (No significance) And within (0) to (0.3 >) and (0) to (-0.3 >)**	**No linear relationship**	This is because researchers agreed that there is no relationship if there is no significance and the relationship is neglectable or very weak within (0) to (0.3 >) and (0) to (-0.3 >)
2	**(0.3 ≥) to (0.5 >) and (-0.3 ≥) to (-0.5 >)**	**Weak linear relationship**	There is a debate about considering moderate linear relationships if r-value is between 0.3 to 0.4. So, this research is considering r-values within (0.3 ≥) to (0.5 >) and (-0.3 ≥) to (-0.5 >) as weak linear relationships
3	**(0.5 ≥) to (0.7 >) and (-0.5 ≥) to (-0.7 >)**	**Moderate linear relationship**	All reviewed literatures agreed on that r-values within (0.7 ≥) to (1) and (-0.7 ≥) to (-1) is strong linear relationships. So, this research is considering moderate linear relationship for r-values within (0.5 ≥) to (0.7 >) and (-0.5 ≥) to (-0.7 >)
4	**(0.7 ≥) to (1) and (-0.7 ≥) to (-1)**	**Strong linear relationship**	

Table 5-8: linear relationships classification with colour coding based on literatures "Pearson's correlation coefficient" r-value classifications (Ratner 2009; Schober, Boer & Schwarte 2018; Konior & Szóstak 2020).

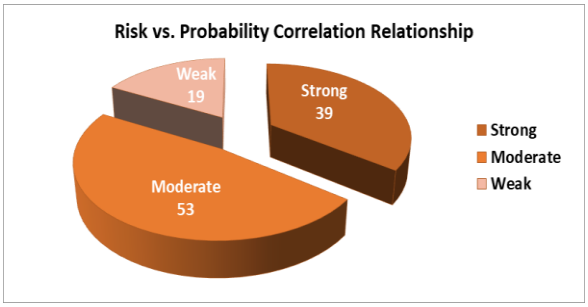


Figure 5-4: weak, moderate, and strong relationship of each risk factor with its probability frequency.

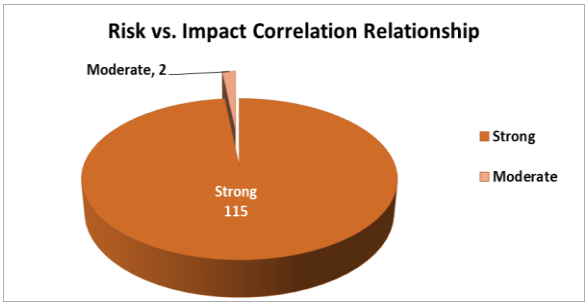


Figure 5-5: weak, moderate, and strong relationship of each risk factor with its impact weight.

After conducting correlation analysis for all included risks to check linear relationships' existence and strengths between its data sets, it has been found that there are 19 weak linear relationships. And 53 moderate linear relationships. Moreover, 39 strong linear relationships for (Risk vs Probability) correlation analysis, as shown in Figure 5-4. On the other hand, it was found that there are 2 moderate linear relationships and 115 strong linear relationships for the (Risk vs Impact) correlation analysis, as shown in Figure 5-5.

The validity of quantitative research is based on the final useability and accuracy (Golafshani 2003; Almquist, Ashir & Brännström 2014). According to positivists, validity can be quantified based on testing the mathematical and measurement models to check if the research outputs can measure what it is intended to measure (Golafshani 2003). This research ensured to include most of its data reliability stability as strong as possible. Moreover, it is concluded that moderate and strong correlations are equal to 77% of the (Risk vs Probability) correlation analysis. Moreover, moderate and strong correlations are equal to 100% of the (Risk vs Probability) correlation analysis. Therefore, this stage is assumed valid for further analysis in regression modelling as per literature recommendation (i.e., a correlation exists) (Ratner 2009; Schober, Boer & Schwarte 2018).

5.3 Data Regression Analysis

The final step in validating experts collected data is the regression analysis. The stability-similarity relationship is conducted based on the significance P-Value between the dependent variable with each of its independent variables (Vanderwal et al. 2021; Golafshani 2003). This research is approaching stability-similarity relationship by ensuring the significance between risks and their impacts/probabilities. Linear regression analysis will be conducted for each risk variable. This will include the risk's value as a dependent variable, while the independent variables will impact its probability values. Linear regression will model each cost risk's mathematical equation to adapt any change in the future related to risks' impact or probability as shown in equations 4-4 and 4-7 (Nazif et al. 2016).

$$d = \frac{\sum_{t=2}^{T} (e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^2}$$

Equation 4-4

d = Durbin -Watson statistic
t = Time
T = total number of observations

$$R^2 = 1 - \frac{\text{sum squared regression (SSR)}}{\text{total sum of squares (SST)}},$$
$$= 1 - \frac{\sum (y_i - \hat{y}_i)^2}{\sum (y_i - \bar{y})^2}.$$

Equation 4-5

R^2 = ariance proportion in dependent variables explained by independent variables
$\mathbf{y_i}$ = actual Observation
$\hat{\mathbf{y}}_\mathbf{i}$ = predicted Observation
$\bar{\mathbf{y}}$ = mean of Actual value

$$Y_i = f(X_i, \beta) + e_i$$ Equation 4-6

Y_i = dependent variable
f = function
X_i = independent variable
β = unknown parameters
e_i = error terms

$$Y = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$ Equation 4-7

Y = the Risk dependent Variable of each factor.

X_{prob} and X_{imp} = the probability and impact independent Variable of each factor.

β_{prob} and β_{imp}, = the Linear Regression Coefficients for X_{prob} and X_{imp}, respectively of each factor.

ξ, = the Error (Considered Zero because this regression is not time-based).

SN	Regression Mandatory Error Assumptions Validation Requirements
1	The error's probability distribution of the regression should be normally distributed (i.e., Bell-shaped).
2	The error's population mean value (μ_ε) must equal to zero.
3	The error's variance (δ^2) must be constant for all independent X values.
4	The errors must be independent for all dependent Y values.

Table 4-3: Regression Mandatory Error Assumptions Validation Requirements (Kadiyala 1970; Nazif et al. 2016; Jafarzadeh et al. 2015).

Before conducting any regression analysis, it is essential to ensure that table 4-3 assumptions are fully satisfied. This has been detailed and discussed in chapter 4, regression part. Therefore, in table 5-10, all cost risks are listed under their groups in a matrix table showing all their regression modelling key information. The first left column represents the serial number and group alphabet. The second column is including all listed variables (i.e., risks). The third column is the significance of P-value. The fourth column is including the R-square values of each regression model. This is clarifying how much of the main population is represented by each linear equation. Nevertheless, it is using equation 4-5, as explained in

chapter 4. The fifth and sixth columns are Durbin Watson and standardized residuals for each variable. However, the mathematics used for Durbin-Watson is shown in equation 4-4 from chapter 4. It is computed using the SPSS software programme. The seventh and eighth columns are the regression modelling linear equations and their reference number, respectively. Finally, the last three right columns are including the valid final sample size, the number of iterations, and the number of outliers. All computed statistical modelling is using SPSS software programme.

Table 5-9 also has colour coding for two columns (i.e., R-Square and Number of Outliers columns). It is important to highlight outliers to track the minimum acceptable data sample size. Therefore, there are four colour codes under the (Number of Outliers) column. In chapter 4, the minimum acceptable sample response rate was concluded from literature is 40 response out of 200 invitations (Akintoye & Fitzgerald 2000; Vidogah & Ndekugri 1998; Elhag, Boussabaine & Ballal 2005; Shash 1993). This research has completed 55 face-to-face survey interviews. So, the optimum scenario is to use all 55 samples in the final regression model. Moreover, the first colour code does not have any colour under the (Number of Outliers) column, as shown in tables 5-9 and 5-10. Second, a light semi-transparent red colour is given to valid data after finding outliers equal to or less than 13, as shown in tables 5-9 and 5-10. This is because validated data will be satisfying the minimum response sample size defined in chapter 4. Third, a solid orange colour code is given to validated data with the number of outliers between 13 to 25, as shown in Table 5-9. This is because it is critical, and it is essential to highlight and track data sets close to the statistical minimum sample threshold (i.e., at least 30 samples) as explained in chapter 4 (Bujang & Baharum 2016; Delice 2010; Shen, Nguyen & Ojiako 2013; Ruiz et al. 2017; Aliverdi, Naeni & Salehipour 2013). However, this criterion has not been met in this research after regression analysis. Fourth, a solid red colour is given

to validated data with the number of outliers more than 25, as shown in tables 5-9. In this case, statistical analysis is no longer valid (i.e., the sample size is less than 30). Moreover, data should be collected for this data set, or the cost risk should be excluded. However, this criterion has not been met in this research after regression analysis. The minimum valid sample found is 44 samples for one risk (Uncompetitive Tender) under the project selection risks group, as shown in table 5-10.

SN	Column	Colour coding criteria (Based on starting sample = 55)	Remarks
1	Number of Outliers	**No colour = Zero outliers**	Full collected sample is used
2	Number of Outliers	**13 ≥ Outliers ≠ Zero**	Minimum acceptable sample response = 42 42 ≤ Sample size
3	Number of Outliers	**13 < Outliers ≠ Zero ≤ 25**	30 < Sample size < 42 (Colour code criterion has not been met)
4	Number of Outliers	**25 < Outliers ≠ Zero**	30 > Sample size (Colour code criterion has not been met)
5	R-Square	**R-Square < 80%**	Only 1 found
6	R-Square	**80 ≤ R-Square < 90%**	-
7	R-Square	**R-Square > 90%**	-

Table 5-9: Regression analysis colour coding criteria used in table 5-10 based on literatures.

It is then important to understand the meaning of the R-Square value in regression analysis and classify its readings. According to researchers, R-Square should be analysed using the goodness of fitness (i.e., GOF) approach (Petroutsatou & Lambropoulos 2010). This approach states that a regression model's R-Square has an acceptable percentage if the goodness of fitness measure meets the required criteria (Petroutsatou & Lambropoulos 2010). R-Square's criterion is to have acceptable goodness of fitness index (i.e., GFI) ratio (Petroutsatou & Lambropoulos 2010). This ratio is based on considering R-Square values from zero to one (Petroutsatou & Lambropoulos 2010). The model is considered not fit and does not represent the sampled population if the GFI ratio equal to zero (Petroutsatou & Lambropoulos

2010). The model is a perfect fit if the GFI ratio is equal to one (Petroutsatou & Lambropoulos 2010). Researchers consider the R-Square value is the goodness of fit index ratio (Petroutsatou & Lambropoulos 2010). The acceptable recommended criterion set by previous literature is to have R-Square (i.e., GFI) ≥ 80% (0.80) (Petroutsatou & Lambropoulos 2010). Therefore, in table 5-9, this research study included three colour-coding criteria, under the R-Square column, to identify data status according to the goodness of fit (i.e., GOF) approach and following goodness of fitness index (i.e., GFI) ratio. First, the light semi-transparent orange colour code is set to identify GFI ratios below the recommended threshold (i.e., ≤ 80% = 0.80). Only one risk (i.e., concessionaire's inability) had an R-Square value of less than 80% (i.e., 63.2%), as shown in table 5-10. According to researchers, this issue required deeper investigation because it is an essential cost risk (Alzahrani 2015; Trangkanont & Charoenngam 2013). However, after reviewing collected data and related literature, it was found that most interviewed experts are from public organizations (i.e., 47 of 55 experts), while only 8 experts are from private organizations, as shown in table 5-1 and Figure 5-2. This required to be highlighted because this research is about modelling costs of residential projects and use real housing project data to validate the final system dynamics model. It is also found that researchers in previous housing cost risks modelling literature declared that the concessionaire's inability must be assigned to the private organization (Trangkanont & Charoenngam 2013). This cost risk shall be included in the final cost estimation model because this research study includes all client types. It is recommended to conduct future research about this risk value using the private sector’s experts in the UAE. The second colour code is the light Gray colour to identify acceptable R-Square values (i.e., GFI ratio) within the range of 80% ≤ R-Square < 90%. Finally, the last colour code is green to identify GFI ratios close to a perfect fit (i.e., R-Square ≥ 90%), as shown in table 5-10.

SN	Cost Risk Description	Regression Analysis						Valid Sample Size	Number of Iterations	Number of Outlier
		Sig.	R - Square	Durbin-Watson	Std. Residual	Equation	Equation Reference			
A	Construction Activities' Risks									
1	Selection Method	**0.000**	**0.956**	**2.071**	**0.000**	$Y_{CA1.1} = -27.785 + 0.461\ X_{prob} + 0.649\ X_{imp}$	**Eq.5- CA1**	**55**	**1**	**0**
2	Type of Client: Solo Individual	**0.000**	**0.945**	**1.605**	**0.000**	$Y_{CA2.1} = -20.684 + 0.362\ X_{prob} + 0.663\ X_{imp}$	**Eq.5- CA2**	**55**	**1**	**0**
3	Type of Client: Bank- Individual Partnership	**0.000**	**0.840**	**2.178**	**0.000**	$Y_{CA3.1} = -19.336 + 0.399\ X_{prob} + 0.481\ X_{imp}$	**Eq.5- CA3**	**55**	**1**	**0**
4	Type of Client: Developer	**0.000**	**0.943**	**2.107**	**0.000**	$Y_{CA4.1} = -24.268 + 0.418\ X_{prob} + 0.577\ X_{imp}$	**Eq.5- CA4**	**55**	**1**	**0**
5	Type of Client: Group of People	**0.000**	**0.955**	**1.536**	**0.000**	$Y_{CA5.1c} = -29.351 + 0.519\ X_{prob} + 0.558\ X_{imp}$	**Eq.5- CA5**	**50**	**3**	**5**
6	Location: City Area	**0.000**	**0.972**	**2.007**	**0.000**	$Y_{CA6.1} = -24.410 + 0.405\ X_{prob} + 0.650\ X_{imp}$	**Eq.5- CA6**	**55**	**1**	**0**
7	Location: Regional Area	**0.000**	**0.943**	**1.898**	**0.000**	$Y_{CA7.1} = -21.507 + 0.341\ X_{prob} + 0.628\ X_{imp}$	**Eq.5- CA7**	**55**	**1**	**0**
8	Location: Beach Area	**0.000**	**0.930**	**2.153**	**0.000**	$Y_{CA8.1} = -19.832 + 0.431\ X_{prob} + 0.487\ X_{imp}$	**Eq.5- CA8**	**55**	**1**	**0**
9	Location: Desert Area	**0.000**	**0.967**	**1.603**	**0.000**	$Y_{CA9.1d} = -41.191 + 0.723\ X_{prob} + 0.5549\ X_{imp}$	**Eq.5- CA9**	**52**	**3**	**3**
10	Building Services Complexity: Operational Services	**0.000**	**0.898**	**2.212**	**0.000**	$Y_{CA10.1} = -28.441 + 0.514\ X_{prob} + 0.529\ X_{imp}$	**Eq.5- CA10**	**55**	**1**	**0**
11	Building Services Complexity: Fitness Services	**0.000**	**0.958**	**1.903**	**0.000**	$Y_{CA11.1} = -10.250 + 0.234\ X_{prob} + 0.490\ X_{imp}$	**Eq.5- CA11**	**55**	**1**	**0**
12	Number of Basement Levels	**0.000**	**0.920**	**1.636**	**0.000**	$Y_{CA12.1} = -22.454 + 0.497\ X_{prob} + 0.481\ X_{imp}$	**Eq.5- CA12**	**55**	**1**	**0**
13	Procurement Method	**0.000**	**0.947**	**2.005**	**0.000**	$Y_{CA13.1} = -32.193 + 0.502\ X_{prob} + 0.636\ X_{imp}$	**Eq.5- CA13**	**55**	**1**	**0**
14	Site Topography	**0.000**	**0.924**	**2.433**	**0.000**	$Y_{CA14.1} = -24.830 + 0.397\ X_{prob} + 0.622\ X_{imp}$	**Eq.5- CA14**	**55**	**1**	**0**
15	Site Conditions	**0.000**	**0.946**	**2.032**	**0.000**	$Y_{CA15.1} = -26.255 + 0.400\ X_{prob} + 0.668\ X_{imp}$	**Eq.5- CA15**	**55**	**1**	**0**
16	Working Space	**0.000**	**0.921**	**1.841**	**0.000**	$Y_{CA16.1} = -17.034 + 0.339\ X_{prob} + 0.531\ X_{imp}$	**Eq.5- CA16**	**55**	**1**	**0**
17	Site Access	**0.000**	**0.945**	**1.979**	**0.000**	$Y_{CA17.1} = -17.168 + 0.285\ X_{prob} + 0.656\ X_{imp}$	**Eq.5- CA17**	**55**	**1**	**0**
18	Frame Structure	**0.000**	**0.940**	**1.503**	**0.000**	$Y_{CA18.1c} = -18.767 + 0.272\ X_{prob} + 0.616\ X_{imp}$	**Eq.5- CA18**	**51**	**3**	**4**
19	Foundation Type	**0.000**	**0.952**	**1.913**	**0.000**	$Y_{CA19.1b} = -15.876 + 0.597\ X_{prob} + 0.257\ X_{imp}$	**Eq.5- CA19**	**53**	**2**	**2**

SN	Cost Risk Description	Regression Analysis						Valid Sample Size	Number of Iterations	Number of Outlier
		Sig.	R - Square	Durbin-Watson	Std. Residual	Equation	Equation Reference			
20	Ground Conditions	**0.000**	**0.951**	**1.708**	**0.000**	$Y_{CA20.1} = -19.644 + 0.295\ X_{prob} + 0.674\ X_{imp}$	**Eq.5- CA20**	**55**	**1**	**0**
21	Type of Soil	**0.000**	**0.920**	**1.693**	**0.000**	$Y_{CA21.1} = -30.697 + 0.495\ X_{prob} + 0.607\ X_{imp}$	**Eq.5- CA21**	**55**	**1**	**0**
22	Mark-up Size	**0.000**	**0.951**	**1.737**	**0.000**	$Y_{CA22.1} = -15.493 + 0.309\ X_{prob} + 0.556\ X_{imp}$	**Eq.5- CA22**	**55**	**1**	**0**
23	Need for Work	**0.000**	**0.937**	**1.996**	**0.000**	$Y_{CA23.1} = -18.179 + 0.322\ X_{prob} + 0.560\ X_{imp}$	**Eq.5- CA23**	**55**	**1**	**0**
24	Deadline Requirements	**0.000**	**0.925**	**1.768**	**0.000**	$Y_{CA24.1} = -36.991 + 0.646\ X_{prob} + 0.572\ X_{imp}$	**Eq.5- CA24**	**55**	**1**	**0**
25	Number of Stories	**0.000**	**0.948**	**2.124**	**0.000**	$Y_{CA25.1} = -19.151 + 0.402\ X_{prob} + 0.502\ X_{imp}$	**Eq.5- CA25**	**55**	**1**	**0**
26	Project Duration	**0.000**	**0.972**	**2.127**	**0.000**	$Y_{CA26.1} = -36.626 + 0.660\ X_{prob} + 0.568\ X_{imp}$	**Eq.5- CA26**	**55**	**1**	**0**
27	Gross Floor Area	**0.000**	**0.882**	**1.867**	**0.000**	$Y_{CA27.1} = -21.393 + 0.433\ X_{prob} + 0.494\ X_{imp}$	**Eq.5- CA27**	**55**	**1**	**0**
28	Equipment Required	**0.000**	**0.955**	**2.148**	**0.000**	$Y_{CA28.1} = -17.916 + 0.315\ X_{prob} + 0.596\ X_{imp}$	**Eq.5- CA28**	**55**	**1**	**0**
29	Construction Technology Availability	**0.000**	**0.950**	**1.699**	**0.000**	$Y_{CA29.1} = -30.265 + 0.509\ X_{prob} + 0.621\ X_{imp}$	**Eq.5- CA29**	**55**	**1**	**0**
B	Political Risks									
1	Change in Law	**0.000**	**0.921**	**1.782**	**0.000**	$Y_{CB1.1} = -26.362 + 0.546\ X_{prob} + 0.517\ X_{imp}$	**Eq.5- CB1**	**54**	**1**	**0**
2	Delay in Project Approvals and Permits	**0.000**	**0.962**	**1.796**	**0.000**	$Y_{CB2.1} = -39.873 + 0.622\ X_{prob} + 0.644\ X_{imp}$	**Eq.5- CB2**	**54**	**1**	**0**
3	Poor Public Decision Making Process	**0.000**	**0.946**	**1.965**	**0.000**	$Y_{CB3.1} = -28.624 + 0.528\ X_{prob} + 0.549\ X_{imp}$	**Eq.5- CB3**	**54**	**1**	**0**
4	Government Intervention	**0.000**	**0.942**	**2.008**	**0.000**	$Y_{CB4.1} = -24.614 + 0.451\ X_{prob} + 0.575\ X_{imp}$	**Eq.5- CB4**	**54**	**1**	**0**
5	Unstable Government	**0.000**	**0.955**	**1.789**	**0.000**	$Y_{CB5.1} = -31.328 + 0.699\ X_{prob} + 0.466\ X_{imp}$	**Eq.5- CB5**	**54**	**1**	**0**
6	Government Reliability	**0.000**	**0.932**	**2.145**	**0.000**	$Y_{CB6.1} = -29.046 + 0.524\ X_{prob} + 0.592\ X_{imp}$	**Eq.5- CB6**	**54**	**1**	**0**
7	Inconsistencies in Government Policies	**0.000**	**0.938**	**1.775**	**0.000**	$Y_{CB7.1} = -28.005 + 0.622\ X_{prob} + 0.477\ X_{imp}$	**Eq.5- CB7**	**54**	**1**	**0**
8	Strong Political Opposition / Hostility	**0.000**	**0.914**	**1.961**	**0.000**	$Y_{CB8.1} = -25.278 + 0.589\ X_{prob} + 0.468\ X_{imp}$	**Eq.5- CB8**	**54**	**1**	**0**

SN	Cost Risk Description	Regression Analysis						Valid Sample Size	Number of Iterations	Number of Outlier
		Sig.	R - Square	Durbin-Watson	Std. Residual	Equation	Equation Reference			
9	Expropriation/ Nationalization of Assets	**0.000**	**0.893**	**1.563**	**0.000**	$Y_{CB9.1} = -25.173 + 0.577\ X_{prob} + 0.449\ X_{imp}$	**Eq.5- CB9**	**54**	**1**	**0**
10	Inability of Concessionaire	**0.000**	**0.632**	**2.079**	**0.000**	$Y_{CB10.1} = -6.461 + 0.106\ X_{prob} + 0.520\ X_{imp}$	**Eq.5- CB10**	**54**	**1**	**0**
C	Legal Risks									
1	Change in Tax Regulation	**0.000**	**0.978**	**1.513**	**0.000**	$Y_{CC1.1c} = -26.870 + 0.598\ X_{prob} + 0.506\ X_{imp}$	**Eq.5- CC1**	**49**	**3**	**6**
2	Corruption and Lack of Respect for Law	**0.000**	**0.918**	**1.925**	**0.000**	$Y_{CC2.1} = -25.470 + 0.609\ X_{prob} + 0.445\ X_{imp}$	**Eq.5- CC2**	**54**	**1**	**0**
3	Legislation Change	**0.000**	**0.938**	**1.888**	**0.000**	$Y_{CC3.1} = -23.051 + 0.481\ X_{prob} + 0.522\ X_{imp}$	**Eq.5- CC3**	**54**	**1**	**0**
4	Import / Export Restrictions	**0.000**	**0.942**	**1.927**	**0.000**	$Y_{CC4.1} = -23.137 + 0.511\ X_{prob} + 0.493\ X_{imp}$	**Eq.5- CC4**	**54**	**1**	**0**
5	Rate of Return Restrictions	**0.000**	**0.925**	**1.937**	**0.000**	$Y_{CC5.1} = -15.100 + 0.424\ X_{prob} + 0.440\ X_{imp}$	**Eq.5- CC5**	**54**	**1**	**0**
6	Industrial Regulatory Change	**0.000**	**0.936**	**1.592**	**0.000**	$Y_{CC6.1} = -21.128 + 0.524\ X_{prob} + 0.455\ X_{imp}$	**Eq.5- CC6**	**54**	**1**	**0**
D	**Economic Change Risks**									
1	Interest Rate Volatility	**0.000**	**0.961**	**2.098**	**0.000**	$Y_{CD1.1} = -16.208 + 0.330\ X_{prob} + 0.571\ X_{imp}$	**Eq.5- CD1**	**54**	**1**	**0**
2	Inflation Rate Volatility	**0.000**	**0.968**	**1.979**	**0.000**	$Y_{CD2.1} = -19.016 + 0.311\ X_{prob} + 0.643\ X_{imp}$	**Eq.5- CD2**	**54**	**1**	**0**
3	Foreign Exchange and Convert	**0.000**	**0.916**	**2.034**	**0.000**	$Y_{CD3.1} = -20.731 + 0.503\ X_{prob} + 0.439\ X_{imp}$	**Eq.5- CD3**	**54**	**1**	**0**
4	Poor Financial Market	**0.000**	**0.936**	**1.543**	**0.000**	$Y_{CD4.1c} = -27.743 + 0.545\ X_{prob} + 0.536\ X_{imp}$	**Eq.5- CD4**	**51**	**3**	**3**
E	**Natural Risks**									
1	Force Majeure	**0.000**	**0.845**	**2.121**	**0.000**	$Y_{CE1.1} = -20.450 + 0.487\ X_{prob} + 0.425\ X_{imp}$	**Eq.5- CE1**	**54**	**1**	**0**
2	Environment	**0.000**	**0.921**	**1.754**	**0.000**	$Y_{CE2.1} = -17.785 + 0.366\ X_{prob} + 0.513\ X_{imp}$	**Eq.5- CE2**	**54**	**1**	**0**
3	Weather	**0.000**	**0.959**	**2.286**	**0.000**	$Y_{CE3.1} = -15.315 + 0.245\ X_{prob} + 0.649\ X_{imp}$	**Eq.5- CE3**	**54**	**1**	**0**
4	Geotechnical Condition	**0.000**	**0.929**	**1.633**	**0.000**	$Y_{CE4.1} = -17.785 + 0.254\ X_{prob} + 0.628\ X_{imp}$	**Eq.5- CE4**	**54**	**1**	**0**

SN	Cost Risk Description	Regression Analysis						Valid Sample Size	Number of Iterations	Number of Outlier
		Sig.	R - Square	Durbin-Watson	Std. Residual	Equation	Equation Reference			
F	**Market Risks**									
1	Market Supply	**0.000**	**0.917**	**1.704**	**0.000**	$Y_{CF1.1} = -18.239 + 0.446\ X_{prob} + 0.473\ X_{imp}$	**Eq.5- CF1**	**54**	**1**	**0**
2	Market Demand	**0.000**	**0.966**	**1.772**	**0.000**	$Y_{CF2.1} = -21.383 + 0.379\ X_{prob} + 0.654\ X_{imp}$	**Eq.5- CF2**	**54**	**1**	**0**
3	Fluctuation of Material Cost by Public/Private	**0.000**	**0.951**	**1.726**	**0.000**	$Y_{CF3.1} = -26.299 + 0.523\ X_{prob} + 0.541\ X_{imp}$	**Eq.5- CF3**	**54**	**1**	**0**
4	Value of Production Effort	**0.000**	**0.916**	**2.236**	**0.000**	$Y_{CF4.1} = -20.887 + 0.429\ X_{prob} + 0.529\ X_{imp}$	**Eq.5- CF4**	**54**	**1**	**0**
G	**Project Selection Risks**									
1	Public Opposition to Projects	**0.000**	**0.867**	**2.200**	**0.000**	$Y_{CG1.1} = -13.799 + 0.432\ X_{prob} + 0.401\ X_{imp}$	**Eq.5- CG1**	**54**	**1**	**0**
2	Uncompetitive Tender	**0.000**	**0.985**	**1.604**	**0.000**	$Y_{CG2.1f} = -30.589 + 0.446\ X_{prob} + 0.738\ X_{imp}$	**Eq.5- CG2**	**44**	**6**	**10**
3	Level of Demand for the Project	**0.000**	**0.910**	**1.598**	**0.000**	$Y_{CG3.1} = -23.854 + 0.532\ X_{prob} + 0.466\ X_{imp}$	**Eq.5- CG3**	**54**	**1**	**0**
4	Land Acquisition	**0.000**	**0.870**	**1.857**	**0.000**	$Y_{CG4.1} = -17.187 + 0.377\ X_{prob} + 0.520\ X_{imp}$	**Eq.5- CG4**	**54**	**1**	**0**
5	Competition Risk	**0.000**	**0.949**	**1.836**	**0.000**	$Y_{CG5.1} = -17.931 + 0.334\ X_{prob} + 0.594\ X_{imp}$	**Eq.5- CG5**	**54**	**1**	**0**
H	**Project Finance Risks**									
1	Inaccurate Estimates	**0.000**	**0.954**	**2.089**	**0.000**	$Y_{CH1.1} = -34.293 + 0.598\ X_{prob} + 0.603\ X_{imp}$	**Eq.5- CH1**	**54**	**1**	**0**
2	High Finance Cost	**0.000**	**0.927**	**2.149**	**0.000**	$Y_{CH2.1} = -26.010 + 0.528\ X_{prob} + 0.521\ X_{imp}$	**Eq.5- CH2**	**54**	**1**	**0**
3	High Bidding Costs	**0.000**	**0.935**	**2.446**	**0.000**	$Y_{CH3.1} = -26.230 + 0.518\ X_{prob} + 0.543\ X_{imp}$	**Eq.5- CH3**	**54**	**1**	**0**
4	Delay in Payment of Annuity	**0.000**	**0.901**	**1.982**	**0.000**	$Y_{CH4.1} = -20.774 + 0.449\ X_{prob} + 0.521\ X_{imp}$	**Eq.5- CH4**	**54**	**1**	**0**
5	Financial Attraction of Project to Investors	**0.000**	**0.965**	**1.608**	**0.000**	$Y_{CH5.1} = -27.694 + 0.550\ X_{prob} + 0.525\ X_{imp}$	**Eq.5- CH5**	**54**	**1**	**0**
6	Lack of Creditworthiness	**0.000**	**0.880**	**2.289**	**0.000**	$Y_{CH6.1} = -18.204 + 0.380\ X_{prob} + 0.532 X_{imp}$	**Eq.5- CH6**	**54**	**1**	**0**
7	Delay in Financial Closure	**0.000**	**0.925**	**2.150**	**0.000**	$Y_{CH7.1} = -30.516 + 0.567\ X_{prob} + 0.531\ X_{imp}$	**Eq.5- CH7**	**54**	**1**	**0**

SN	Cost Risk Description	Regression Analysis						Valid Sample Size	Number of Iterations	Number of Outlier
		Sig.	R - Square	Durbin-Watson	Std. Residual	Equation	Equation Reference			
8	Inability to Service Debt	0.000	0.894	1.738	0.000	$Y_{CH8.1} = -28.090 + 0.536\ X_{prob} + 0.504\ X_{imp}$	Eq.5- CH8	54	1	0
9	Lack of Government Guarantees	0.000	0.947	1.822	0.000	$Y_{CH9.1b} = -19.149 + 0.329\ X_{prob} + 0.635\ X_{imp}$	Eq.5- CH9	53	2	1
10	Financer Unwilling to Take High Risk	0.000	0.922	2.350	0.000	$Y_{CH10.1} = -24.299 + 0.453\ X_{prob} + 0.566\ X_{imp}$	Eq.5- CH10	54	1	0
I	**Building Functionality and Serviceability Risks**									
1	Construction Time Delay	0.000	0.964	2.047	0.000	$Y_{CI1.1} = -31.763 + 0.483\ X_{prob} + 0.685\ X_{imp}$	Eq.5- CI1	54	1	0
2	Material Availability	0.000	0.966	1.868	0.000	$Y_{CI2.1b} = -13.223 + 0.266\ X_{prob} + 0.561\ X_{imp}$	Eq.5- CI2	50	2	4
3	Labor Availability	0.000	0.959	1.729	0.000	$Y_{CI3.1} = -26.526 + 0.538\ X_{prob} + 0.524\ X_{imp}$	Eq.5- CI3	54	1	0
4	Poor Quality of Workmanship	0.000	0.956	1.675	0.000	$Y_{CI4.1} = -20.011 + 0.433\ X_{prob} + 0.542 X_{imp}$	Eq.5- CI4	54	1	0
5	Default of Sub-Contractors or Suppliers	0.000	0.962	1.820	0.000	$Y_{CI5.1} = -27.842 + 0.493\ X_{prob} + 0.605\ X_{imp}$	Eq.5- CI5	54	1	0
6	Design & Construction Complexity	0.000	0.972	1.577	0.000	$Y_{CI6.1c} = -32.106 + 0.570\ X_{prob} + 0.584\ X_{imp}$	Eq.5- CI6	54	1	0
7	Design Deficiency	0.000	0.974	1.505	0.000	$Y_{CI7.1} = -36.247 + 0.674\ X_{prob} + 0.556\ X_{imp}$	Eq.5- CI7	54	1	0
8	Late Design Change	0.000	0.958	1.856	0.000	$Y_{CI8.1} = -27.519 + 0.474\ X_{prob} + 0.624\ X_{imp}$	Eq.5- CI8	54	1	0
9	Construction Technology Complexity	0.000	0.945	2.061	0.000	$Y_{CI9.1} = -23.389 + 0.408\ X_{prob} + 0.573\ X_{imp}$	Eq.5- CI9	54	1	0
10	Contractual Risk	0.000	0.957	2.283	0.000	$Y_{CI10.1} = -21.148 + 0.410\ X_{prob} + 0.539\ X_{imp}$	Eq.5- CI10	54	1	0
11	Contractor Failure	0.000	0.988	1.559	0.000	$Y_{CI11.1d} = -50.875 + 0.760\ X_{prob} + 0.669\ X_{imp}$	Eq.5- CI11	48	4	6
12	Quality and Reliability	0.000	0.960	2.061	0.000	$Y_{CI12.1} = -32.094 + 0.589\ X_{prob} + 0.553\ X_{imp}$	Eq.5- CI12	54	1	0
J	**Stakeholders Relationship Risks**									
1	Different Working Method Between Partners	0.000	0.943	1.969	0.000	$Y_{CJ1.1} = -15.742 + 0.319\ X_{prob} + 0.542\ X_{imp}$	Eq.5- CJ1	54	1	0
2	Inadequate Experience in Residential Projects	0.000	0.894	1.694	0.000	$Y_{CJ2.1} = -26.927 + 0.523\ X_{prob} + 0.517\ X_{imp}$	Eq.5- CJ2	54	1	0

SN	Cost Risk Description	Regression Analysis						Valid Sample Size	Number of Iterations	Number of Outlier
		Sig.	R - Square	Durbin-Watson	Std. Residual	Equation	Equation Reference			
3	Lack of Commitment From Public/Private Sector	0.000	0.933	1.953	0.000	$Y_{CJ3.1} = -19.470 + 0.395\ X_{prob} + 0.508\ X_{imp}$	Eq.5- CJ3	54	1	0
4	Organization and Coordination Risk	0.000	0.915	2.318	0.000	$Y_{CJ4.1} = -27.211 + 0.547\ X_{prob} + 0.490\ X_{imp}$	Eq.5- CJ4	54	1	0
5	Inadequate Distribution of Responsibility & Risk	0.000	0.952	2.306	0.000	$Y_{CJ5.1} = -21.988 + 0.371\ X_{prob} + 0.621\ X_{imp}$	Eq.5- CJ5	54	1	0
6	Inadequate Negotiation Period Prior to Initiation	0.000	0.911	2.389	0.000	$Y_{CJ6.1} = -20.968 + 0.457\ X_{prob} + 0.453\ X_{imp}$	Eq.5- CJ6	54	1	0
7	Conflict Between Project's Participants	0.000	0.944	2.241	0.000	$Y_{CJ7.1} = -24.109 + 0.497\ X_{prob} + 0.512\ X_{imp}$	Eq.5- CJ7	54	1	0
8	Workers Strike	0.000	0.913	2.016	0.000	$Y_{CJ8.1} = -16.370 + 0.390\ X_{prob} + 0.484\ X_{imp}$	Eq.5- CJ8	54	1	0
9	Cultural Differences Between Main Stakeholders	0.000	0.906	1.716	0.000	$Y_{CJ9.1} = -14.387 + 0.373\ X_{prob} + 0.415\ X_{imp}$	Eq.5- CJ9	54	1	0
K	**Knowledge Risks**									
1	Expertise	0.000	0.932	1.954	0.000	$Y_{CK1.1} = -28.386 + 0.475\ X_{prob} + 0.604\ X_{imp}$	Eq.5- CK1	54	1	0
2	Familiarities	0.000	0.947	1.989	0.000	$Y_{CK2.1} = -24.478 + 0.479\ X_{prob} + 0.524\ X_{imp}$	Eq.5- CK2	54	1	0
3	Number of Bidders	0.000	0.974	1.582	0.000	$Y_{CK3.1} = -13.106 + 0.224\ X_{prob} + 0.598\ X_{imp}$	Eq.5- CK3	54	1	0
4	Market Conditions	0.000	0.957	1.982	0.000	$Y_{CK4.1} = -20.929 + 0.386\ X_{prob} + 0.606\ X_{imp}$	Eq.5- CK4	54	1	0
5	Size of the Project	0.000	0.920	1.806	0.000	$Y_{CK5.1} = -18.089 + 0.387\ X_{prob} + 0534\ X_{imp}$	Eq.5- CK5	54	1	0
6	Type of Building	0.000	0.960	1.833	0.000	$Y_{CK6.1} = -20.515 + 0.393\ X_{prob} + 0.566\ X_{imp}$	Eq.5- CK6	54	1	0
7	Extent of Database	0.000	0.852	1.535	0.000	$Y_{CK7.1} = -13.046 + 0.333\ X_{prob} + 0.456\ X_{imp}$	Eq.5- CK7	54	1	0
8	Homogeneity of Samples	0.000	0.966	1.982	0.000	$Y_{CK8.1} = -9.893 + 0.212\ X_{prob} + 0.534\ X_{imp}$	Eq.5- CK8	54	1	0
9	Details of Information	0.000	0.963	1.956	0.000	$Y_{CK9.1} = -20.361 + 0.374\ X_{prob} + 0.594\ X_{imp}$	Eq.5- CK9	54	1	0
O	**OPEX Activities' Risks**									
1	Energy Costs	0.000	0.924	2.047	0.000	$Y_{O1.1} = -29.619 + 0.554\ X_{prob} + 0.554\ X_{imp}$	Eq.5- O1	54	1	0

SN	Cost Risk Description	Regression Analysis						Valid Sample Size	Number of Iterations	Number of Outlier
		Sig.	R - Square	Durbin-Watson	Std. Residual	Equation	Equation Reference			
2	Service Life of Building Components	0.000	0.961	1.663	0.000	$Y_{O2.1} = -19.639 + 0.355\ X_{prob} + 0.593\ X_{imp}$	Eq.5- O2	54	1	0
3	Building Components' Eco-Costs	0.000	0.885	1.858	0.000	$Y_{O3.1} = -14.620 + 0.312\ X_{prob} + 0.499\ X_{imp}$	Eq.5- O3	54	1	0
4	Asset Operation Eco-Costs	0.000	0.939	1.975	0.000	$Y_{O4.1} = -13.456 + 0.272\ X_{prob} + 0.544\ X_{imp}$	Eq.5- O4	54	1	0
5	Disposal Eco-Costs	0.000	0.958	1.768	0.000	$Y_{O5.1} = -11.825 + 0.247\ X_{prob} + 0.549\ X_{imp}$	Eq.5- O5	54	1	0
6	Components' Deterioration Rate	0.000	0.940	2.305	0.000	$Y_{O6.1} = -15.652 + 0.329\ X_{prob} + 0.553\ X_{imp}$	Eq.5- O6	54	1	0
7	Fabric Maintenance	0.000	0.922	2.388	0.000	$Y_{O7.1} = -14.582 + 0.277\ X_{prob} + 0.535\ X_{imp}$	Eq.5- O7	54	1	0
8	Services	0.000	0.934	1.639	0.000	$Y_{O8.1} = -14.609 + 0.252\ X_{prob} + 0.596\ X_{imp}$	Eq.5- O8	54	1	0
9	Equipment's Maintenance	0.000	0.977	1.914	0.000	$Y_{O9.1b} = -16.289 + 0.305\ X_{prob} + 0.558\ X_{imp}$	Eq.5- O9	51	2	3
10	Overheads	0.000	0.954	1.778	0.000	$Y_{O10.1} = -21.626 + 0.349\ X_{prob} + 0.615\ X_{imp}$	Eq.5- O10	54	1	0
11	Utilities	0.000	0.962	2.303	0.000	$Y_{O11.1} = -16.552 + 0.294\ X_{prob} + 0.554\ X_{imp}$	Eq.5- O11	54	1	0
12	Cleaning	0.000	0.836	1.901	0.000	$Y_{O12.1} = -14.313 + 0.285\ X_{prob} + 0.480\ X_{imp}$	Eq.5- O12	54	1	0
13	Percentage of Current Replacement Value	0.000	0.934	2.041	0.000	$Y_{O13.1} = -15.053 + 0.287\ X_{prob} + 0.539\ X_{imp}$	Eq.5- O13	54	1	0
14	Ratio of Maintenance to Capital Cost	0.000	0.942	2.123	0.000	$Y_{O14.1} = -14.588 + 0.291\ X_{prob} + 0.538\ X_{imp}$	Eq.5- O14	54	1	0
15	Ratio of Operation to Capital Cost	0.000	0.949	2.124	0.000	$Y_{O15.1} = -17.726 + 0.363\ X_{prob} + 0.525\ X_{imp}$	Eq.5- O15	54	1	0

Table 5-10: Show how the detailed summary of each regression analysis conducted for each of the 117 risk factors.

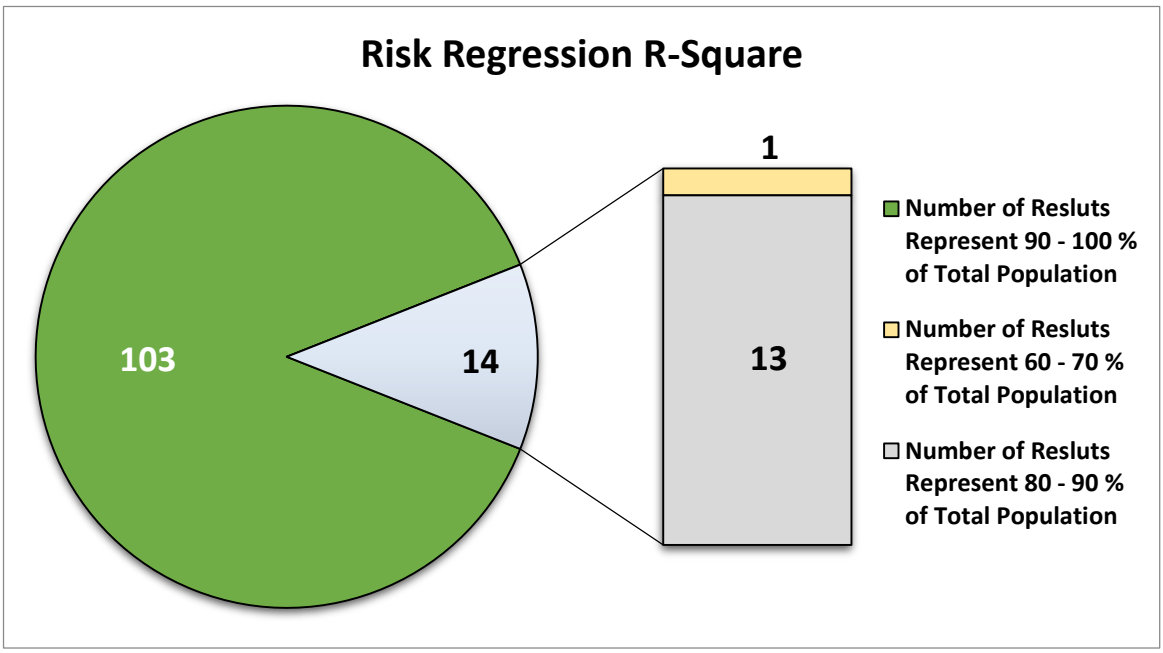


Figure 5-6: Show how much of the population is represented by the data analysis results in table 5-10.

From the conducted regression analysis, as shown in appendix B, and summarized in table 5-10, for each of the 117 risk factors. It has been found that the R-Square (i.e., population represented by the regression model equation) is ranging between 60% and 100%. In summarizing Figure 5-6, this research data regression analysis resulted in 103 out of 117 risks regression model represent more than 90% of the population (i.e., almost a perfect fit). Also, results showed 14 out of 117 risk regression models representing less than 90% of the main population. First, one risk regression model was found to represent 63.2% of the population. However, the reason behind considering those risks in the final system dynamics model has been explained previously in this chapter. Furthermore, because similar studies about buildings lifecycle cost estimation considered in the final regression model 3 cost variables having R^2 ranging between 44.1% to 67% because of their valid significance P-Value (Krstić & Marenjak 2012). Therefore, this cost risk will be considered because its significance P-Value equals 0.000. Then, 13 risk regression models were found, representing 80% – 90% of the population.

Therefore, based on variables' resulted in significance and R^2 values from appendix B and table 5-10, data has been validated to proceed with the Monte Carlo Simulation stage.

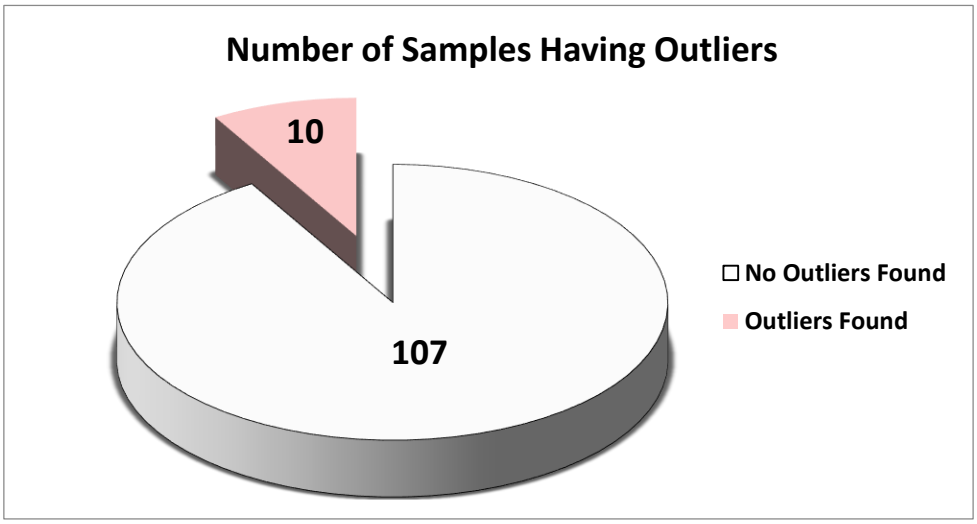


Figure 5-7: Show how many risks had outliers during validating the collected survey data in table 5-10.

After that, in Figure 5-7, the risks having outliers in this research regression modelling found equal to 10 out of 117 cost risks. However, as mentioned previously, the R-Square value was still valid after removing outliers from the analysed data sets, although it represented less of the population in some cases. For more details about each iteration, please refer to appendix B. Durbin-Watson's value is ranging from 0 to 4 (Nazif et al. 2016; Jafarzadeh et al. 2015). However, according to researchers, it is important to keep the Durbin-Watson value as close as possible to 2 (i.e., complete avidness of autocorrelation) (Nazif et al. 2016; Jafarzadeh et al. 2015). It is impossible to have data Durbin-Watson exactly equal to 2 (Nazif et al. 2016; Jafarzadeh et al. 2015). However, it can be as close as possible to be considered autocorrelation with no-impact or neglectable impact on data sets (Nazif et al. 2016; Jafarzadeh et al. 2015). Mathematically, values above 1.5 can be approximated to 2 (i.e., $X \approx 2$, if $X > 1.5$). And values below 2.5 can be approximated to 2 (i.e., $X \approx 2$, if $X < 2.5$). Therefore, the outliers had to be removed to keep the Durbin-Watson value between 1.5 to 2.5 (i.e., $1.5 <$ Durbin-Watson < 2.5)

for avoiding any autocorrelation within the analysis results (Nazif et al. 2016; Jafarzadeh et al. 2015). Nevertheless, the final required iterations, for data including outliers, were found between 2 and 6 iterations. It is found that 5 risks had 1 to 3 outliers (i.e., 1, 2, and 3 outliers), And 4 risks had 4 to 9 outliers (i.e., 4, 5, and 6 outliers). Furthermore, 1 risk has 10 outliers. Finally, these outliers are mandatory to be removed from any regression model to have accurate regression equations successfully representing the main population. Furthermore, to have appropriate equation coefficients connecting the risks with their probabilities and impacts. This will help predict adjusted risks in the future based on probability or impact possible changes using the developed regression equation for each risk.

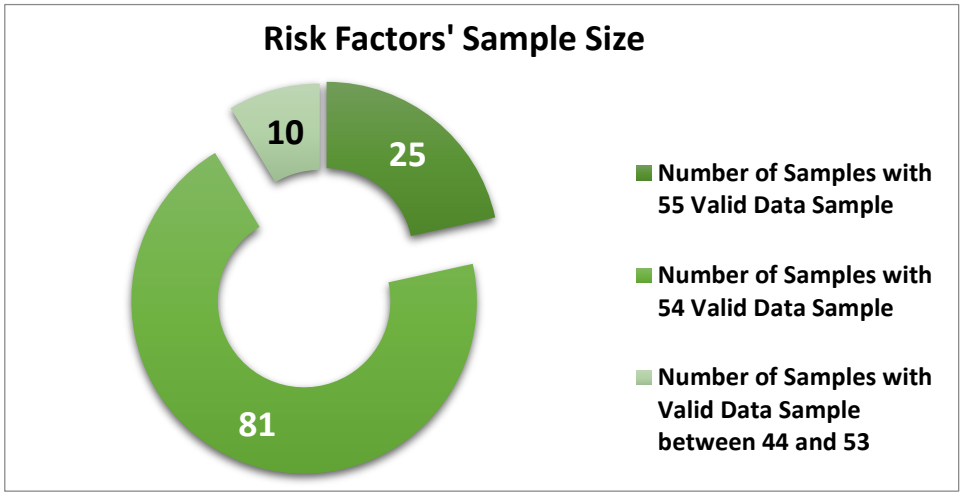


Figure 5-8: Valid sample size resulted from data analysis in table 5-10.

Next, the validated data through regression modelling have a final valid sample size ranging from 44 to 55. It is essential to ensure having at least 30 valid samples to shape the normalization (Bujang & Baharum 2016; Delice 2010; Shen, Nguyen & Ojiako 2013; Ruiz et al. 2017; Aliverdi, Naeni & Salehipour 2013). Therefore, in Figure 5-8, 10 risks have valid samples ranging between 44 and 53 sample sizes. Furthermore, 81 risks have a valid sample size equal to 54. Finally, 25 risks have a valid sample size equal to 55. The sample size variations resulted from either the outlier points that had to be removed or the incomplete (i.e.,

missing) answers for some of the risks. This is done based on interviewees' request to skip answering questions that they are not aware of its exact values.

5.4 Summary

To sum up, this chapter has detailed how the collected data for this research is validated before proceeding with further analysing steps. Experts' general information contributed to this research data collection was presented and described, as shown in table 5-1, to validate experts themselves. Validating experts was based on qualifications and related specialized experience. This will support the expected accuracy of collected data according to previous research critique. All collected data has been analysed through SPSS to examine the correlation between risks and their impacts and probabilities, as shown in table 5-6. Furthermore, this chapter discussed the regression analysis of risks (i.e., dependent variable) with its independent variables (i.e., impact and probability) using SPSS software and summarized the results in table 5-10. Results are critiqued against previous literature and concluded that final validated data is acceptable. The degree of measurements' repeatability to fall within a given range under high significance value is proving that the results are reliable to be used for analysis and discussion (Golafshani 2003). This research ensures data reliability by satisfying all reliability criteria types after collecting it quantitively before any analysis or discussion. This will provide the possible accurate cost estimation and cash flow modelling results. Therefore, the data after correlation analysis and regression modelling can be used in the Monte-Carlo Simulation to use the final model's VENSIM system dynamics. Finally, all SPSS analysis results can be found with all required details in APPENDIX B for further verification and information whenever it is required and needed.

Chapter 6
MONTE-CARLO MODELLING

"*We need to understand how to develop Monte Carlo methods based on sampled stochastic processes*".

(Graham & Talay 2013, p.8)

6.0 Introduction

In this chapter, the process of computing accurate risks' errors, which will be used in the VENSIM system dynamics model, will be detailed following the designed research methodology in chapter 4. This research will conduct Monte-Carlo Simulation to compute the adjusted and adjusting risks used in the cost estimation modelling. It will reflect the actual costs and cash flow, which will occur after experiencing predicted risks' impact. Therefore, this chapter's Monte-Carlo simulation will be based on taking 10,000 random measures for each risk factor (i.e., 117 final validated risks) to provide accurate cost estimation results.

6.1 Monte-Carlo Simulation Approach

It is important to know about the Monte Carlo approach's history to better understand its value and importance (Jackel 2002). In the 1940s, the Monte Carlo method for mathematical computation started by three American mathematicians (i.e., Nicholas Metropolis, John von Neumann, and Stanislav Ulam) during the entrance programable computers for the first time (Jackel 2002). The approach did not have a name until Nicholas Metropolis, and Stanislav Ulam scientists used it to conduct a multi-dimensional statistical calculation analysis in 1949 and called it the Monte Carlo method (Jackel 2002). Monte Carlo analysis is based on a computer algorithm to generate sufficiently random numbers to support mathematical prediction equation approaching a stochastic process (Jackel 2002). Therefore, as explained and justified in chapter 4, it is mandatory to approach the Monte Carlo method in this research to obtain the minimum, mean, and maximum risks error. This process will have the required 10,000 random iterations generated using the Microsoft Office Excel software programme. Furthermore, start computing using equations 4-10 to 4-19.

Adjusted Mean Value = Min + [MC * (Max – Min)] Equation 4-10

Min = the Minimum Survey Risk Value

Max = the Maximum Survey Risk Value

MC = Monte Carlo average of 10,000 random values (between 0 to 1).

Adjustment Mean Value = $\delta = \left| \frac{v_A - v_E}{v_E} \right| \cdot 100\%$ Equation 4-11

δ = **Percent error**

v_A = **Believed actual value (i.e. Adjusted value)**

v_E = **Experts estimated value**

Based on 95% Confidence of Normally Distributed Data (i.e., at least 30 samples):

Max Risk $= \bar{X} + 2\sigma$ Equation 4-12

Min Risk $= \bar{X} - 2\sigma$ Equation 4-13

$\boldsymbol{\sigma}$ is the risk standard deviation

$\bar{X}$ is the survey sample mean risk

Max Risk is the Normal Distribution Upper Limit

Min Risk is the Normal Distribution Lower Limit

From equations 4-12 and 4-13

$2\sigma = Max\ Risk - \bar{X} = \bar{X} - Min\ Risk$ Equation 4-14

$2\,\bar{X} = Min\ Risk + Max\ Risk$ Equation 4-15

From equation 4-11:

Adjustment Mean Value (error) $= \frac{Adjusted\ Mean - \bar{X}}{\bar{X}}$ Equation 4-16

By feeding equation 4-16 into equation 4-15 and by using mathematical multiplication and division properties:

$$2\,\bar{X} * \frac{Adjusted\ Mean - \bar{X}}{\bar{X}} = (Min\ Risk + Max\ Risk) * \frac{Adjusted\ Mean - \bar{X}}{\bar{X}}$$

$$2\,\bar{X} * Adjustment\ Mean = (Min\ Risk + Max\ Risk) * Adjustment\ Mean$$

$$2\ Adjustment\ Mean = \left(\frac{Min\ Risk}{\bar{X}} + \frac{Max\ Risk}{\bar{X}}\right) * Adjustment\ Mean \quad \text{Equation 4-17}$$

Therefore, equations 4-15 and 4.16 can be concluded from equations 4-13 and 4-14.

Adjustment minimum risk value $= \frac{Min\ Risk}{\bar{X}} * Adjustment\ Mean$ Equation 4-18

Adjustment maximum risk value $= \frac{Max\ Risk}{\bar{X}} * Adjustment\ Mean$ Equation 4-19

Apply equation 4-10 in Excel using Mersenne Twister random number generation algorithm.

Adjusted Mean Using Excel `=RAND()*(b-a)+a` Equation 6-1

Adjusted Mean Using Excel $= \frac{\sum_1^{10,000} RAND()}{10,000} * (b - a) + a$ Equation 6-2

a = the Minimum Survey Risk Value

b = the Maximum Survey Risk Value

RAND() = Monte Carlo pseudo-random values (between 0 to 1).

Formula	Description	Result
=RAND()	A random number greater than or equal to 0 and less than 1	varies
=RAND()*100	A random number greater than or equal to 0 and less than 100	varies
=INT(RAND()*100)	A random whole number greater than or equal to 0 and less than 100	varies
	Note: When a worksheet is recalculated by entering a formula or data in a different cell, or by manually recalculating (press **F9**), a new random number is generated for any formula that uses the RAND function.	

Figure 6-1: Microsoft office official random equation used in excel (RAND function 2020).

In order to ensure the implementation of accurate and successful Monte Carlo simulation for the verified data, it is mandatory to understand the basic software mathematics used to generate random numbers. Furthermore, to confirm that chapter 4 developed mathematical modelling equations that can be computed utilising Excel software. Therefore, by reviewing the Microsoft Office Excel official manual, it has been found that Excel RAND() function is the approach to generate random numbers between 0 and 1 (RAND function 2020). It is also stated clearly that RAND() function uses the Mersenne twister algorithm to generate random numbers (RAND function 2020). According to the literature, the Mersenne twister algorithm is one of many computer algorithms to generate pseudorandom outputs (Self & Mackey 2016; Graham & Talay 2013). According to the linear feedback shift register, the Mersenne twister is one of the most important random number generating algorithm based on its historical strength (Self & Mackey 2016). It has been proved accurate for linear congruential generation and linear functions (Self & Mackey 2016). Therefore, this research will use the Microsoft Office Excel software programme to approach Monte Carlo stochastic mathematical modelling to compute risks error using Figure 6-1 algorithm and equations 6-1 and 6-2.

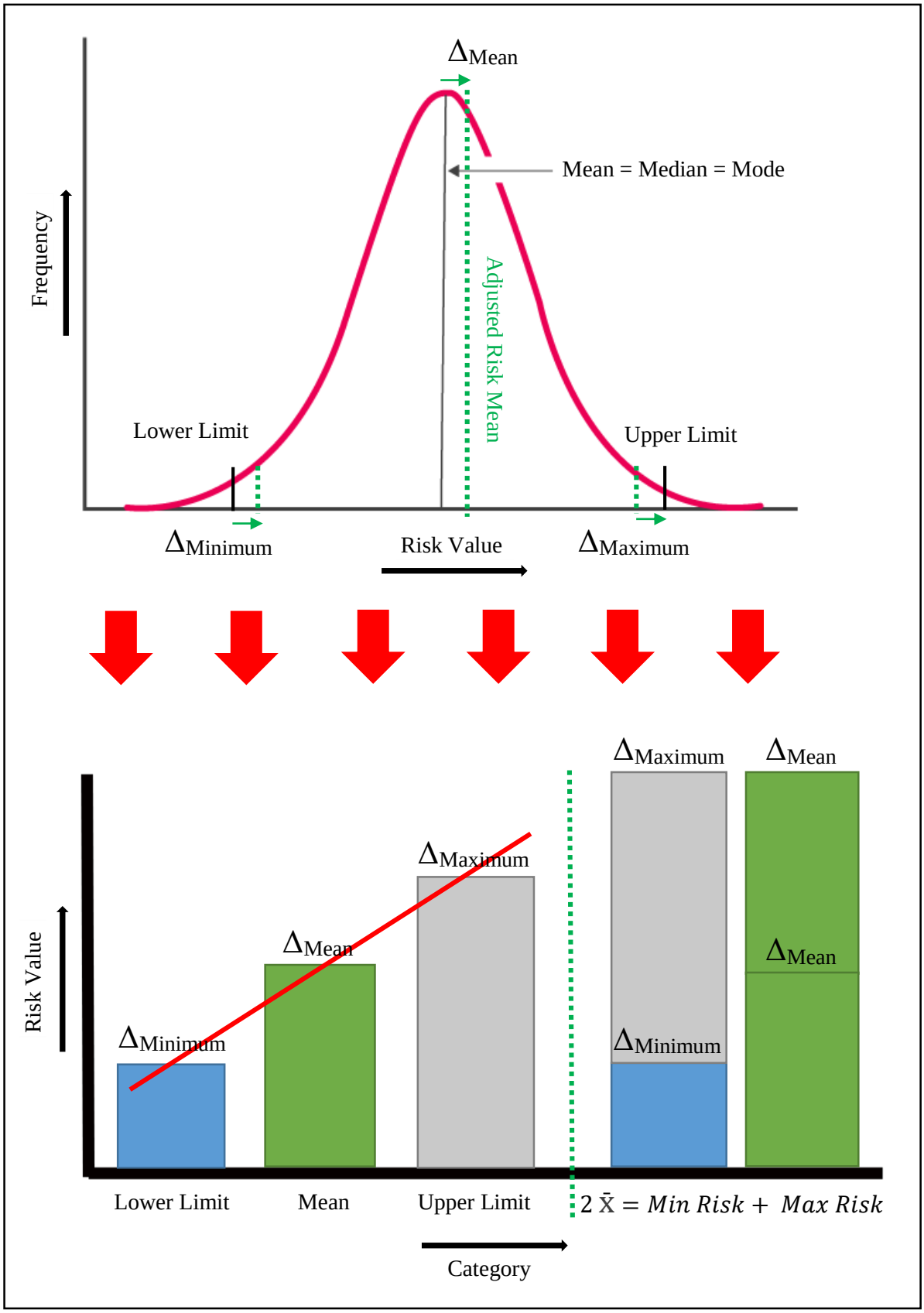


Figure 6-2: Computing $\Delta_{Minimum}$ and $\Delta_{Maximum}$ using Δ_{Mean} and equations 4-16 and 4-17 as detailed in chapter 4.

This research data's calculated error is based on normally distributed data as explained and justified in chapter 4. It will be taken based on using distribution properties (i.e., Mean and Standard Deviation) to apply risks' error impact on the contract value at the design stage to estimate final costs and cashflows. Therefore, each error set related to a variable requires to have the same behaviour of its data (i.e., normal distribution mean, standard deviation, upper limit, and lower limit). The detailed process shown in Figure 6-2 must be followed and reflected in the analysis to satisfy this requirement. Otherwise, the mean risk might be lower than the upper limit or more than the upper limit. The procedure shown in Figure 6-2 ensures that mathematical statistics theory applies on a higher generalization level. Similar research about buildings' operations and management used this approach to check if a theory's relevance can be extended (Meredith 1998). Researchers' evidence, for approaching testing theories' relevance extension, is based on replacing Newton's gravity theory with Einstein's relativity theory due to generalization (Meredith 1998). Previous literature declared that weighted cost-risks measurement in a project's delivery is achieved by conducting a sensitivity analysis to measure its relativity using a risk assessment probabilistic approach (Akinyemi et al. 2009). It is essential to understand the driving risk force to assign it as the relativity gravity centre of each problem (Flores-Colen, Brito & Freitas 2010). Gravity term is used because objects' behaviour relatively changes toward each other concerning their response to gravity force. Relativity change in this research can be defined as the change of data errors (i.e., $\Delta_{Minimum}$ and $\Delta_{Maximum}$) using Δ_{Mean} as the main driving force connecting all data distribution changes relative to its change.

6.2 Cost Risks Monte-Carlo Modelling

According to researchers, to identify the accuracy of parameters and attributes measurements, it is most recommended to have a stepwise regression followed by a Monte Carlo simulation (Yang et al. 2019). Built environment projects have cost estimation issues due to client requirements (Ahiaga-Dagbui & Juffermans 2019; Oswald et al. 2020). This requires having an estimation model from client perspectives, as explained and justified in the literature review chapter. Monte-Carlo calculation of adjusted and adjusting risks is based on the final SPSS validated data outputs.

In table 6-1, Monte Carlo modelling is fully detailed to obtain the final desired outputs (i.e., risks errors). The first column from the left side is including the serial numbers of each cost risk and the alphabet letter of each variables' group, as shown in Figure 6-3. However, in Figure 6-3, the risk description is represented in the second column of table 6-1, and its reference is CA1 (i.e., C = CAPEX, A = Group Symbol, and 1 = the activity number under the group).

SN	Cost Variable Description
A	Construction Activities' Risks
1	Selection Method

Figure 6-3: Cost risks description and reference code (i.e., CA1) from table 6-1.

Survey Risk Mean % X1	Risk Standard Deviation %
31.930	22.386

Figure 6-4: CA1 Cost risks SPSS Mean and Standard Deviation from table 6-1.

The third and fourth columns are the survey risk mean and standard deviation after validating data using SPSS software, as shown in Figure 6-4. However, to facilitate clarifying further coming calculations in Table 6-1, the survey risk mean column is given a symbol X1as shown in Figure 6-4. After that, the lower and upper limits are calculated, as shown in Figure

6-5, using equations 4-12 and 4-13 fifth and sixth column of table 6-1. However, they are given symbols Xmin and Xmax, respectively, to facilitate further calculations understanding of Monte Carlo simulation. In Figure 6-6, the seventh and eighth columns present the average percentage of 10,000 random values used in Monte Carlo simulation and the adjusted Mean value (i.e., X2 in table 6-1) using equation 4-10.

Min. Survey Risk Value % Xmin	Max Survey Risk Value % Xmax
9.544	54.316

Figure 6-5: CA1 Cost risks Lower and Upper Limits from table 6-1.

10,000 Random Values Avg.	Monti-Carlo Modelling adjusted Mean Risk value % X2
0.503	32.082

Figure 6-6: CA1 10,000 iterations average and cost risks adjusted Mean from table 6-1.

Then, the calculations of mean error and the relativity change of data upper and lower limits, as explained earlier, is done using equations 4-16 to 4-19, as shown in Figure 6-7. However, these calculations occur in each cell of the ninth, tenth, and eleventh columns of table 6-1, respectively. However, the equations used in each of these columns use introduced symbols mentioned previously in table 6-1 column for better understanding, as shown in Figure 6-7.

Relativity Change Between Survey Minimum Risk Value % and Survey Mean Risk value % Rmin= (Xmax/X1)*Rmean	Relativity Change Between Survey Maximum Risk Value % and Survey Mean Risk value % Rmax= (Xmax/X1)*Rmean	Relativity Change Between Monti-Carlo Modelling adjusted Risk Mean Value % and Survey Mean Risk value % Rmean=ABS(X2-X1)/X1
0.001422906	0.008097921	0.004760413

Figure 6-7: CA1 $\Delta_{Minimum}$, Δ_{Mean}, and $\Delta_{Maximum}$ from table 6-1. Calculations are using equations 4-14 to 4-19 and figure 6-2.

Finally, in Figure 6-8, the difference between validated data survey means and adjusted Monte Carlo simulation means is presented graphically and numerically, respectively, in the

twelfth column. It is used to have a balanced random value's average by ensuring almost 50% of the differences under positive and negative changes. This will avoid any bias with or against experts provided data, as shown in Figure 6-9.

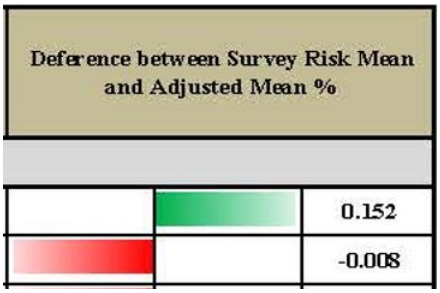


Figure 6-8: CA1 and CA2 Cost risks deference between the survey and the adjusted Means from table 6-1.

Deference between Survey Risk Mean and Adjusted Mean %	
Positive	Negative
58	**59**
117	

Figure 6-9: Balancing table 6-1 Cost risks deference between the survey and the adjusted Means.

The model is finalized after simulating several random iterations and fixed the values that caused 58 positives and 59 negatives (i.e., almost 50% in positive and 50% in negative) as counted in the last column 6-1 and as shown in Figure 6-9. After that, from Figures 6-1 to 6-8, table 6-1 is explained using the same cost risk (i.e., under CAPEX, construction activities group, selection method risk = CA1). Thus, the Monte Carlo simulation of this risk will be detailed as an example of what table 6-1 data reflects. The most important part is how columns nine to eleven calculate relativity change using Figure 6-2 approach. From using equation 4-15 (i.e., $2\,\bar{x} = Min\ Risk + Max\ Risk$) Figure 6-7 shows that Rmin (i.e., risk lower limit relativity change) is equal to 0.001422906. Furthermore, Rmax (i.e., risk upper limit relativity change) is equal to 0.008097921. Moreover, Rmean (i.e., risk's adjustment Mean) is equal to 0.004760413. Therefore, equation 4-15 can be satisfied through the following substitution.

$$2 * 0.004760413 = 0.001422906 + 0.008097921$$

$$\checkmark \quad 0.00952083 = 0.00952083$$

Each row in table 6-1 is a Monte Carlo Simulation for each risk, as explained in this chapter.

SN	Cost Variable Description	Survey Risk Mean % X1	Risk Standard Deviation %	Min. Survey Risk Value % Xmin	Max Survey Risk Value % Xmax	10,000 Random Values Avg.	Monti-Carlo Modelling adjusted Mean Risk value % X2	Relativity Change Between Survey Minimum Risk Value % and Survey Mean Risk value % Rmin= (Xmax/X1)*Rmean	Relativity Change Between Survey Maximum Risk Value % and Survey Mean Risk value % Rmax= (Xmax/X1)*Rmean	Relativity Change Between Monti-Carlo Modelling adjusted Risk Mean Value % and Survey Mean Risk value % Rmean=ABS(X2-X1)/X1	Deference between Survey Risk Mean and Adjusted Mean %
A	Construction Activities' Risks										
1	Selection Method	31.930	22.386	9.544	54.316	0.503	32.082	0.001422906	0.008097921	0.004760413	0.152
2	Type of Client: Solo Individual	24.550	23.277	1.273	47.827	0.500	24.542	1.68972E-05	0.000634834	0.000325866	-0.008
3	Type of Client: Bank- Individual Partnership	22.580	17.649	4.931	40.229	0.495	22.411	0.001634458	0.013334541	0.0074845	-0.169
4	Type of Client: Developer	21.220	15.645	5.575	36.865	0.501	21.254	0.000420952	0.002783572	0.001602262	0.034
5	Type of Client: Group of People	26.080	15.807	10.273	41.887	0.498	26.014	0.000996841	0.004064508	0.002530675	-0.066
6	Location: City Area	22.670	19.730	2.940	42.400	0.500	22.684	8.00889E-05	0.001155024	0.000617556	0.014
7	Location: Regional Area	22.840	18.129	4.711	40.969	0.502	22.919	0.000713424	0.006204264	0.003458844	0.079
8	Location: Beach Area	23.550	16.722	6.828	40.272	0.501	23.571	0.000258542	0.001524898	0.00089172	0.021
9	Location: Desert Area	31.650	23.420	8.230	55.070	0.506	31.934	0.002333301	0.015612987	0.008973144	0.284
10	Building Services Complexity: Operational Services	26.820	17.132	9.688	43.952	0.505	26.987	0.002249226	0.010204167	0.006226696	0.167
11	Building Services Complexity: Fitness Services	24.150	15.401	8.749	39.551	0.495	23.983	0.00250519	0.011325038	0.006915114	-0.167
12	Number of Basement Levels	22.560	18.953	3.607	41.513	0.498	22.493	0.000474835	0.005464881	0.002969858	-0.067
13	Procurement Method	29.200	17.190	12.010	46.390	0.499	29.149	0.000718369	0.002774782	0.001746575	-0.051
14	Site Topography	26.930	17.920	9.010	44.850	0.499	26.903	0.000335441	0.001669758	0.001002599	-0.027
15	Site Conditions	29.330	20.110	9.220	49.440	0.490	28.934	0.00424426	0.022758809	0.013501534	-0.396
16	Working Space	19.130	16.546	2.584	35.676	0.497	19.045	0.00060018	0.008286386	0.004443283	-0.085
17	Site Access	19.910	18.686	1.224	38.596	0.498	19.823	0.000268632	0.008470695	0.004369663	-0.087
18	Frame Structure	18.450	13.281	5.169	31.731	0.499	18.416	0.000516289	0.003169348	0.001842818	-0.034
19	Foundation Type	18.870	13.951	4.919	32.821	0.500	18.881	0.000151959	0.001013913	0.000582936	0.011
20	Ground Conditions	30.310	17.055	13.255	47.365	0.501	30.338	0.000403986	0.001443589	0.000923788	0.028
21	Type of Soil	28.270	18.006	10.264	46.276	0.503	28.393	0.001579684	0.00712212	0.004350902	0.123
22	Mark-up Size	17.850	16.672	1.178	34.522	0.501	17.890	0.000147887	0.004333906	0.002240896	0.040
23	Need for Work	17.670	14.934	2.736	32.604	0.504	17.800	0.001139164	0.013575041	0.007357102	0.130
24	Deadline Requirements	36.710	20.623	16.087	57.333	0.502	36.782	0.000859486	0.003063151	0.001961318	0.072
25	Number of Stories	22.020	15.841	6.179	37.861	0.502	22.088	0.000866548	0.005309656	0.003088102	0.068
26	Project Duration	33.350	21.961	11.389	55.311	0.496	33.189	0.001648617	0.008006555	0.004827586	-0.161
27	Gross Floor Area	21.450	16.726	4.724	38.176	0.497	21.362	0.00090352	0.007301608	0.004102564	-0.088
28	Equipment Required	25.800	18.664	7.136	44.464	0.503	25.894	0.001007728	0.006279094	0.003643411	0.094
29	Construction Technology Availability	30.670	21.461	9.209	52.131	0.503	30.804	0.001311867	0.007426314	0.00436909	0.134
B	Political Risks										
1	Change in Law	27.440	23.599	3.841	51.039	0.492	27.056	0.001958878	0.026029461	0.013994169	-0.384
2	Delay in Project Approvals and Permits	41.410	20.110	21.300	61.520	0.498	41.327	0.001030973	0.002977721	0.002004347	-0.083
3	Poor Public Decision Making Process	31.540	17.959	13.581	49.499	0.499	31.502	0.00051879	0.001890848	0.001204819	-0.038
4	Government Intervention	30.570	19.296	11.274	49.866	0.500	30.559	0.000132703	0.000586957	0.00035983	-0.011
5	Unstable Government	36.650	25.307	11.343	61.957	0.501	36.693	0.000363119	0.001983403	0.001173261	0.043
6	Government Reliability	38.260	23.664	14.596	61.924	0.497	38.108	0.00151561	0.006430025	0.003972818	-0.152
7	Inconsistencies in Government Policies	29.350	22.868	6.482	52.218	0.502	29.421	0.000534258	0.004303902	0.00241908	0.071
8	Strong Political Opposition / Hostility	27.070	23.768	3.302	50.838	0.501	27.107	0.000166726	0.002566928	0.001366827	0.037
9	Expropriation/ Nationalization of Assets	26.440	22.576	3.864	49.016	0.502	26.539	0.000547204	0.006941449	0.003744327	0.099
10	Inability of Concessionaire	22.560	19.908	2.652	42.468	0.498	22.475	0.000442909	0.007092552	0.00376773	-0.085
C	Legal Risks										
1	Change in Tax Regulation	30.470	22.963	7.507	53.433	0.501	30.530	0.000485146	0.003453154	0.00196915	0.060
2	Corruption and Lack of Respect for Law	30.960	22.622	8.338	53.582	0.496	30.770	0.001652774	0.010621127	0.006136951	-0.190
3	Legislation Change	25.560	19.411	6.149	44.971	0.498	25.477	0.000781198	0.005713325	0.003247261	-0.083
4	Import / Export Restrictions	22.830	19.872	2.958	42.702	0.495	22.644	0.0010556	0.01523875	0.00814717 5	-0.186

SN	Cost Variable Description	Survey Risk Mean % X1	Risk Standard Deviation %	Min. Survey Risk Value % Xmin	Max Survey Risk Value % Xmax	10,000 Random Values Avg.	Monti-Carlo Modelling adjusted Mean Risk value % X2	Relativity Change Between Survey Minimum Risk Value % and Survey Mean Risk value % Rmin= (Xmax/X1)*Rmean	Relativity Change Between Survey Maximum Risk Value % and Survey Mean Risk value % Rmax= (Xmax/X1)*Rmean	Relativity Change Between Monti-Carlo Modelling adjusted Risk Mean Value % and Survey Mean Risk value % Rmean=ABS(X2-X1)/X1	Deference between Survey Risk Mean and Adjusted Mean %
5	Rate of Return Restrictions	18.610	19.755	-1.145	38.365	0.496	18.470	-0.000462851	0.015508525	0.007522837	-0.140
6	Industrial Regulatory Change	24.980	20.551	4.429	45.531	0.504	25.157	0.001256302	0.012915035	0.007085669	0.177
D	Economic Change Risks										
1	Interest Rate Volatility	22.670	20.536	2.134	43.206	0.497	22.554	0.00048167	0.009752119	0.005116895	-0.116
2	Inflation Rate Volatility	26.220	21.914	4.306	48.134	0.500	26.236	0.000100214	0.001120228	0.000610221	0.016
3	Foreign Exchange and Convert	20.630	17.709	2.921	38.339	0.499	20.604	0.000178446	0.002342155	0.001260301	-0.026
4	Poor Financial Market	30.450	19.669	10.781	50.119	0.501	30.472	0.000255804	0.001189188	0.000722496	0.022
E	Natural Risks										
1	Force Majeure	18.350	18.789	-0.439	37.139	0.498	18.265	-0.000110818	0.009375123	0.004632153	-0.085
2	Environment	18.070	17.122	0.948	35.192	0.500	18.082	3.48396E-05	0.001293329	0.000664084	0.012
3	Weather	17.440	16.317	1.123	33.757	0.506	17.649	0.000771673	0.023196217	0.011983945	0.209
4	Geotechnical Condition	23.690	18.247	5.443	41.937	0.498	23.627	0.000611011	0.004707689	0.00265935	-0.063
F	Market Risks										
1	Market Supply	25.110	20.860	4.250	45.970	0.503	25.232	0.000822347	0.008894897	0.004858622	0.122
2	Market Demand	27.070	23.514	3.556	50.584	0.505	27.328	0.001252002	0.01780969	0.009530846	0.258
3	Fluctuation of Material Cost by Public/Private	24.810	20.746	4.064	45.556	0.504	24.997	0.001234644	0.013839923	0.007537283	0.187
4	Value of Production Effort	22.300	20.355	1.945	42.655	0.499	22.245	0.000215116	0.004717619	0.002466368	-0.055
G	Project Selection Risks										
1	Public Opposition to Projects	18.540	20.705	-2.165	39.245	0.498	18.443	-0.000610956	0.011074818	0.005231931	-0.097
2	Uncompetitive Tender	25.500	20.831	4.669	46.331	0.493	25.210	0.002082291	0.020662807	0.011372549	-0.290
3	Level of Demand for the Project	24.190	19.179	5.011	43.369	0.504	24.338	0.001267402	0.010969059	0.006118231	0.148
4	Land Acquisition	25.000	18.473	6.527	43.473	0.504	25.156	0.001629139	0.010850861	0.00624	0.156
5	Competition Risk	19.610	18.296	1.314	37.906	0.502	19.699	0.00030411	0.008772892	0.004538501	0.089
H	Project Finance Risks										
1	Inaccurate Estimates	31.410	22.055	9.355	53.465	0.494	31.143	0.00253174	0.014469215	0.008500478	-0.267
2	High Finance Cost	26.260	21.016	5.244	47.276	0.499	26.197	0.000479086	0.004319086	0.002399086	-0.063
3	High Bidding Costs	26.850	20.754	6.096	47.604	0.496	26.673	0.001496682	0.011687675	0.006592179	-0.177
4	Delay in Payment of Annuity	27.980	20.087	7.893	48.067	0.497	27.879	0.001018282	0.00620116	0.003609721	-0.101
5	Financial Attraction of Project to Investors	23.890	17.372	6.518	41.262	0.501	23.917	0.000308351	0.001952009	0.00113018	0.027
6	Lack of Creditworthiness	22.870	17.394	5.476	40.264	0.500	22.879	9.42266E-05	0.000692831	0.000393529	0.009
7	Delay in Financial Closure	27.850	19.082	8.768	46.932	0.504	28.002	0.001718279	0.00919734	0.00545781	0.152
8	Inability to Service Debt	26.410	17.615	8.795	44.025	0.503	26.509	0.001248344	0.006248816	0.00374858	0.099
9	Lack of Government Guarantees	23.470	20.526	2.944	43.996	0.500	23.462	4.27564E-05	0.000638965	0.000340861	-0.008
10	Financer Unwilling to Take High Risk	28.090	20.574	7.516	48.664	0.505	28.276	0.001771725	0.011471422	0.006621574	0.186
I	Building Functionality and Serviceability Risks										
1	Construction Time Delay	33.240	23.063	10.177	56.303	0.499	33.211	0.000267113	0.001477772	0.000872443	-0.029
2	Material Availability	21.720	19.022	2.698	40.742	0.501	21.760	0.000228761	0.00345448	0.001841621	0.040
3	Labor Availability	24.480	21.043	3.437	45.523	0.500	24.476	2.29412E-05	0.000303856	0.000163399	-0.004
4	Poor Quality of Workmanship	27.720	22.443	5.277	50.163	0.495	27.477	0.00166881	0.015863657	0.008766234	-0.243
5	Default of Sub-Contractors or Suppliers	27.260	22.192	5.068	49.452	0.501	27.307	0.00032054	0.003127735	0.001724138	0.047
6	Design & Construction Complexity	28.860	20.276	8.584	49.136	0.500	28.860	0	0	0	0.000
7	Design Deficiency	34.370	21.935	12.435	56.305	0.498	34.266	0.001094763	0.004957026	0.003025895	-0.104
8	Late Design Change	33.240	20.054	13.186	53.294	0.501	33.286	0.00054897	0.002218779	0.001383875	0.046
9	Construction Technology Complexity	24.090	17.485	6.605	41.575	0.502	24.170	0.000910519	0.005731241	0.00332088	0.080
10	Contractual Risk	24.610	16.973	7.637	41.583	0.501	24.641	0.000390896	0.002128405	0.001259651	0.031
11	Contractor Failure	36.290	20.888	15.402	57.178	0.500	36.279	0.000128646	0.000477582	0.000303114	-0.011

SN	Cost Variable Description	Survey Risk Mean % X1	Risk Standard Deviation %	Min. Survey Risk Value % Xmin	Max Survey Risk Value % Xmax	10,000 Random Values Avg.	Monti-Carlo Modelling adjusted Mean Risk value % X2	Relativity Change Between Survey Minimum Risk Value % and Survey Mean Risk value % Rmin= (Xmax/X1)*Rmean	Relativity Change Between Survey Maximum Risk Value % and Survey Mean Risk value % Rmax= (Xmax/X1)*Rmean	Relativity Change Between Monti-Carlo Modelling adjusted Risk Mean Value % and Survey Mean Risk value % Rmean=ABS(X2-X1)/X1	Deference between Survey Risk Mean and Adjusted Mean %
12	Quality and Reliability	25.170	18.248	6.922	43.418	0.496	25.019	0.001649841	0.01034857	0.005999205	-0.151
J	Stakeholders Relationship Risks										
1	Different Working Method Between Partners	22.670	16.968	5.702	39.638	0.499	22.629	0.000454892	0.003162223	0.001808558	-0.041
2	Inadequate Experience in Residential Projects	25.850	18.700	7.150	44.550	0.497	25.720	0.001391004	0.008667023	0.005029014	-0.130
3	Lack of Commitment From Public/Private Sector	24.800	16.725	8.075	41.525	0.500	24.806	7.87754E-05	0.000405096	0.000241935	0.006
4	Organization and Coordination Risk	17.830	15.720	2.110	33.550	0.498	17.767	0.000418139	0.006648603	0.003533371	-0.063
5	Inadequate Distribution of Responsibility & Risk	20.610	17.066	3.544	37.676	0.500	20.610	0	0	0	-0.063
6	Inadequate Negotiation Period Prior to Initiation	20.260	13.902	6.358	34.162	0.495	20.118	0.00219953	0.011818239	0.007008885	-0.142
7	Conflict Between Project's Participants	23.190	17.059	6.131	40.249	0.500	23.186	4.56026E-05	0.000299374	0.000172488	-0.004
8	Workers Strike	19.200	18.867	0.333	38.067	0.501	19.230	2.70996E-05	0.0030979	0.0015625	0.030
9	Cultural Differences Between Main Stakeholders	15.060	14.330	0.730	29.390	0.501	15.083	7.40288E-05	0.00298042	0.001527224	0.023
K	Knowledge Risks										
1	Expertise	26.260	18.559	7.701	44.819	0.504	26.427	0.00186498	0.010853984	0.006359482	0.167
2	Familiarities	21.170	15.358	5.812	36.528	0.503	21.264	0.001219023	0.007661469	0.004440246	0.094
3	Number of Bidders	20.020	15.540	4.480	35.560	0.498	19.969	0.000570059	0.004524846	0.002547453	-0.051
4	Market Conditions	25.700	20.870	4.830	46.570	0.495	25.472	0.001667308	0.016075883	0.008871595	-0.228
5	Size of the Project	25.690	21.231	4.459	46.921	0.502	25.788	0.000662118	0.00696731	0.003814714	0.098
6	Type of Building	23.190	19.125	4.065	42.315	0.502	23.254	0.00048377	0.00503585	0.00275981	0.064
7	Extent of Database	17.110	15.633	1.477	32.743	0.502	17.184	0.000373347	0.008276566	0.004324956	0.074
8	Homogeneity of Samples	14.890	15.298	-0.408	30.188	0.499	14.866	-4.41654E-05	0.003267805	0.00161182	-0.024
9	Details of Information	21.740	19.511	2.229	41.251	0.500	21.721	8.96075E-05	0.001658323	0.000873965	-0.019
O	OPEX Activities' Risks										
1	Energy Costs	27.190	21.098	6.092	48.288	0.497	27.078	0.00092291	0.007315413	0.004119161	-0.112
2	Service Life of Building Components	23.000	18.703	4.297	41.703	0.501	23.028	0.00022744	0.002207342	0.001217391	0.028
3	Building Components' Eco-Costs	17.310	15.076	2.234	32.386	0.499	17.284	0.000193848	0.002810195	0.001502022	-0.026
4	Asset Operation Eco-Costs	18.350	14.947	3.403	33.297	0.499	18.313	0.000373931	0.003658766	0.002016349	-0.037
5	Disposal Eco-Costs	16.090	15.966	0.124	32.056	0.501	16.129	1.86799E-05	0.004829052	0.002423866	0.039
6	Components' Deterioration Rate	17.540	17.103	0.437	34.643	0.501	17.570	4.26131E-05	0.003378139	0.001710376	0.030
7	Fabric Maintenance	16.020	13.216	2.804	29.236	0.502	16.068	0.000524438	0.005468071	0.002996255	0.048
8	Services	21.930	15.286	6.644	37.216	0.502	21.983	0.000732197	0.004101364	0.002416781	0.053
9	Equipment's Maintenance	21.880	13.414	8.466	35.294	0.504	21.976	0.001697676	0.007077461	0.004387569	0.096
10	Overheads	20.560	17.649	2.911	38.209	0.498	20.502	0.000399415	0.005242609	0.002821012	-0.058
11	Utilities	22.810	14.523	8.287	37.333	0.505	22.957	0.002341338	0.010547746	0.006444542	0.147
12	Cleaning	15.090	12.363	2.727	27.453	0.500	15.088	2.39517E-05	0.000241124	0.000132538	-0.002
13	Percentage of Current Replacement Value	17.760	14.762	2.998	32.522	0.496	17.644	0.001102564	0.011960499	0.006531532	-0.116
14	Ratio of Maintenance to Capital Cost	19.190	15.857	3.333	35.047	0.501	19.209	0.000171965	0.001808233	0.000990099	0.019
15	Ratio of Operation to Capital Cost	22.220	16.769	5.451	38.989	0.497	22.106	0.001263945	0.009040534	0.005152239	-0.114

Table 6-1: Monte-Carlo Modelling table for all validated risks' value. This will be used in the Systems Dynamics Final Cost Estimation Model.

6.3 Summary

In conclusion, this chapter introduced the history of Monte Carlo modelling and its importance in estimating unknown numerical values using a probabilistic stochastic approach. Also, it is clarified how the Monte Carlo simulation relates to chapters 4 and 5 outputs. Therefore, this chapter is presenting 117 Monte Carlo simulations following chapter 4 research methodology design. However, the detailed approach of how the simulation satisfied the research design criteria has been clarified and detailed to justify each step of the conducted models. An example of how each modelling simulation step is covered in Table 6-1 is provided for better understanding. It utilizes developed and justified calculations from chapter 4 and ends with the 117 values of Rmin, Rmean, and Rmax to be used in system dynamics cost modelling. Finally, the covered risks' value is clear, including all 11 CAPEX risks groups and OPEX risks group.

Chapter 7
SYSTEM DYNAMICS COST MODEL DEVELOPMENT

"*One can easily imagine that a rigorous mathematical definition of 'sampling a continuous function' presents technical difficulties, and that other difficulties arise when one desires to design an algorithm to sample such a function on a computer*".

(Graham & Talay 2013, p.3)

7.0 Introduction

In this chapter, the system dynamics modelling system's development will be detailed for residential projects' whole life cycle cost estimation, including CAPEX and OPEX sub-models. The final complete model will include the equipment replacement cost and the net present value (NPV) of each timestep point through the project's lifecycle. Nevertheless, the NPV will be included in the model to cover CAPEX, OPEX, and equipment costs over 60 years of the life cycle. Therefore, the chapter will start developing the S-Curve of CAPEX cash flows and risks in detail; then, it will start developing each adjusting risk group of the 11 CAPEX and OPEX groups. Also, the model will include the final combining calculations.

The mathematical equation modelling will be entered in the system dynamics model software programme VENSIM based on the previous chapter's outputs and the relationships between the mathematical equation variables. Thus, the final equations set for each risk group model will explain how mathematical modelling is entered using the VENSIM algorithm and how variables are connected graphically.

Finally, the entered risk rate of each risk factor, as an input, will be the output of the Monte Carlo Simulation. This is because it is including the final adjustment risk results for each variable. After building the full model of residential projects, the whole lifecycle cost estimation model in this chapter will be the final model for cost estimation. It will be taken to the next chapter for validation and discussion to declare its effectiveness and accuracy after testing it on real projects from the United Arab Emirates.

7.1 Cost Cash Flow S-Curve Development

First, based on chapter 4mathematical modelling of construction cash flow, past researches' output equations and integration provided valid Construction Cost S-Curve as shown in equations 4-20 to 4-21 (Cristóbal 2017; Odeyinka, Lowe & Kaka 2013; Abanda, Tah & Cheung 2013; Ahiaga-Daghui 2014; Kucharavy & Guio 2014). It agreed that the construction s-curve is following the logistic exponential s-cure shown in equation 4-20 (Cristóbal 2017; Odeyinka, Lowe & Kaka 2013; Abanda, Tah & Cheung 2013; Ahiaga-Daghui 2014; Kucharavy & Guio 2014). Researchers developed equation 4-20 to equation 4-21a for better performance in computing construction cash flow (Cristóbal 2017; Ahiaga-Daghui 2014; Kucharavy & Guio 2014).

$$f(x) = \frac{1}{1 + e^{-x}}$$ Equation 4-20

X = the time point on S-Curve chart

e = exponential constant

$$f(x) = \frac{1}{1 + e^{-\propto(t-T_0)}}$$ Equation 4-21a

T_0 = the maximum slop adjusting parameter.

The maximum slop increases as it increases.

t = the time step of f(x) cash flow point.

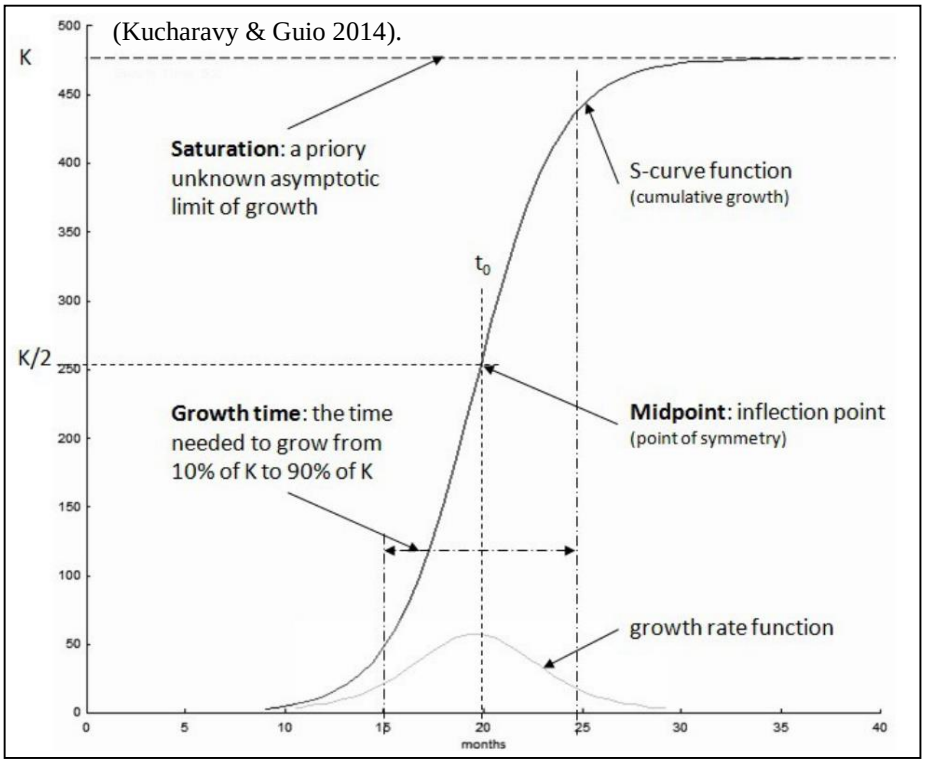
α = is the stepness of the curve $\begin{cases} \propto (t_1 - T_0) = \ln\left(\frac{1}{f_1} - 1\right) \\ \propto (t_2 - T_0) = \ln\left(\frac{1}{f_2} - 1\right) \end{cases}$

$f(X)$ = *Cost* S-Curve = $\frac{1}{1+e^{-1.22(t-1.88)}}$ (From similar literature) Equation 4-21b

$f(X)$ = *Cost* S-Curve = $\frac{1}{1+e^{-2.7(t-1.4)}}$ (Adapted from similar literature) Equation 4-21

Creating an s-curve in construction cost research is including three main approaches (Cristóbal 2017; Kucharavy & Guio 2014). The first approach uses historical related projects' cost s-curve to build the estimating model's s-curve (Cristóbal 2017). This is commonly used to ensure accurate estimation of similar projects after understanding and implementing lessons learned and best practices (Cristóbal 2017; Odeyinka, Lowe & Kaka 2013; Abanda, Tah & Cheung 2013; Ahiaga-Daghui 2014; Kucharavy & Guio 2014). It will be based on measuring curve parameters from the actual project's cost curve data (Cristóbal 2017). These parameters are including 4 points to decide the behaviour of desired s-curve (Cristóbal 2017). These 4 points will be substituting the α and T_0 shown in equation 4-21a (Cristóbal 2017). The 4 points are extracted from the actual projects s-curve (i.e., time-cost curve) to include the data of 20%-point, 25%-point, 75%-point, and 80%-point (Cristóbal 2017). It is proved accurate in previous literature to draw s-curve accurate yield points and its growth (Cristóbal 2017). The second approach is by taking an s-curve equation related to the same project type of desired research and having the same duration to start estimating costs based on possible investigation scenarios (Cristóbal 2017; Odeyinka, Lowe & Kaka 2013; Abanda, Tah & Cheung 2013; Kucharavy & Guio 2014). This approach is accurate in modelling the researcher's investigation topics related to cost cash flow in the construction stage (Cristóbal 2017; Odeyinka, Lowe & Kaka 2013; Abanda, Tah & Cheung 2013; Kucharavy & Guio 2014). This research is modelling cash flow itself and will not completely follow previous researchers' s-curves. This is because other s-curves may have experienced factors that are not included in this research. Therefore, it may impact this research accuracy. The third approach is to have a standard simple logistic S-curve for the desired cash flow quantity over the desired project's construction duration (Kucharavy & Guio 2014). This will require certain requirements to be established, as shown in Figure 7-1 (Kucharavy & Guio 2014).

Year Time Step	Cost Cash Flow Increasing S-Curve
Design Stage	0
0	0.022
0.125	0.031
0.25	0.043
0.375	0.059
0.5	0.081
0.625	0.110
0.75	0.147
0.875	0.195
1	0.254
1.125	0.322
1.25	0.400
1.375	0.483
1.5	0.567
1.625	0.647
1.75	0.720
1.875	0.783
2	0.835
2.125	0.876
2.25	0.908
2.375	0.933
2.5	0.951
2.625	0.965
2.75	0.975
2.875	0.982
3	1.000



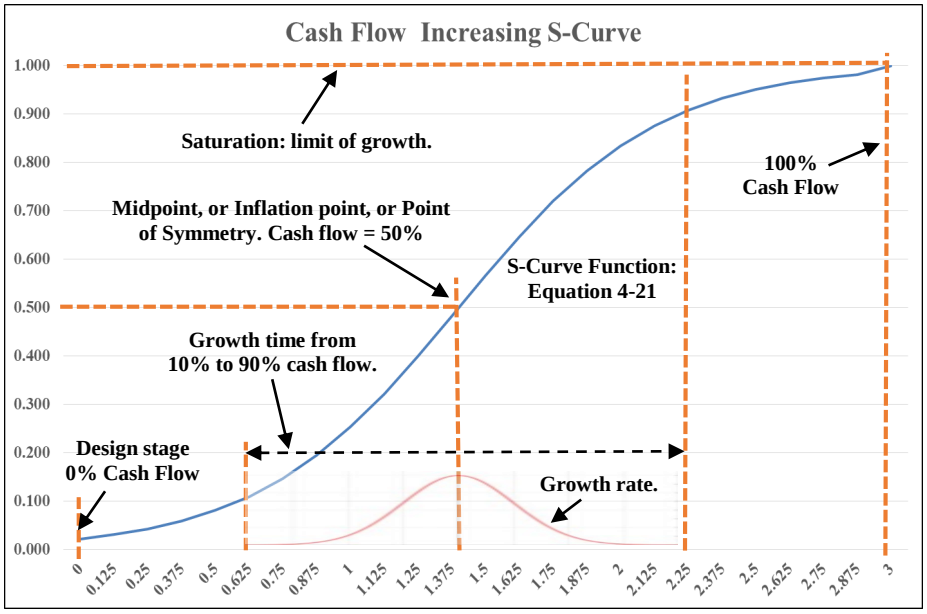


Figure 7-1: adapted figure 4-20 showing fitting parameters: The final S-Curve used in this research construction system dynamics cost modelling based on literature guidance (Cristóbal 2017; Kucharavy & Guio 2014). However, K value represent construction cost of this research.

Three steps need to be satisfied to create a fitted simple estimating s-curve meeting actual data accuracy level (Kucharavy & Guio 2014). First, estimating the curve lower and upper limits (Kucharavy & Guio 2014). This research's lower limit starts from zero cash spent,

and the upper limit is equal to 100% of project cash spent. Second, allocate s-curve fitting parameters, as shown in Figure 7-1 (Kucharavy & Guio 2014). This will include the growth time needed for costs to increase from 10% spent to 90% spent (Kucharavy & Guio 2014). Then, allocate the time midpoint where estimated costs reach 50% of total costs (Kucharavy & Guio 2014). Third, examine and reduce the actual-to-estimate residuals (i.e., data-to-model residuals) to ensure that the estimated s-curve reflects the actual estimated costs (Kucharavy & Guio 2014). However, in this research study, it is required to set a simple cost s-curve because all residuals' analysis is done by validating collected data, as explained in previous chapters, and will experience adjusting risks using a mathematical modelling system to ensure that estimated values reflect actual end costs.

Therefore, this research used previous construction equations to fit its adjustment parameter (i.e., $\alpha\ (t - T_0)$) to meet the literature's required fitting rules, as shown in Figure 7-1. Equation 4-21 is the final used equation is the system dynamics CAPEX estimation model.

7.2 Risk S-Curve Development

It is essential to realize that the risk s-curve is based on cost s-curve, as shown in chapter 4. Therefore, the probability of facing risk in remaining time multiply by the probability of facing danger in remaining cash flow will be this research Risk S-Curve as shown in equation 4-22 to 4-26 and Figure 7-2 (Pajares & López-Paredes 2010; Techet 2005; Dowd & Cotter 2007). This s-curve will be implemented on all risks identified by experts and validated in previous chapters to include 11 CAPEX groups. This will make risk rates ready to be connected to other cost modelling components.

$$P_T = \frac{T_E - T_S}{T_E} = \textbf{Time Risk}$$ Equation 4-22

P_T = the probability of time danger

T_E = the total execution time.

T_S = the risk time step value.

$$C_S = \lim_{T_S \to t} \left(\frac{1}{1 + e^{-1.22(t-1.88)}} \right)$$ Equation 4-23

C_S = the cost S curve value at each time step (from 0 to 1).

t = the time step of f(x) cash flow point.

$$P_C = [1 - C_S]$$ Equation 4-24

P_C = the probability of cost danger

$$P\,(Time\ Risk \cap Cost\ Risk) = P_T * P_C$$ Equation 4-25

$$\textbf{Risk S-Curve} = \frac{T_E - T_S}{T_E} * \left(1 - \lim_{T_S \to t} \left(\frac{1}{1 + e^{-1.22(t-1.88)}} \right)\right)$$ Equation 4-26

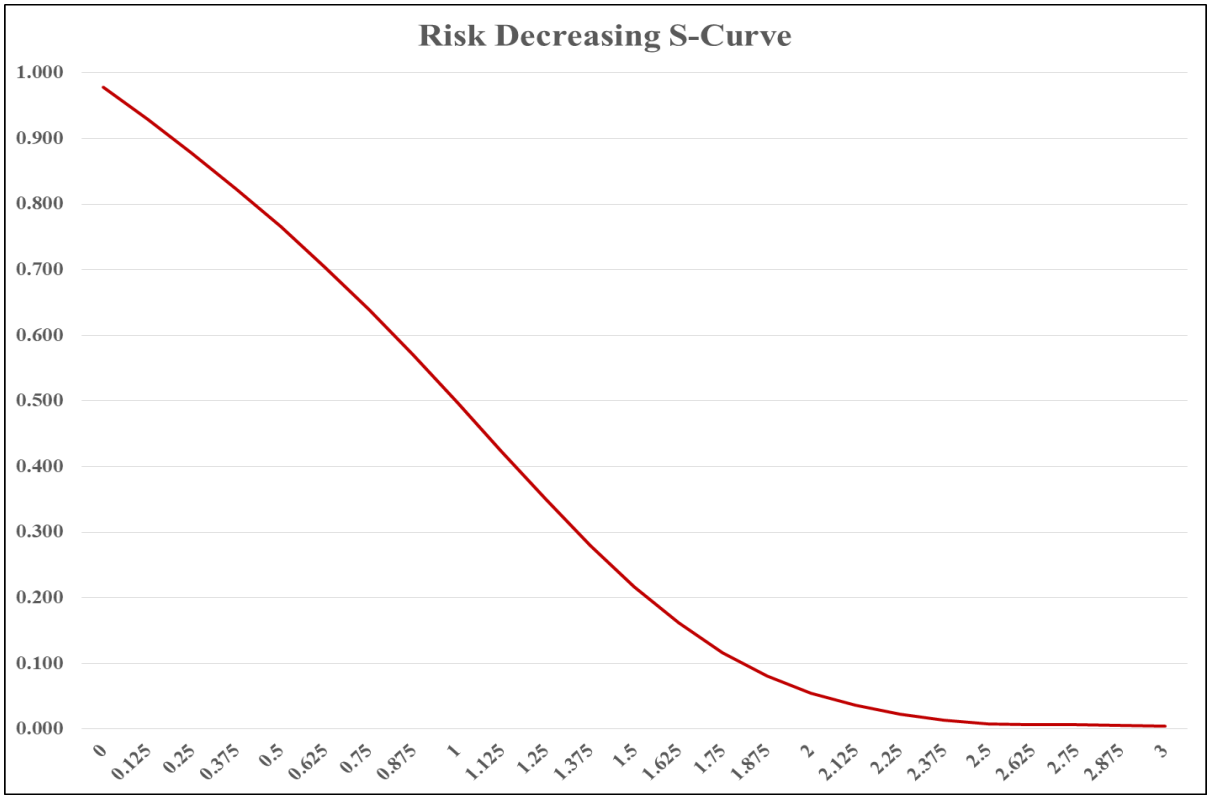


Figure 7-2: Trending construction Risk decreasing S-Curve to be used in system dynamics final model.

A- Construction Activities' Risks

The system dynamics model for adjusting risks cost group will be based on stock and flow dynamical system over time as the following:

1- The Type of Client adjusting risk is collecting all adjusting risks related to different client types and feed the model valve variable Construction Activities' Risk to create its impact flow on the system.

2- The Location adjusting risk is collecting all adjusting risks related to changing location between projects and feed the model valve variable Construction Activities' Risk to create its impact flow on the system.

3- The Buildings Services Complexity adjusting risk is collecting all adjusting risks related to changing fitness and operational complexity and feed the model valve variable Construction Activities' Risk to create its impact flow on the system.

4- All remaining rates of this group are fed directly into the model valve variable Construction Activities' Risk to create its impact flow on the system.

5- The risk rates in points 1 to 4 are entered as constant using the validated adjusting rates resulted from experts' data, SPSS modelling, and Monte Carlo Simulation; however, they are considered constant in VENSIM system type and their unit AED/Year.

6- The Construction Activities' Risks is the flow valve of the group dynamical system which is collecting all adjusting risks rates to flow it on time step bases; however, it is also considered as constant in VENSIM system type and their unit AED/Year which is flowing through years (i.e., AED/Year multiply by Year in the end when it reaches the stock).

7- The Construction Activities' Risks Costs is the stock where the impacts of risks are collected in each time step of the model lifecycle; however, it is entered as Auxiliary type in VENSIM system dynamics, and it has AED unit after multiplying the collected flow into the risk behaviour S-Curve and into the total contract value of the project's CAPEX. Nevertheless, these calculations algorithm is shown as the following:

"Design Stage (Construction Contract Estimated Cost)"*Construction Activities Risk*"Risk S-Curve".

8- Figure 7-3 shows the final development of Construction Activities' Risks system dynamics modelling, including the above-mentioned points 1 to 7.

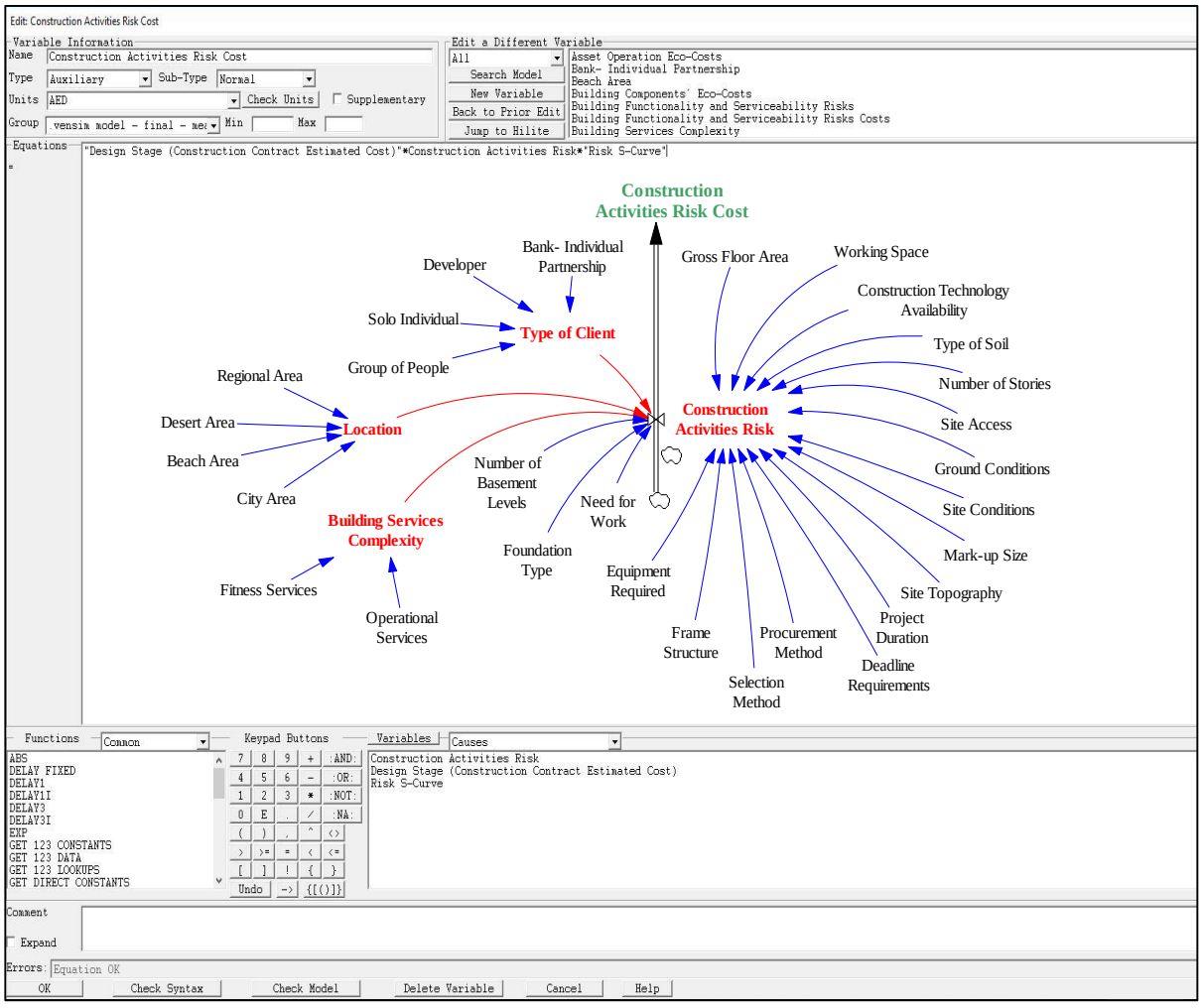


Figure 7-3: Developing the stock and flow system dynamics model of CAPEX Construction Activities' Risks and finalizing its mathematical equations system.

B- Political Risks

The system dynamics model of this adjusting risks cost group will be based on stock and flow dynamical system over time as the following:

1- All adjusting rates of this group are fed directly into the model valve variable Construction Activities' Risks to create its impact flow on the system.

2- The risk rates in point 1 are entered as constant using the validated adjusting rates resulted from experts' data, SPSS modelling, and Monte Carlo Simulation; however, they are considered constant in VENSIM system type and their unit AED/Year.

3- The Political Risks is the flow valve of the group dynamical system which is collecting all adjusting risks rates to flow it on time step bases; however, it is also considered as constant in VENSIM system type and their unit AED/Year, which is flowing through years (i.e., AED/Year multiply by Year in the end when it reaches the stock).

4- The Political Risks Costs is the stock where the impacts of risks are collected in each time step of the model lifecycle; however, it is entered as Auxiliary type in VENSIM system dynamics, and it has AED unit after multiplying the collected flow into the risk behaviour S-Curve and into the total contract value of the project's CAPEX. Nevertheless, these calculations algorithm is shown as the following:

"Design Stage (Construction Contract Estimated Cost)"*Political Risks*"Risk S-Curve."

5- Figure 7-4 shows that the final development of Political Risks system dynamics modelling is shown in points mentioned above 1 to 4.

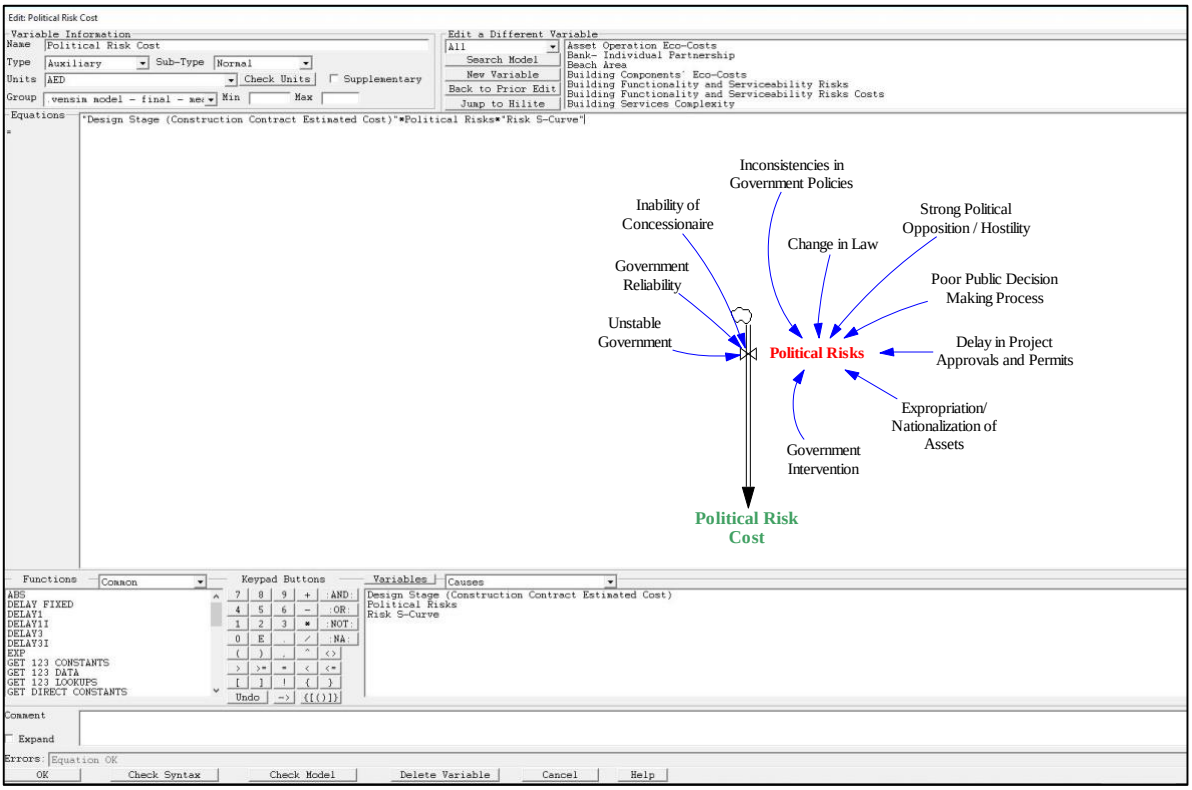


Figure 7-4: Developing the stock and flow system dynamics model of CAPEX Political Risks and finalizing its mathematical equations system.

C- Legal Risks

The system dynamics model of this adjusting risks cost group will be based on stock and flow dynamical system over time as the following:

1- All adjusting rates of this group are fed directly into the model valve variable Legal Risks to create its impact flow on the system.

2- The risk rates in point 1 are entered as constant using the validated adjusting rates resulted from experts' data, SPSS modelling, and Monte Carlo Simulation; however, they are considered constant in VENSIM system type and their unit AED/Year.

3- The Legal Risks is the flow valve of the group dynamical system which is collecting all adjusting risks rates to flow it on time step bases; however, it is also considered as

constant in VENSIM system type and their unit AED/Year, which is flowing through years (i.e., AED/Year multiply by Year in the end when it reaches the stock).

4- The Legal Risks Costs is the stock where the impacts of risks are collected in each time step of the model lifecycle; however, it is entered as Auxiliary type in VENSIM system dynamics, and it has AED unit after multiplying the collected flow into the risk behaviour S-Curve and into the total contract value of the project's CAPEX. Nevertheless, these calculations algorithm is shown as the following:

"Design Stage (Construction Contract Estimated Cost)"*Legal Risks*"Risk S-Curve."

5- In Figure 7-5, the final development of Legal Risks system dynamics modelling is shown, including the points mentioned above 1 to 4.

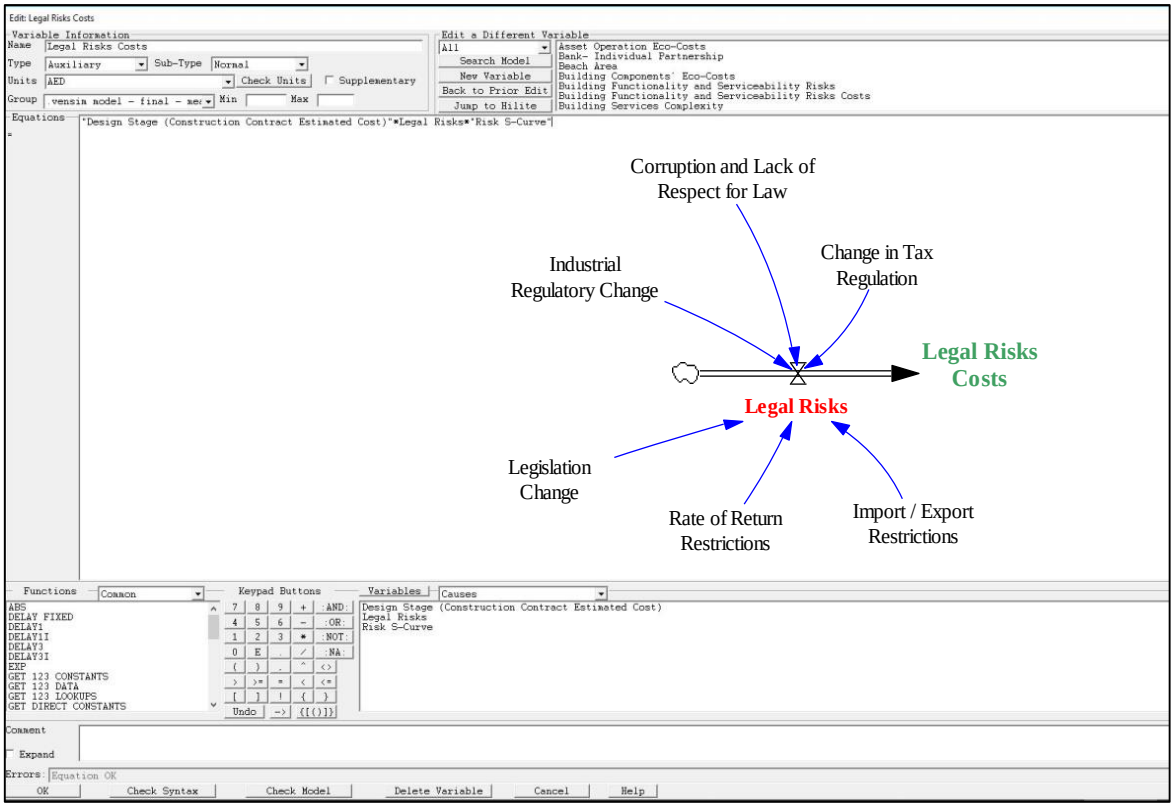


Figure 7-5: Developing the stock and flow system dynamics model of CAPEX Legal Risks and finalizing its mathematical equations system.

D- Economic Change Risks

The system dynamics model of this adjusting risks cost group will be based on stock and flow dynamical system over time as the following:

1- All adjusting rates of this group are fed directly into the model valve variable Economic Change Risks to create its impact flow on the system.

2- The risk rates in point 1 are entered as constant using the validated adjusting rates resulted from experts' data, SPSS modelling, and Monte Carlo Simulation; however, they are considered constant in VENSIM system type and their unit AED/Year.

3- The Economic Change Risks is the flow valve of the group dynamical system which is collecting all adjusting risks rates to flow it on time step bases; however, it is also considered as constant in VENSIM system type and their unit AED/Year, which is flowing through years (i.e., AED/Year multiply by Year in the end when it reaches the stock).

4- The Economic Change Risks Costs is the stock where the impacts of risks are collected in each time step of the model lifecycle; however, it is entered as Auxiliary type in VENSIM system dynamics, and has AED unit after multiplying the collected flow into the risk behaviour S-Curve and into the total contract value of the project's CAPEX. Nevertheless, these calculations algorithm is shown as the following:

"Design Stage (Construction Contract Estimated Cost)"* Economic Change Risks*"Risk S-Curve."

5- Figure 7-6 shows that the final development of Economic Change Risks system dynamics modelling is shown, including the points mentioned above 1 to 4.

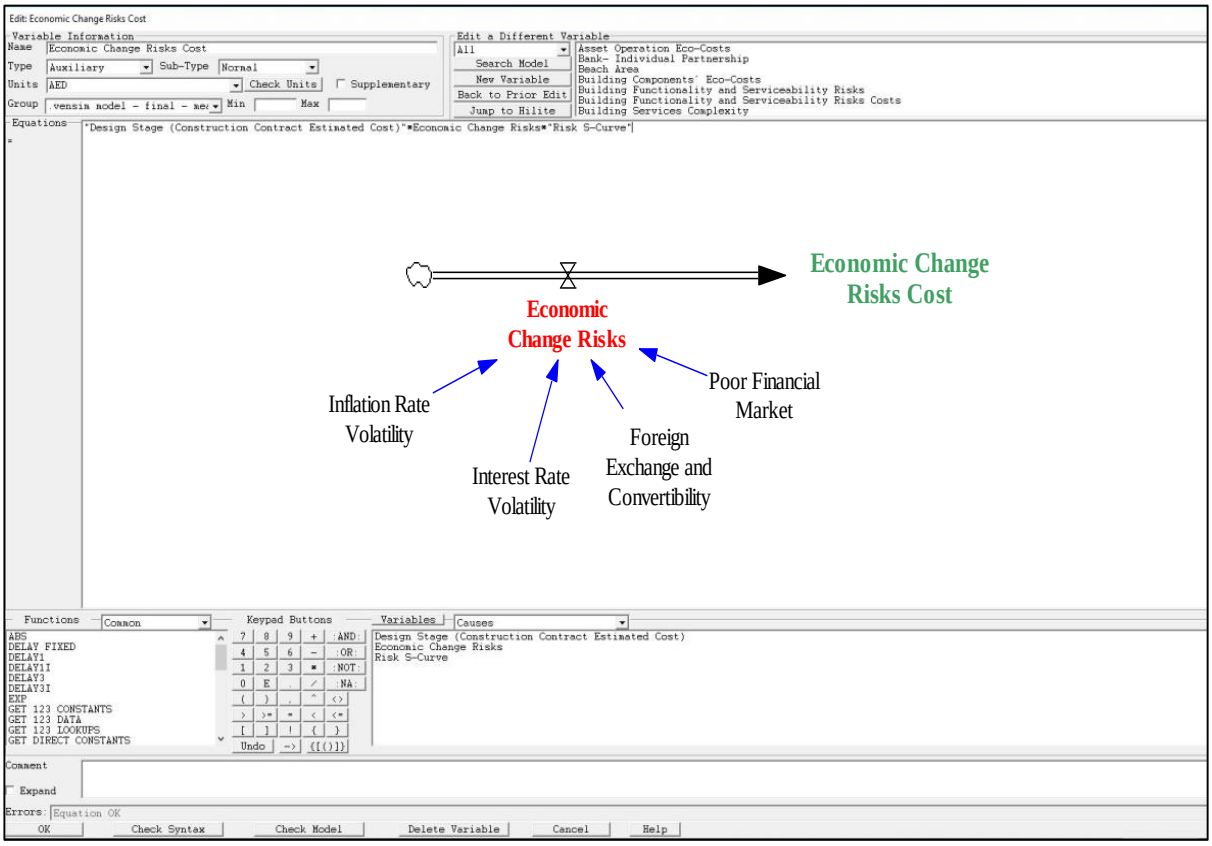


Figure 7-6: Developing the stock and flow system dynamics model of CAPEX Economic Change Risks and finalizing its mathematical equations system.

E- Natural Forces Risks

The system dynamics model of this adjusting risks cost group will be based on stock and flow dynamical system over time as the following:

1- All adjusting rates of this group are fed directly into the model valve variable Natural Risks to create its impact flow on the system.

2- The risk rates in point 1 are entered as constant using the validated adjusting rates resulted from experts' data, SPSS modelling, and Monte Carlo Simulation; however, they are considered constant in VENSIM system type and their unit AED/Year.

3- The Natural Risks is the flow valve of the group dynamical system which is collecting all adjusting risks rates to flow it on time step bases; however, it is also considered as

constant in VENSIM system type and their unit AED/Year, which is flowing through years (i.e., AED/Year multiply by Year in the end when it reaches the stock).

4- The Natural Risks Costs is the stock where the impacts of risks are collected in each time step of the model lifecycle; however, it is entered as Auxiliary type in VENSIM system dynamics, and it has AED unit after multiplying the collected flow into the risk behaviour S-Curve and into the total contract value of the project's CAPEX. Nevertheless, these calculations algorithm is shown as the following:

"Design Stage (Construction Contract Estimated Cost)"* Natural Risks*"Risk S-Curve."

5- Figure 7-7 shows that the final development of Natural Risks system dynamics modelling is shown, including the points mentioned above 1 to 4.

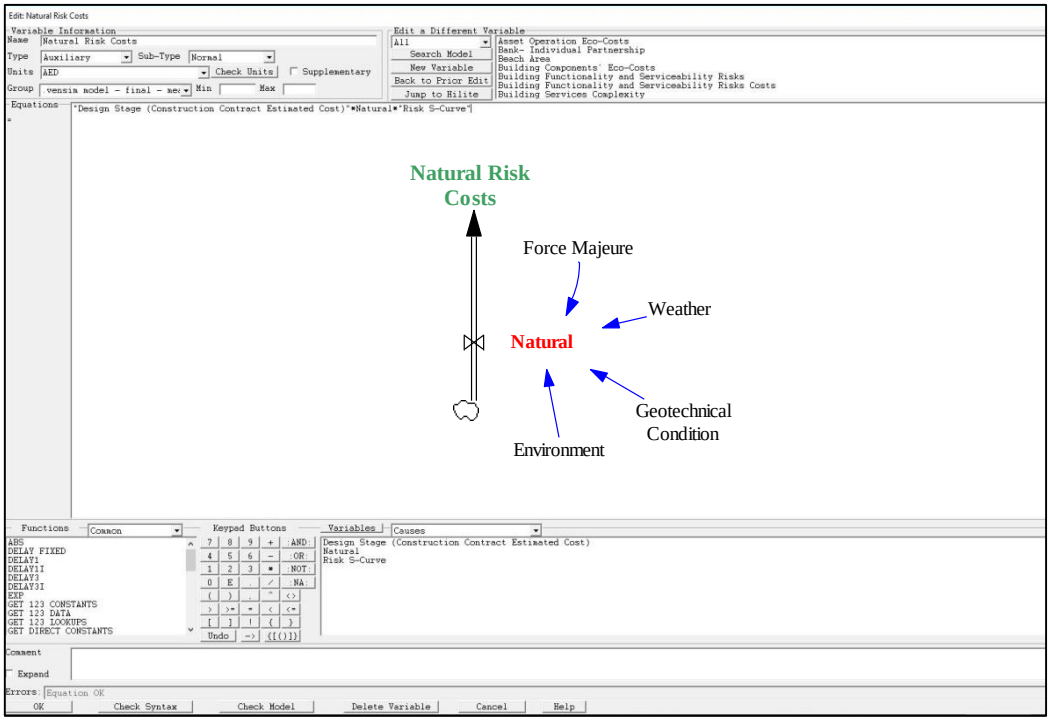


Figure 7-7: Developing the stock and flow system dynamics model of CAPEX Natural Forces Risks and finalizing its mathematical equations system.

F- Market Risks

The system dynamics model of this adjusting risks cost group will be based on stock and flow dynamical system over time as the following:

1- All adjusting rates of this group are fed directly into the model valve variable Market Risks to create its impact flow on the system.

2- The risk rates in point 1 are entered as constant using the validated adjusting rates resulted from experts' data, SPSS modelling, and Monte Carlo Simulation; however, they are considered constant in VENSIM system type and their unit AED/Year.

3- The Market Risks is the flow valve of the group dynamical system which is collecting all adjusting risks rates to flow it on time step bases; however, it is also considered as constant in VENSIM system type and their unit AED/Year, which is flowing through years (i.e., AED/Year multiply by Year in the end when it reaches the stock).

4- The Market Risks Costs is the stock where the impacts of risks are collected in each time step of the model lifecycle; however, it is entered as Auxiliary type in VENSIM system dynamics, and it has AED unit after multiplying the collected flow into the risk behaviour S-Curve and into the total contract value of the project's CAPEX. Nevertheless, these calculations algorithm is shown as the following:

"Design Stage (Construction Contract Estimated Cost)"* Market Risks*"Risk S-Curve."

5- Figure 7-8 shows that the final development of Market Risks system dynamics modelling is shown, including the points mentioned above 1 to 4.

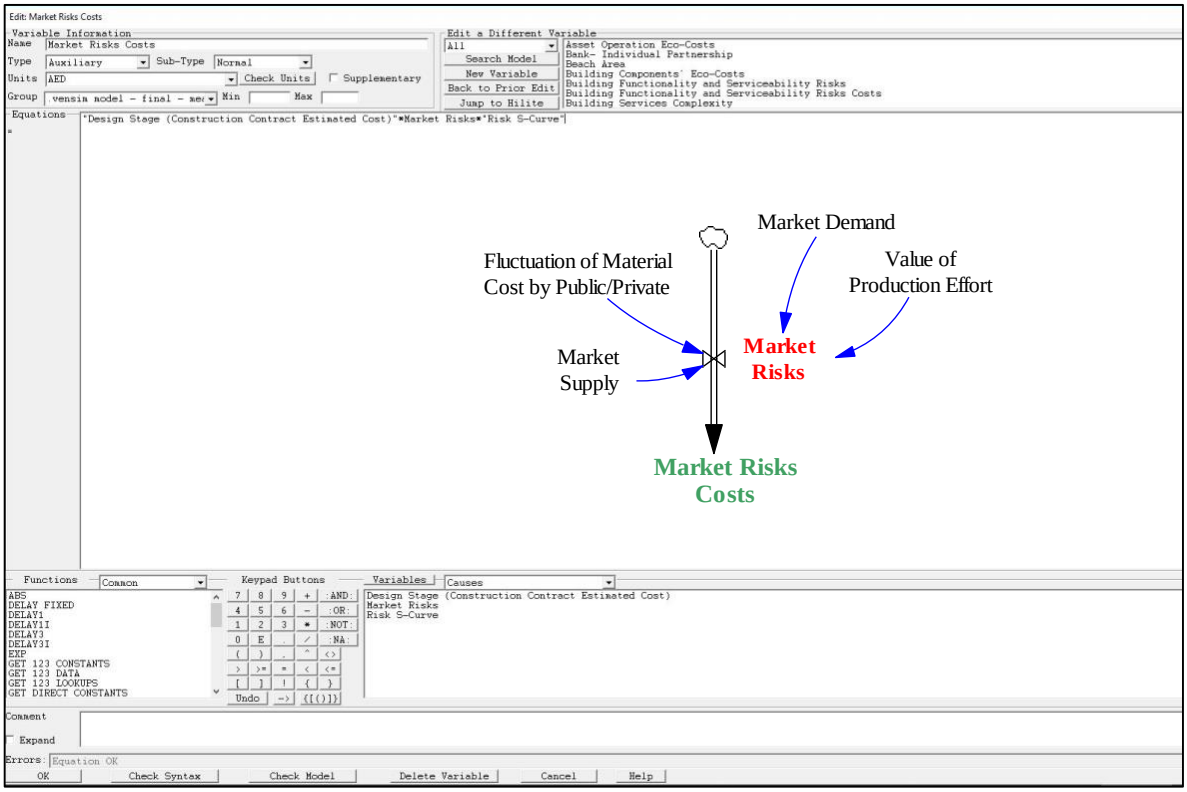


Figure 7-8: Developing the stock and flow system dynamics model of CAPEX Market Risks and finalizing its mathematical equations system.

G- Project Selection Risks

The system dynamics model of this adjusting risks cost group will be based on stock and flow dynamical system over time as the following:

1- All adjusting rates of this group are fed directly into the model valve variable Project Selection Risks to create its impact flow on the system.

2- The risk rates in point 1 are entered as constant using the validated adjusting rates resulted from experts' data, SPSS modelling, and Monte Carlo Simulation; however, they are considered constant in VENSIM system type and their unit AED/Year.

3- The Project Selection Risks is the group dynamical system flow valve which is collecting all adjusting risks rates to flow it on time step bases; however, it is also considered as constant in VENSIM system type and their unit AED/Year which is

flowing through years (i.e., AED/Year multiply by Year in the end when it reaches the stock).

4- The Project Selection Risks Costs is the stock where the impacts of risks are collected in each time step of the model lifecycle; however, it is entered as Auxiliary type in VENSIM system dynamics, and it has AED unit after multiplying the steady flow into the risk behaviour S-Curve and into the total contract value of the project's CAPEX. Nevertheless, these calculations algorithm is shown as the following:

"Design Stage (Construction Contract Estimated Cost)"* Project Selection Risks*"Risk S-Curve."

5- Figure 7-9 shows that the final development of Project Selection Risks system dynamics modelling is shown, including the points mentioned above 1 to 4.

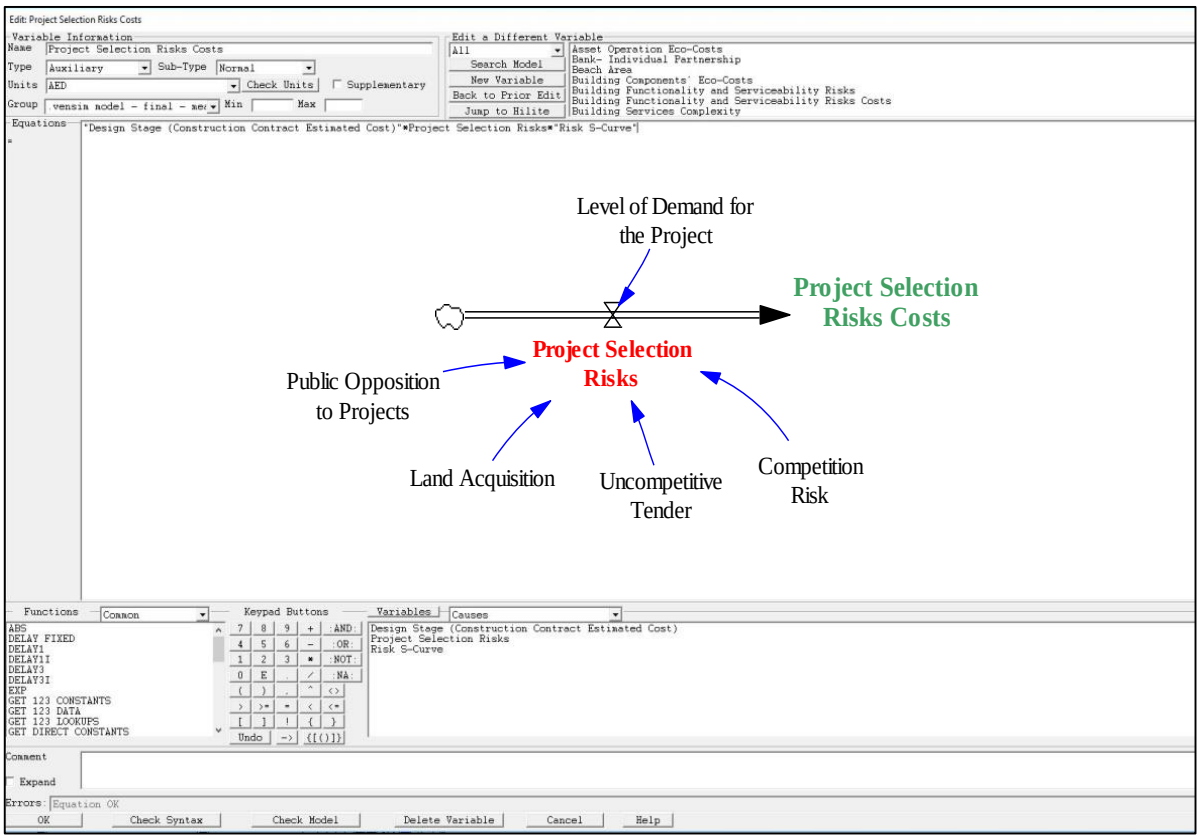


Figure 7-9: Developing the stock and flow system dynamics model of CAPEX Project Selection Risks and finalizing its mathematical equations system.

H- Project Finance Risks

The system dynamics model of this adjusting risks cost group will be based on stock and flow dynamical system over time as the following:

1- All adjusting rates of this group are fed directly into the model valve variable Project Finance Risks to create its impact flow on the system.

2- The risk rates in point 1 are entered as constant using the validated adjusting rates resulted from experts' data, SPSS modelling, and Monte Carlo Simulation; however, they are considered constant in VENSIM system type and their unit AED/Year.

3- The Project Finance Risks is the flow valve of the group dynamical system which is collecting all adjusting risks rates to flow it on time step bases; however, it is also considered as constant in VENSIM system type and their unit AED/Year, which is flowing through years (i.e., AED/Year multiply by Year in the end when it reaches the stock).

4- The Project Finance Risks Costs is the stock where the impacts of risks are collected in each time step of the model lifecycle; however, it is entered as Auxiliary type in VENSIM system dynamics, and it has AED unit after multiplying the collected flow into the risk behaviour S-Curve and into the total contract value of the project's CAPEX. Nevertheless, these calculations algorithm is shown as the following:

"Design Stage (Construction Contract Estimated Cost)"* Project Finance Risks*"Risk S-Curve."

5- Figure 7-10 shows that the final development of Project Finance Risks system dynamics modelling is shown, including the points mentioned above 1 to 4.

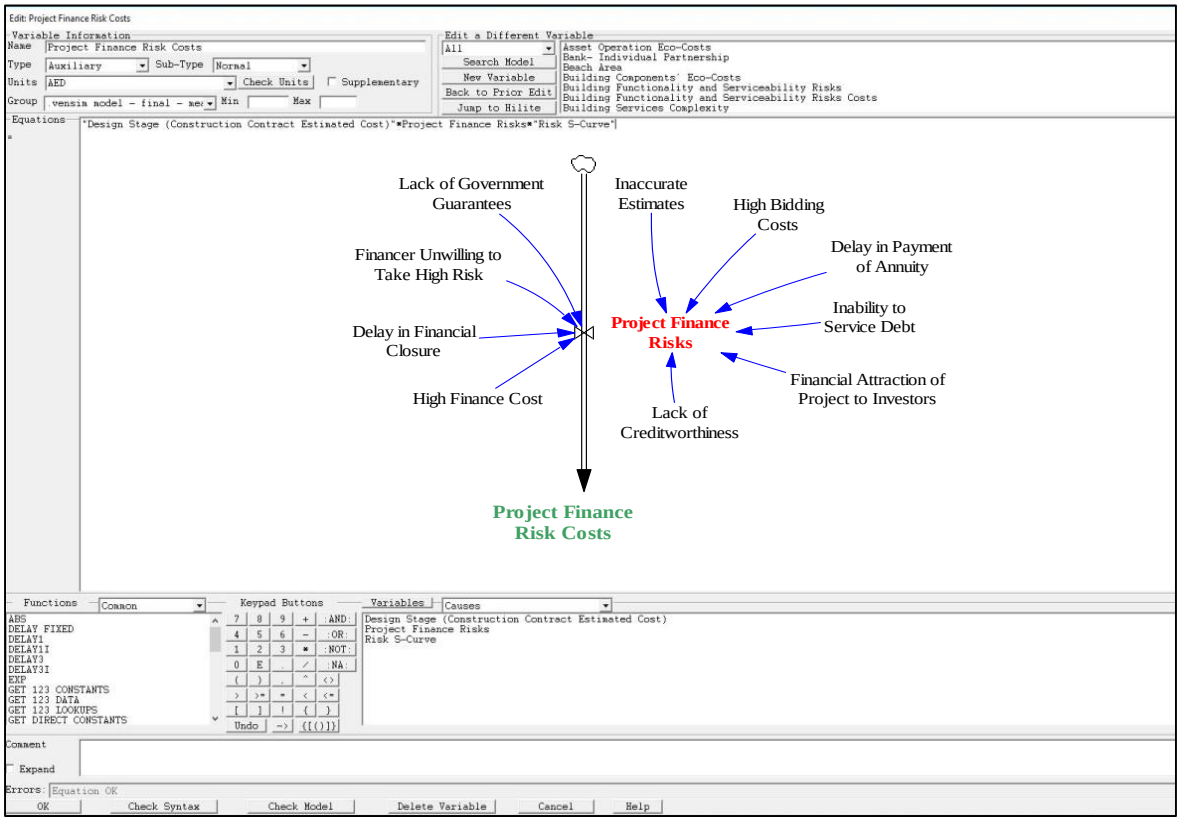


Figure 7-10: Developing the stock and flow system dynamics model of CAPEX Project Finance Risks and finalizing its mathematical equations system.

I- Building Functionality and Serviceability Risks

The system dynamics model of this adjusting risks cost group will be based on stock and flow dynamical system over time as the following:

1- All adjusting rates of this group are fed directly into the model valve variable Building Functionality and Serviceability Risks to create its impact flow on the system.

2- The risk rates in point 1 are entered as constant using the validated adjusting rates resulted from experts' data, SPSS modelling, and Monte Carlo Simulation; however, they are considered constant in VENSIM system type and their unit AED/Year.

3- The Building Functionality and Serviceability Risks is the flow valve of the group dynamical system which is collecting all adjusting risks rates to flow it on time step

bases; however, it is also considered as constant in VENSIM system type and their unit AED/Year, which is flowing through years (i.e., AED/Year multiply by Year in the end when it reaches the stock).

4- The Building Functionality and Serviceability Risks Costs is the stock where the impacts of risks are collected in each time step of the model lifecycle. However, it is entered as Auxiliary type in VENSIM system dynamics, and it has an AED unit after multiplying the collected flow into the risk behaviour S-Curve and into the total contract value of the project's CAPEX. Nevertheless, these calculations algorithm is shown as the following:

"Design Stage (Construction Contract Estimated Cost)"* Building Functionality and Serviceability Risks*"Risk S-Curve."

5- Figure 7-11 shows that the final development of Building Functionality and Serviceability Risks system dynamics modelling is shown, including the above points mentioned 1 to 4.

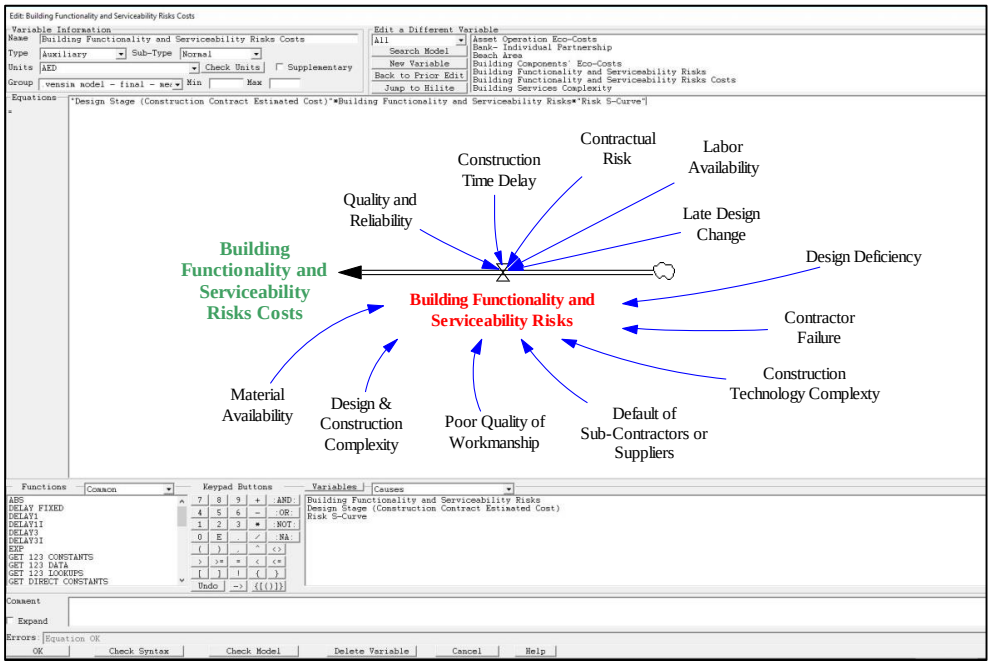


Figure 7-11: Developing the stock and flow system dynamics model of CAPEX Building Functionality and Serviceability Risks and finalizing its mathematical equations system.

J- Stakeholders Relationship Risks

The system dynamics model of this adjusting risks cost group will be based on stock and flow dynamical system over time as the following:

1- All adjusting rates of this group are fed directly into the model valve variable Stakeholders Relationship Risks to create its impact flow on the system.

2- The risk rates in point 1 are entered as constant using the validated adjusting rates resulted from experts' data, SPSS modelling, and Monte Carlo Simulation; however, they are considered constant in VENSIM system type and their unit AED/Year.

3- The Stakeholders Relationship Risks is the flow valve of the group dynamical system which is collecting all adjusting risks rates to flow it on time step bases; however, it is also considered as constant in VENSIM system type and their unit AED/Year, which is flowing through years (i.e., AED/Year * Year in the end when it reaches the stock).

4- The Stakeholders Relationship Risks Costs is the stock where the impacts of risks are collected in each time step of the model lifecycle. However, it is entered as Auxiliary type in VENSIM system dynamics, and it has an AED unit after multiplying the collected flow into the risk behaviour S-Curve and into the total contract value of the project's CAPEX. Nevertheless, this calculations algorithm is shown in the following: "Design Stage (Construction Contract Estimated Cost)"* Stakeholders Relationship Risks*"Risk S-Curve."

5- Figure 7-12 shows that the final development of Stakeholders Relationship Risks system dynamics modeling is shown, including the points mentioned above 1 to 4.

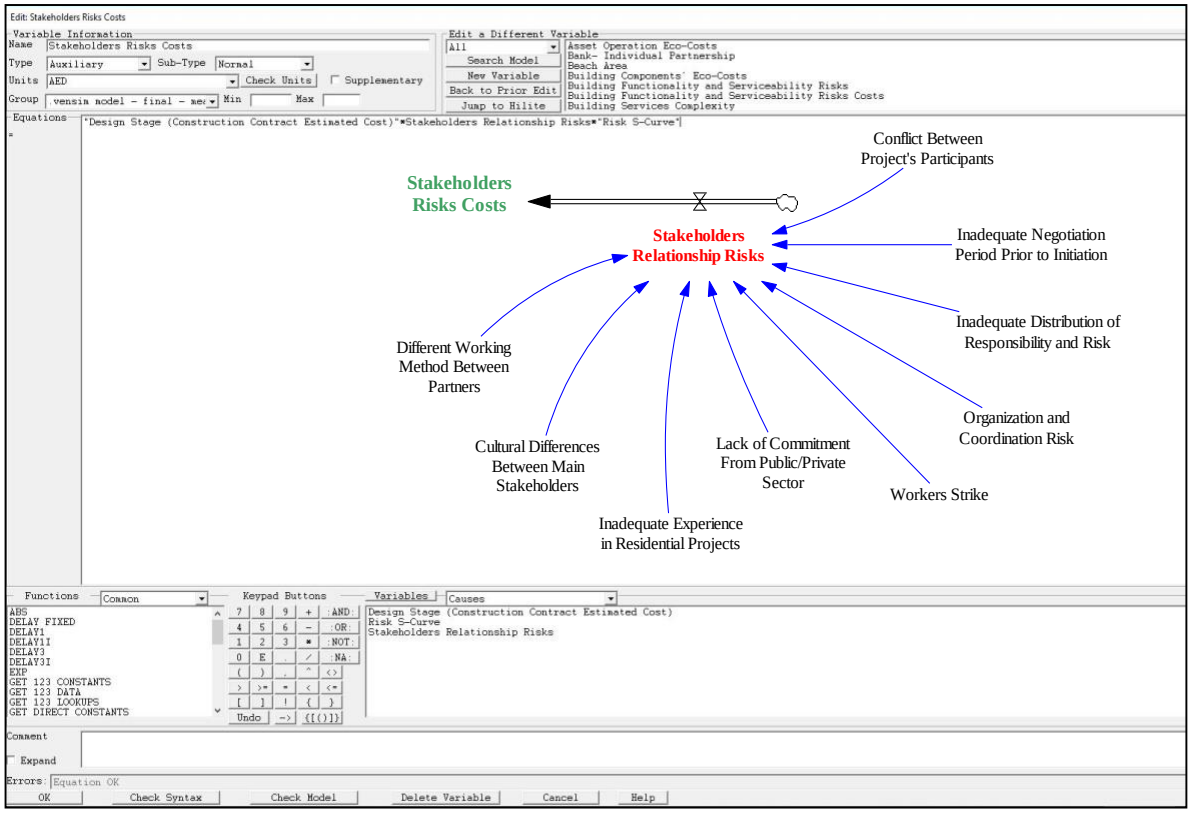


Figure 7-12: Developing the stock and flow system dynamics model of CAPEX Stakeholders Relationship Risks and finalizing its mathematical equations system.

K- Knowledge Risks

The system dynamics model of this adjusting risks cost group will be based on stock and flow dynamical system over time as the following:

1- All adjusting rates of this group are fed directly into the model valve variable Knowledge Risks to create its impact flow on the system.

2- The risk rates in point 1 are entered as constant using the validated adjusting rates resulted from experts' data, SPSS modelling, and Monte Carlo Simulation; however, they are considered constant in VENSIM system type and their unit AED/Year.

3- The Knowledge Risks is the flow valve of the group dynamical system which is collecting all adjusting risks rates to flow it on time step bases; however, it is also

considered as constant in VENSIM system type and their unit AED/Year, which is flowing through years (i.e., AED/Year multiply by Year in the end when it reaches the stock).

4- The Knowledge Risks Costs is the stock where the impacts of risks are collected in each time step of the model lifecycle; however, it is entered as Auxiliary type in VENSIM system dynamics, and it has AED unit after multiplying the collected flow into the risk behaviour S-Curve and into the total contract value of the project's CAPEX. Nevertheless, this calculations algorithm is shown in the following:

"Design Stage (Construction Contract Estimated Cost)"* Knowledge Risks*"Risk S-Curve."

5- Figure 7-13 shows the final development of Knowledge Risks system dynamics modelling, including the points mentioned above 1 to 4.

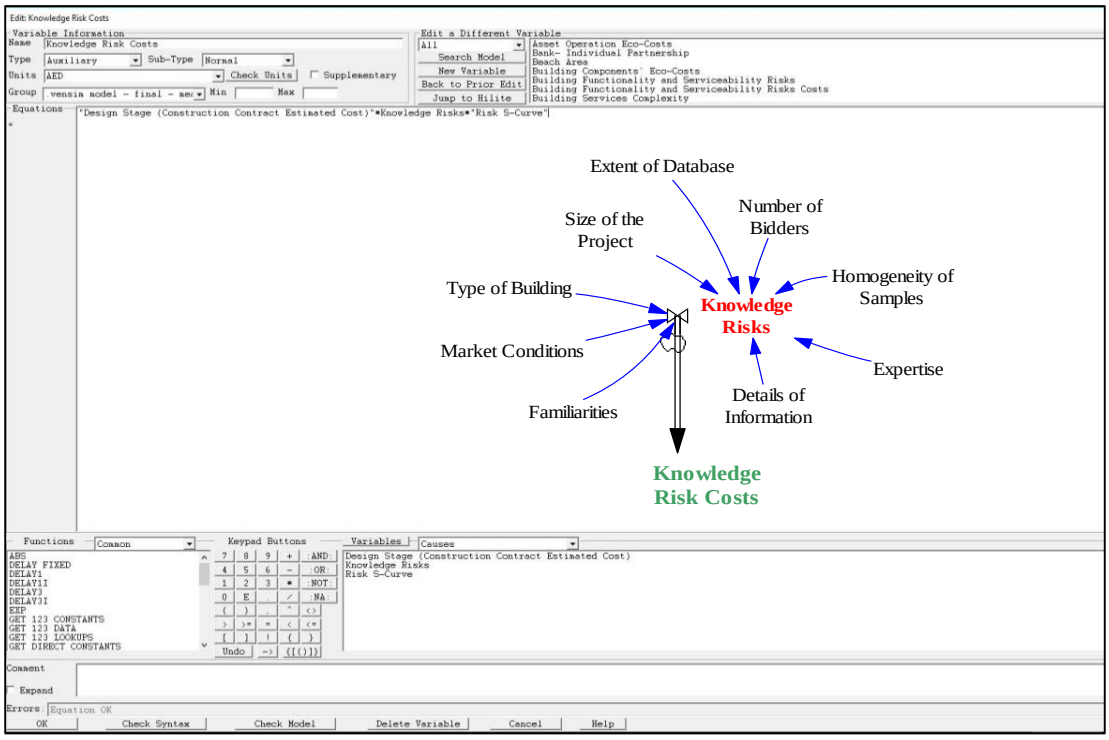


Figure 7-13: Developing the stock and flow system dynamics model of CAPEX Knowledge Risks and finalizing its mathematical equations system.

7.3 OPEX System Dynamics Model Development

The system dynamics model of this adjusting risks cost group will be based on stock and flow dynamical system over time as the following:

1- Concerning the cost of equipment (i.e., MEP), it is the main base of calculating operations and maintenance costs in this research model. It is mandatory to know how to allocate the accurate costs based on the project's contract value at the pre-construction stage. However, as per researchers' outputs, residential MEP cost percentage of total building costs ranges from 15 to 25 per cent, as shown in Figure 4-22. Therefore, since the housing projects are low MEP system complexity, unlike the high-rise buildings and palaces, the chosen percentage of MEP costs of the total residential project cost is equal to 15% (Riley et al. 2005)

	MEP cost classification		
Facility type	High	Medium	Low
	MEP cost as percent of total building cost		
Semiconductor plants	60	50	40
Biotechnology plants	65	55	45
Heavy industrial plants	60	50	40
Multiresidential complexes	25	20	15
Commercial buildings	40	30	15
Research laboratories	50	40	30
Hospitals	50	40	30

Figure 4-22: This figure is adapted by Riley et al. (2005) for Tao et al. (2001) table showing the percentage of MEP costs compared to the total building costs including residential building projects (Riley et al. 2005).

2- After knowing how much MEP CAPEX systems cost in residential buildings, it is mandatory, according to Tao et al. (2001), to extract from previous research the latest operational and maintenance costs percentage (Riley et al. 2005). Therefore, based on studied 20 building projects' operation and maintenance (i.e., O&M) data over 25 years

in previous research, it is found that active serviceable and functional buildings have average maintenance and operation costs equal to 9 times their initial CAPEX costs.

Ratios	Median	Mean	Standard deviation	Skewness	Kurtosis
Maintenance costs over initial costs	0.63	0.69	0.31	2.74	7.95
Operating and maintenance costs over initial costs	7.77	9	5.17	3.29	12.33

Figure 4-23: This figure is adapted by Wu and Clements-Croome (2007) for Schaufelberger and Jacobson (2000) and Fuller (2005) table showing the percentage of operations and maintenance costs compared to the total building costs including residential buildings projects (Riley et al. 2005).

3- The first three years of which CAPEX takes place before OPEX will have zero operation and maintenance cash flow, then O&M will start counting after CAPEX completion.

4- In the first year of operational and maintenance cost, the cash flow will be gradually spent over the year instead of annual payments increasing in steps' pulse. However, this will be solved in system dynamics VENSIM cost estimation modelling by having a lockup table, as explained in chapter 4.

5- All adjusting rates of this group are fed directly into the model valve variable OPEX Activities Risks creating its impact flow on the system.

6- The risk rates in point 1 are entered as constant using the validated adjusting rates resulted from experts' data, SPSS modelling, and Monte Carlo Simulation; however, they are considered constant in VENSIM system type and their unit AED/Year.

7- The OPEX Activities Risks is the flow valve of the group dynamical system which is collecting all adjusting risks rates to flow it on time step bases; however, it is also considered as constant in VENSIM system type and their unit AED/Year, which is flowing through years (i.e., AED/Year multiply by Year in the end when it reaches the stock).

8- The OPEX Activities Risks Costs is the stock where the impacts of risks are collected in each step of the model lifecycle. However, it is entered as Auxiliary type in VENSIM system dynamics, and it has the AED unit after using the IF THEN ELSE equations to satisfy the different conditions of calculating OPEX in this cost estimation model. Nevertheless, this calculations algorithm is shown in the following:

IF THEN ELSE ("<Time>"<4, 0, "Design Stage (Construction Contract Estimated Cost)"*OPEX Activities Risks*"<Time>"*(9/25)*0.15) + (OPEX Lockup table ("<Time>")* "Design Stage (Construction Contract Estimated Cost)"*OPEX Activities Risks*(9/25)*0.15)

9- So, in Figure 7-14, the final development of OPEX Activities Risks system dynamics modelling is shown detailing from the system points 1 to 4 mentioned above.

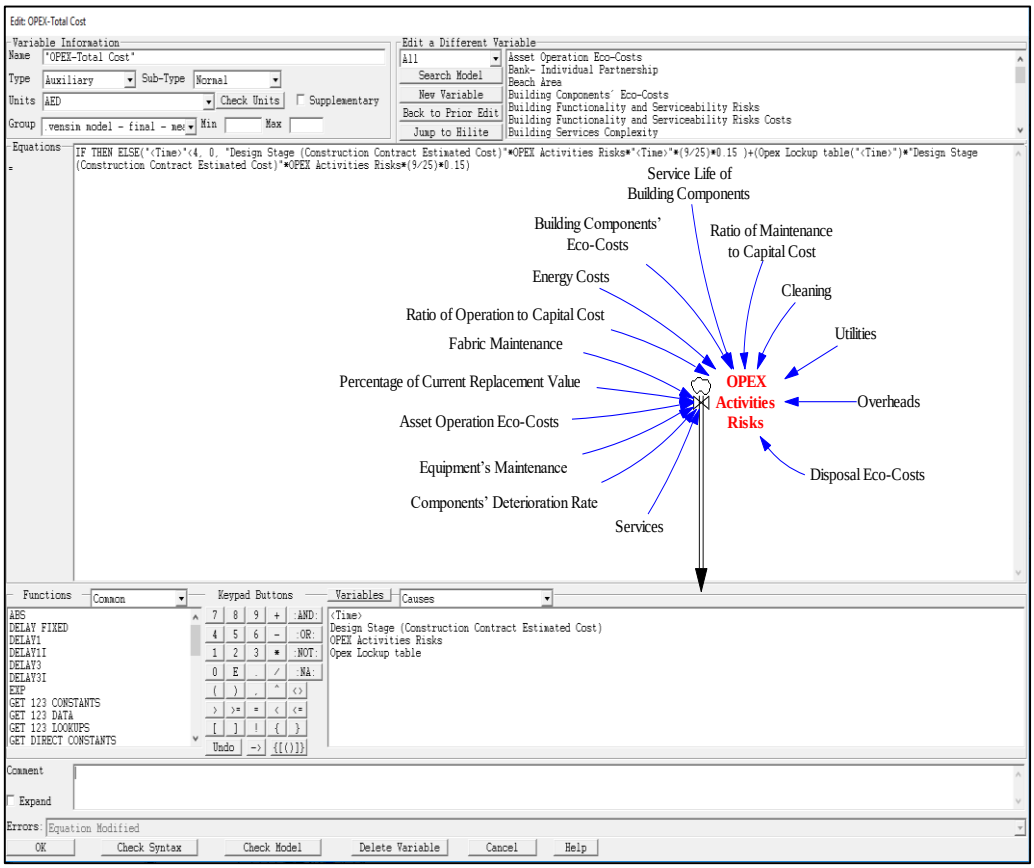


Figure 7-14: Developing the stock and flow system dynamics model of OPEX Risks and finalizing its mathematical equations system.

7.4 Project's Whole Life Cycle Cost Model Cost and Net Present Value

The system dynamics model at this final part in estimating and predicting costs has several perspectives; however, this part of the model is not based on stock and flow while it is based on mathematical equations which deploy the previous developed stock and flow models' result to end up with the outputs of the required cost. So, the criteria for calculating the final system dynamics model development will be summarized as the following:

1- The System dynamics variable Design Stage (Construction Contract Estimated Cost) is feeding the CAPEX-Total Cost and has a sub icon Contract Value Cash Flow, the S-Curve at zero adjusting risks.

2- The CAPEX-Total Cost and OPEX Total Cost system dynamics variables feed the Final Estimated Cost equation from the Client Perspective of the Project's Whole lifecycle. However, the Equipment Replacement Rate contributes to the Equipment Replacement Cost equation, which is impacting as an additional cost on the Final Estimated Cost from Client Perspective of Project's Whole life cycle on pulse impact.

3- NPV discount rate was extracted from UAE Central Bank, as shown in Figure 4-23.

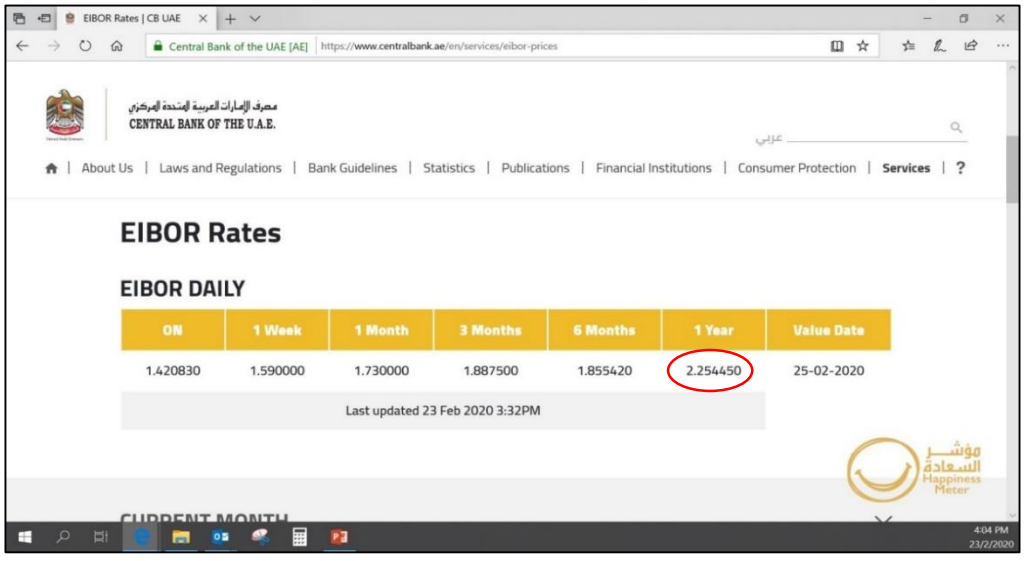


Figure 4-24: a screen shot of the official EIBOR rate value in the United Arab Emirates as of 23rd February 2020 which is used in calculating the net present value of the developed system dynamics model and its mathematical equation system.

4- The OPEX Total Cost system dynamics variables are directly moving to enter the Project's OPEX net present value equation while Final Estimated Cost from Client Perspective of Project's Whole lifecycle moves directly to enter the project's Whole lifecycle net present value equation.

5- Finally, all variable types of this part of the model are entered as Auxiliary type in VENSIM system dynamics, and it has an AED unit. Nevertheless, this calculation algorithm is shown, as shown in table 7-1.

SN	Algorithm Description
1	Contract Value Cash Flow: "Design Stage (Construction Contract Estimated Cost)"*" Cost S-Curve."
2	CAPEX-Total Cost: (Building Functionality and Serviceability Risks Costs+Construction Activities Risk Cost+Economic Change Risks Cost+Knowledge Risk Costs+Legal Risks Costs+ Market Risks Costs+Natural Risk Costs+Political Risk Cost+Project Finance Risk Costs+Project Selection Risks Costs+Stakeholders Risks Costs+"Design Stage (Construction Contract Estimated Cost)")*"Cost S-Curve."
3	Equipment Replacement Cost: "Design Stage (Construction Contract Estimated Cost)"*Equipment Replacement Rate("<Time>")
4	Final Estimated Cost from Client Perspective of Project's Whole lifecycle: "CAPEX-Total Cost"+Equipments Replacement Cost+"OPEX-Total Cost"
5	Project's OPEX net present value: IF THEN ELSE(Time NPV<=3, 0, ("OPEX-Total Cost"/POWER(1.02254, Time NPV)))
6	Project's Whole lifecycle net present value: (Equipments Replacement Cost/POWER(1.02254, Time NPV))+Projects OPEX Net Present Value+"CAPEX-Total Cost"

Table 7-1: Final system dynamics model combining algorithms to satisfy chapter 4 mathematical modelling.

6- Figure 7-15 shows the final development of the Final Estimated Cost and Net Present Value System Dynamics Model Development system dynamics modelling, including the points mentioned above 1 to 5.

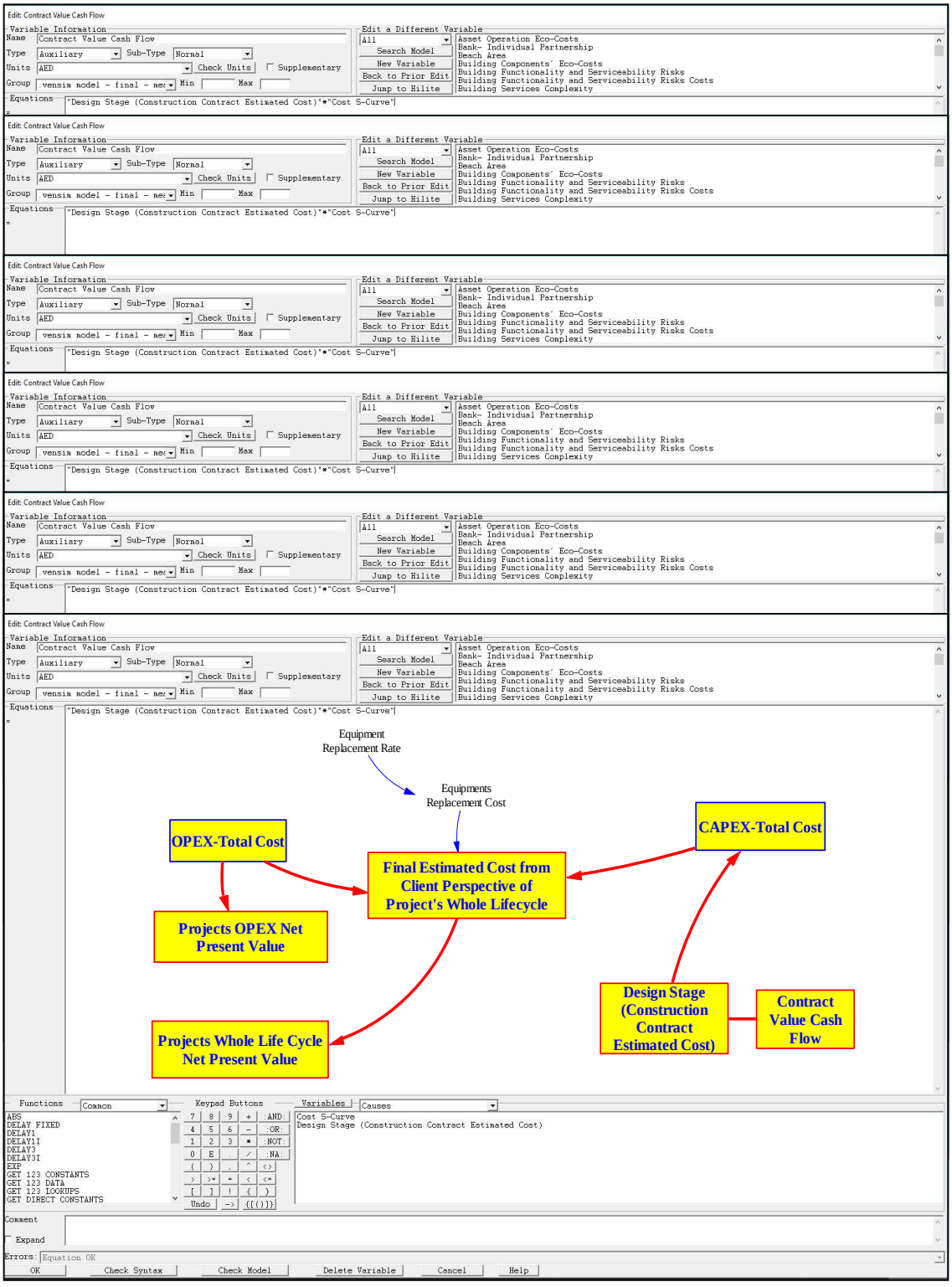


Figure 7-15: Developing the system dynamics model of final cost estimation and its Net Present Value including CAPEX and OPEX Total costs and finalizing its mathematical equations system.

7.5 Summary

To sum up, this chapter detailed the development process of implementing chapter 4 methodological design. It is including the development of CAPEX s-curves (i.e., cash flow and risks curves). Moreover, the development of CAPEX groups sub-modelling (i.e., 11 groups). And the development of OPEX group sub-modelling. Moreover, the development of the projects' whole life cycle cost estimation sub-modelling. Therefore, this model is ready for simulating real data.

After successfully developing each group's system dynamics final model, it is crucial to collect all model parts to finalize the full cost estimation system dynamics model. However, this system will contain all CAPEX 11 groups' sub-models, OPEX activities sub-model, equipment replacement sub-model, project's whole life cycle cost sub-model, and NPV sub-models for both OPEX and project's whole life cycle. CAPEX is considered the first investment value and does not have a separate NPV sub-model.

So, data collection, data validation, Monte Carlo simulation, and VENSIM system dynamics modelling are completed successfully by reaching this part of this research. Nevertheless, the modelling journey to reach applicable outputs contributing to the project management body of knowledge requires validation, verification, and analytical discussion.

Finally, in the following chapter of the thesis, each part's system dynamics validation (i.e., using demo contract cost) will be conducted for its verification or re-adjustments (i.e., VENSIM algorithm adjustments). In case if the model has been successfully validated, the verification (i.e., using real projects' data) will be proceeded to check whether the model can work on real projects data or there will be challenges that require further adjustments (i.e., mathematical adjustments, diagram adjustments, relationships adjustments, or risk-allocation adjustments). Figure 7-16 is the final developed system dynamics cost model.

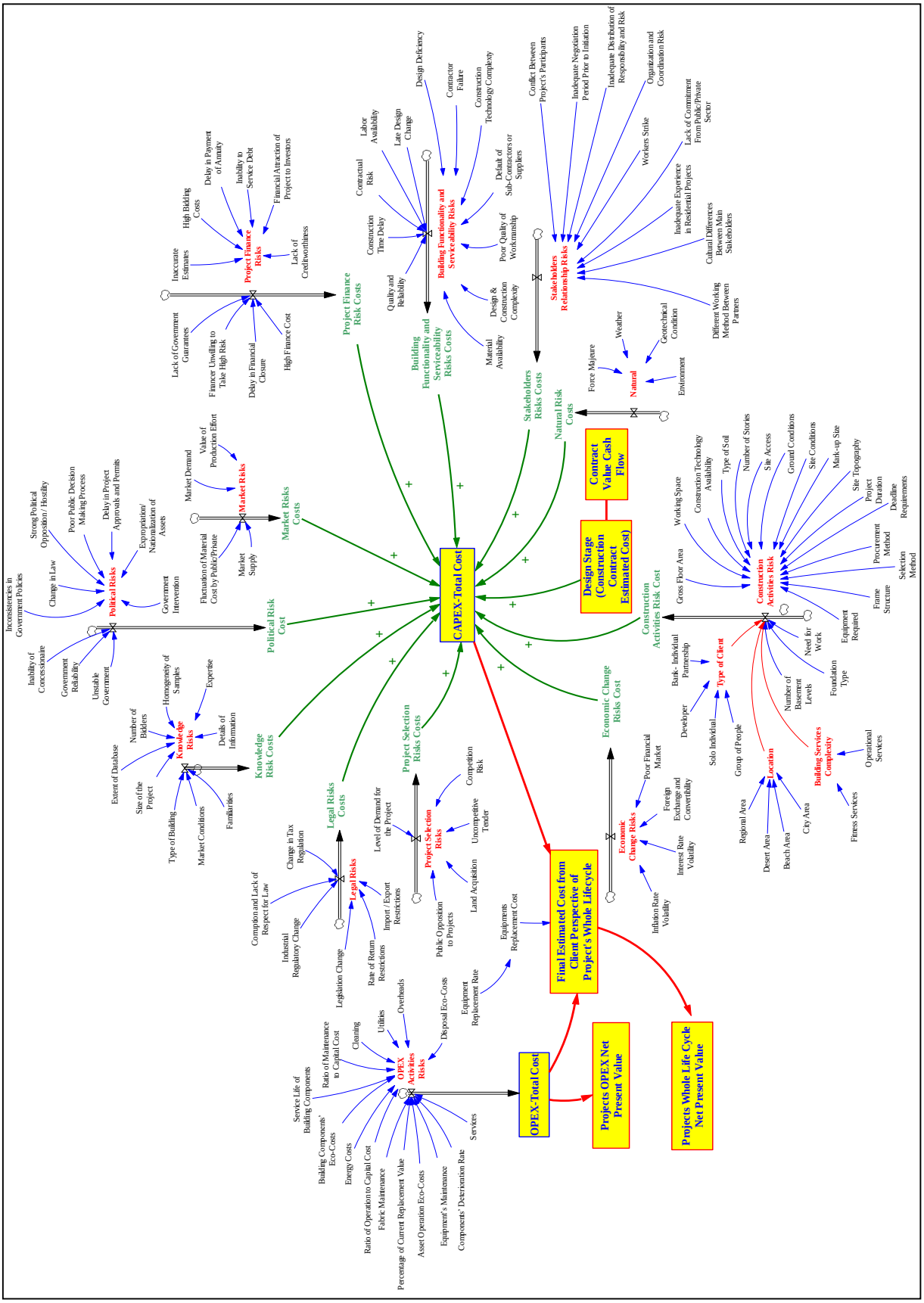


Figure 7-16: Final developed system dynamics model of estimating and predicting residential projects whole lifecycle cost from the client perspective at the pre-construction stage.

Chapter 8

SYSTEM DYNAMICS COST MODEL VALIDATION, VERIFICATION, AND DISCUSSION

"Models change a lot and are used in ways that may be different than originally anticipated".

(Sawyer 2015, p. 19)

8.0 Introduction

In this chapter, the developed system dynamics cost model from chapter 7 will be validated and verified. However, model validation can be defined as "*conducting some tests after identifying and defining all variables and functions*" (Marzouk & Azab 2014, p.44). Validation is essentially required after the model's development processes (Alshamrani 2017). Model verification (i.e., "parameter verification test") is the "*test is to check whether the parameters in the model correspond conceptually and numerically to real-life*" (Marzouk & Azab 2014, p.45). other researchers defined model's verification as "*the research process with continual checks of the credibility, plausibility, and trustworthiness of the findings*" (Steinar 1992, p. 24). This research study will approach DEMO methodology for validating all developed model's components; however, it is considered the best option for measuring model's validity across many fields, including construction and project management discipline (Federici et al. 2018; Bustreo, Bolzonella & Zollino 2015; Meszaros et al. 2015; Bachmann et al. 2017; Gonçalves, Sousa & Zacarias 2013; Ruan 2001). This research will then approach completed real housing projects to conduct the verification process and satisfy the model's real-life projects trustworthiness. Finally, cash flow discussion and error computation will be conducted to finalize this research results and discussion at the end of this chapter.

8.1 System Dynamics Validation DEMO Model

The system dynamics validation process is based on considering the developed VENSIM model in chapter 7 as a DEMO model. According to previous literature, the DEMO process analyzes a designed system to describe its progress and performance, approaching the same desired technologies used in the real project (Federici et al. 2018). It is also an early

assessment of technologies capabilities and economic impact of a designed project before its execution (Bustreo, Bolzonella & Zollino 2015). Besides, researchers have introduced demos as the controlled analysis to evaluate a complex system through simulating real-life applications (Meszaros et al. 2015; Bachmann et al. 2017). Finally, the literature introduced DEMO as a methodology of representing systems complexity and behaviour to understand its dynamics (Gonçalves, Sousa & Zacarias 2013; Ruan 2001).

Therefore, DEMO modelling can be defined in this research study as an early assessment of technology's ability (i.e., VENSIM) to model real designed systems (i.e., project's TOTEX) under controlled simulations to identify (1) performance dynamical behaviour (i.e., outputs generation ability), (2) complexity analysis (i.e., mathematical applications), and (3) critical-integration issues (i.e., VENSIM mapping and algorithms) of the developed system dynamics model. After that, assigning a demo project's contract-value required to have a guideline. However, previous research declared that an "educated guess" is a forecast of variable measure which needs to be based on previous related data (Cane 2019, pp 1768). Therefore, from previous similar research (i.e., "Design/Build/Operate/Transfere (DBOT) project"), a project worth 400 million US dollars was considered a large and complex to proceed with project management dynamical planning and control (Lee, Pen˜a-Mora & Park 2006, p.92). In this research, irrespective of currency, the DEMO contract value has been set as 400 million to ensure the most valuable outputs from this research large and complex DEMO model validation before using it for real projects. However, in this case, the currency is an adjustable unit entered manually in the model as USD or AED, regardless, prior simulation. VENSIM software programme will provide numerical outputs as cash flow data represented with the model's defined unit. The units are important because VENSIM will process them, and this will explain and identify possible issues if the final numerical values are not presented

with the currency unit (i.e., AED in this model). The demo construction contract value has been chosen to be AED 400 Million.

This research validation DEMO is conducted to observe the simulation results to fix any fault, which may happen in the outputs, to avoid any impact on the final model's accuracy. Therefore, the validation will be conducted for contract value cash flow at zero adjusting risks, minimum adjusting risks, mean adjusting risks, and maximum adjusting risks. CAPEX applications will be ensured to comply with cash flow increasing S-Curve behaviour and risk decreasing S-Curve behaviour. Each CAPEX risk's cost group (i.e., a total of 11 groups) will be checked independently. OPEX trend behaviour will be checked separately and combined with remaining outputs, including CAPEX cash flow, equipment replacement pattern (i.e., pulse impact every 25 years), and net present value (NPV). Finally, the projects' whole life cycle cost model is evaluated and validated for further use in real applications.

8.1.1 CAPEX System Dynamics Model Validation

In CAPEX validation, the AED 400 Million's contract value is entered in the model and simulated to check the several points. First, check the behaviour of the mathematical equation of contract value cash flow at zero adjusting risk. It has been found to shape the cost cash flow as per the developed S-Curve, as shown in Figure 8-1 from system dynamics simulation. Second, checking the outputs of adjusted cash flow curves subject to a minimum, mean, and maximum risks impact. According to the built mathematical system, there should be three curves, including minimum risks cash flow, mean risks cash flow, and maximum risks cash flow, as shown in Figure 8-2. Third, checking the mathematical modelling constraints, which should stop the cash flow increment after the last construction time step. Moreover, maintain CAPEX cumulative value constant for the remaining projects' whole life cycle (i.e.57 years out

of 60 years in this system dynamics model). However, this should be valid for the zero adjusting cost risks, minimum adjusting cost risks, mean adjusting cost risks, and the maximum adjusting cost risks S-Curves as shown in Figure 8-3 and Figure 8-4. Finally, the validation process will check the differences between risk values to ensure that the model utilizes all functions aimed at its development. In other words, the minimum, mean, and maximum risks impact S-Curves should be, respectively, different from each other. For example, the maximum risk costs curve is the highest, mean risks curve is the middle values, and the minimum risks are the lowest curve. Nevertheless, all cost S-Curves, which are impacted by risks, should be more than the zero risk S-Curve, as shown in Figures 8-1 and 8-2.

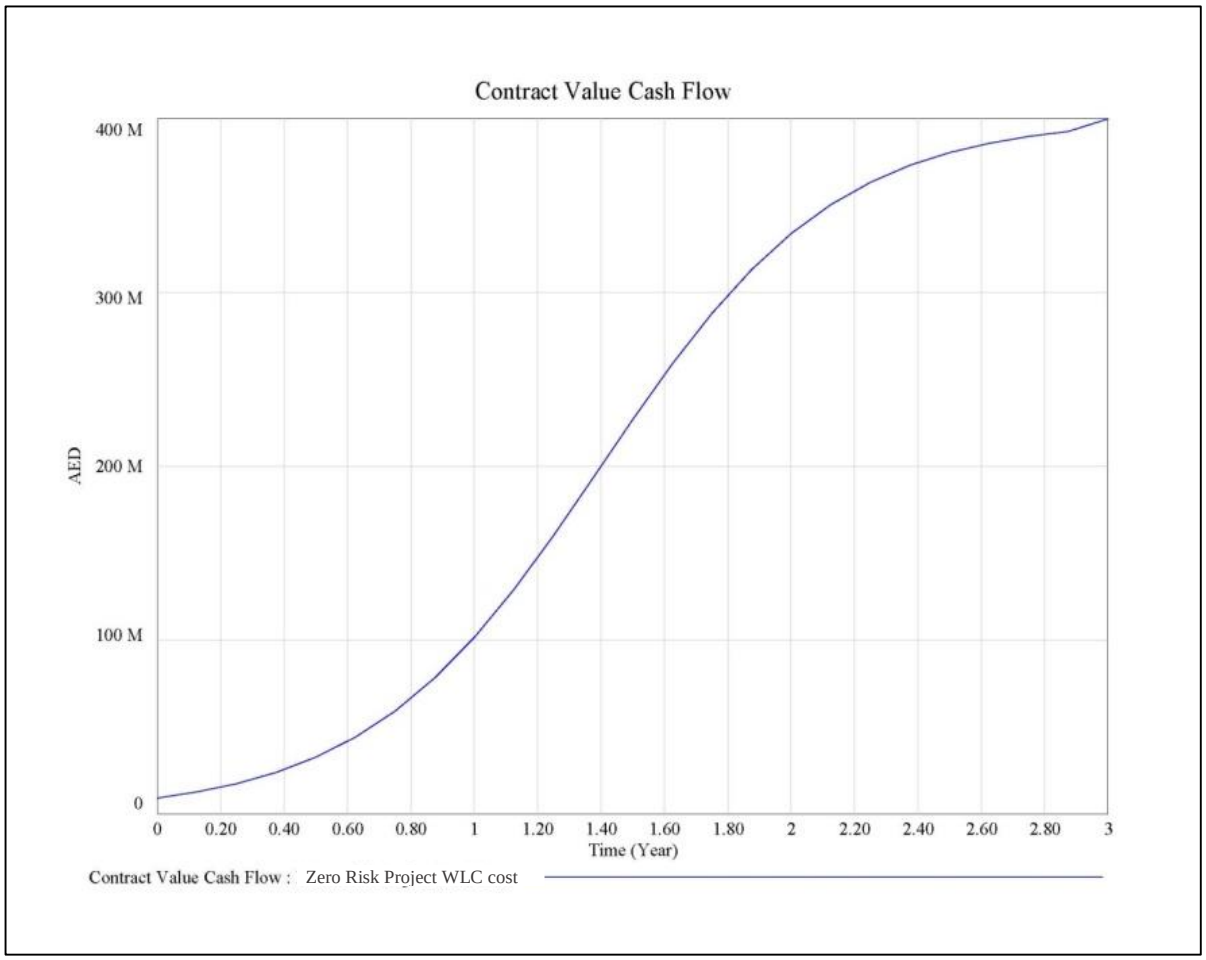


Figure 8-1: It is showing the Zero Risk CAPEX cost cash flow S-Curve of the DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

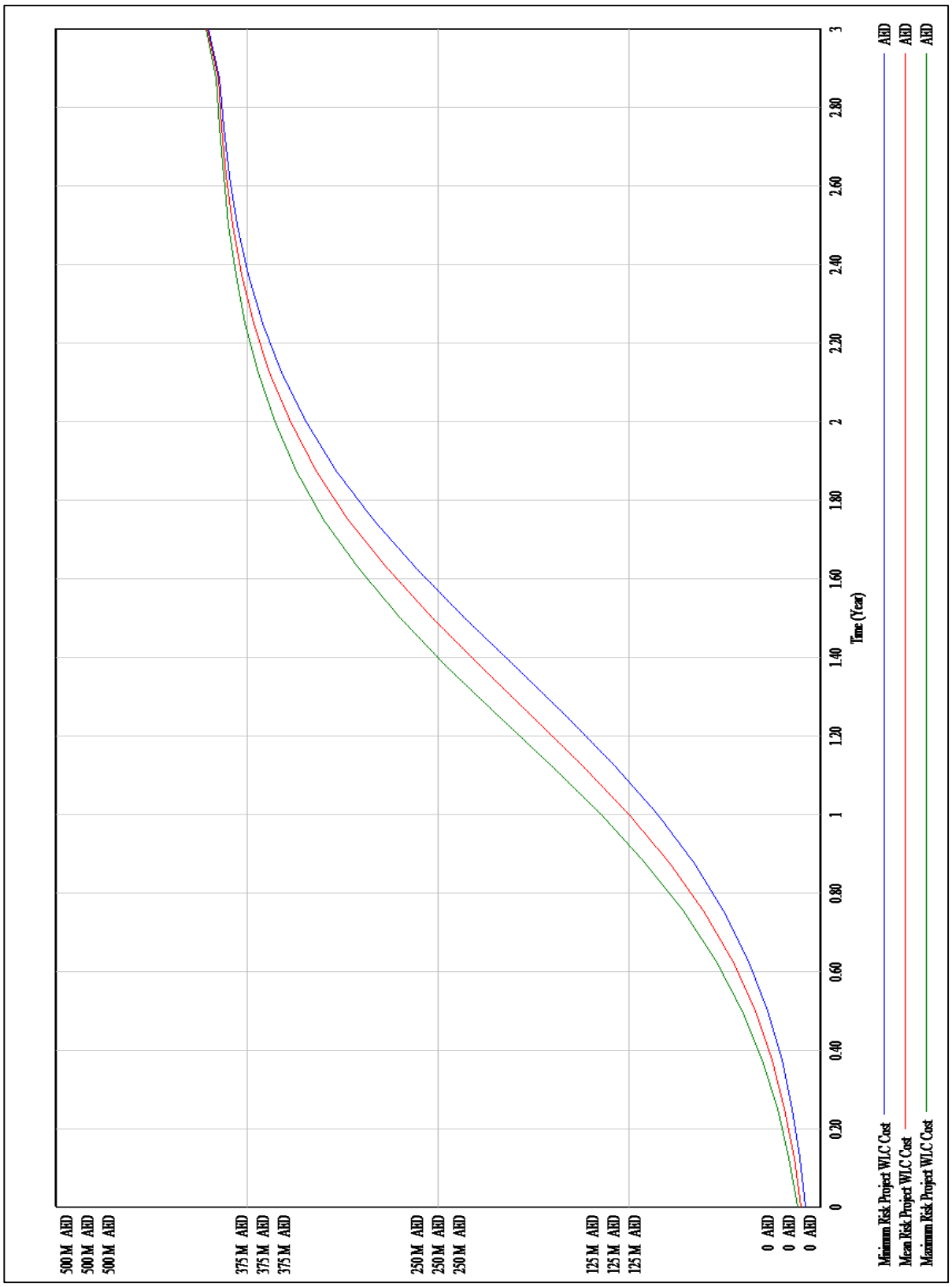


Figure 8-2: It is showing the minimum, mean and maximum CAPEX cost cash flow S-Curves using the validation demo project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

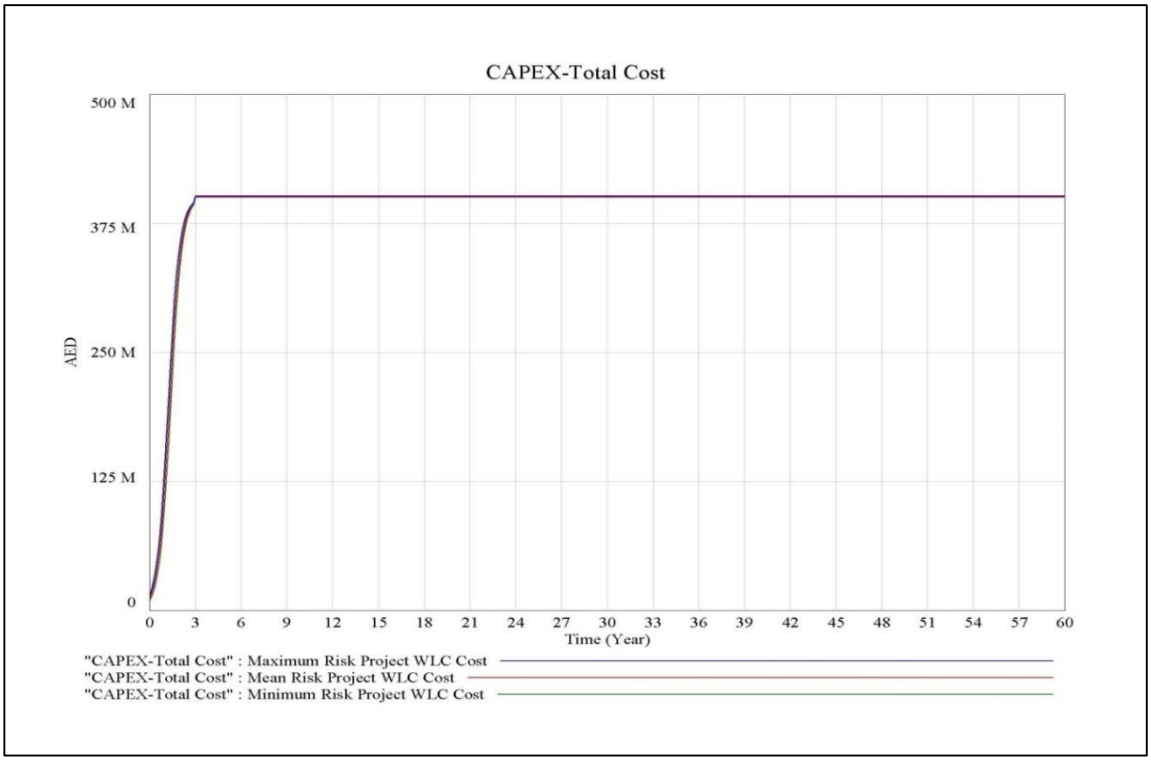


Figure 8-3: It is showing the adjusted CAPEX Cash Flow S-Curve including minimum, mean, and maximum adjusting risks using the validation demo project. DEMO cost is assigned equal to AED 400 million over 60 years projects whole lifecycle.

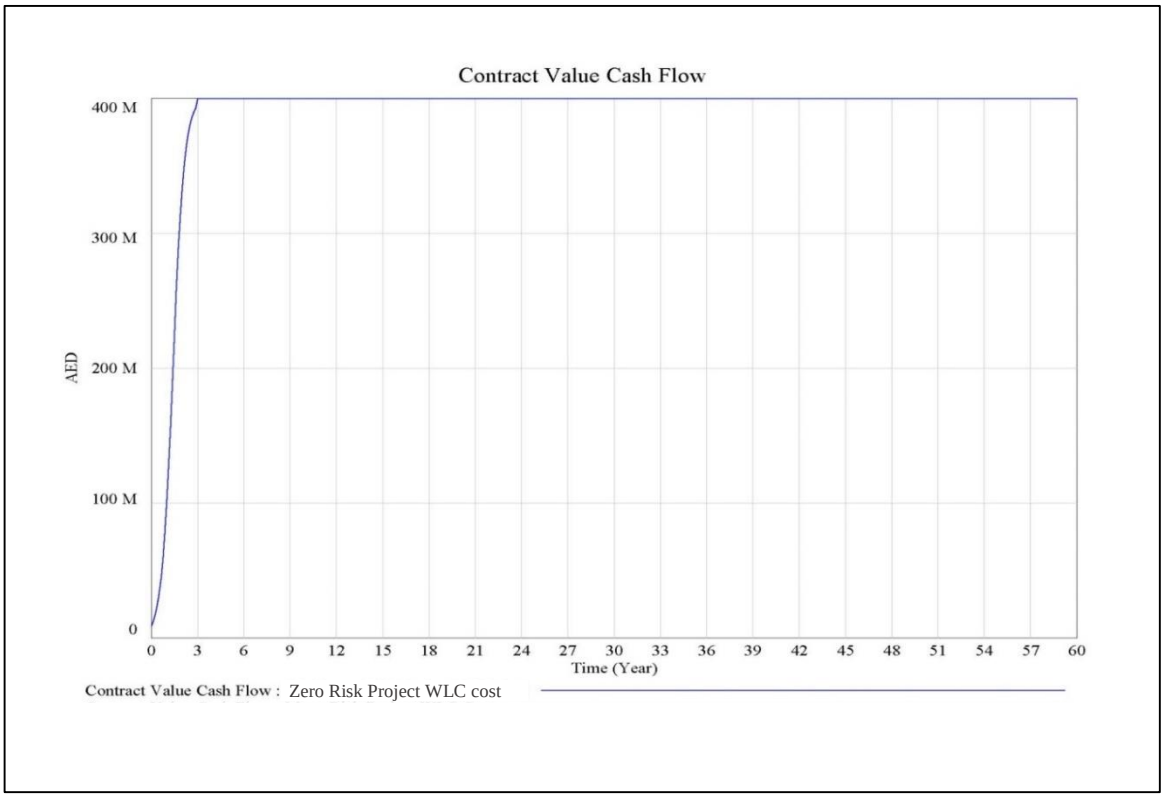


Figure 8-4: It is showing the Zero Risk CAPEX cost cash flow S-Curve of the DEMO project cost. DEMO cost is assigned equal to AED 400 million over 60 years projects whole lifecycle.

A- Construction Activities' Risks

The construction activities risk group in this system dynamics modelling validation has provided a decreasing S-Curve as expected from developed mathematics. However, Figure 8-5 shows that the risk is at the highest point at the beginning of the project and showed a value of AED 43,452,600. In other words, in case if the full project's cash flow is spent at the beginning of the project, the risk cost of this risk group only (i.e., Contraction activities) will be the possibility of facing danger to lose AED 43,452,600. Therefore, the mathematical model minimizes the cash spent at the start of project construction using cost increasing cash flow S-Curve.

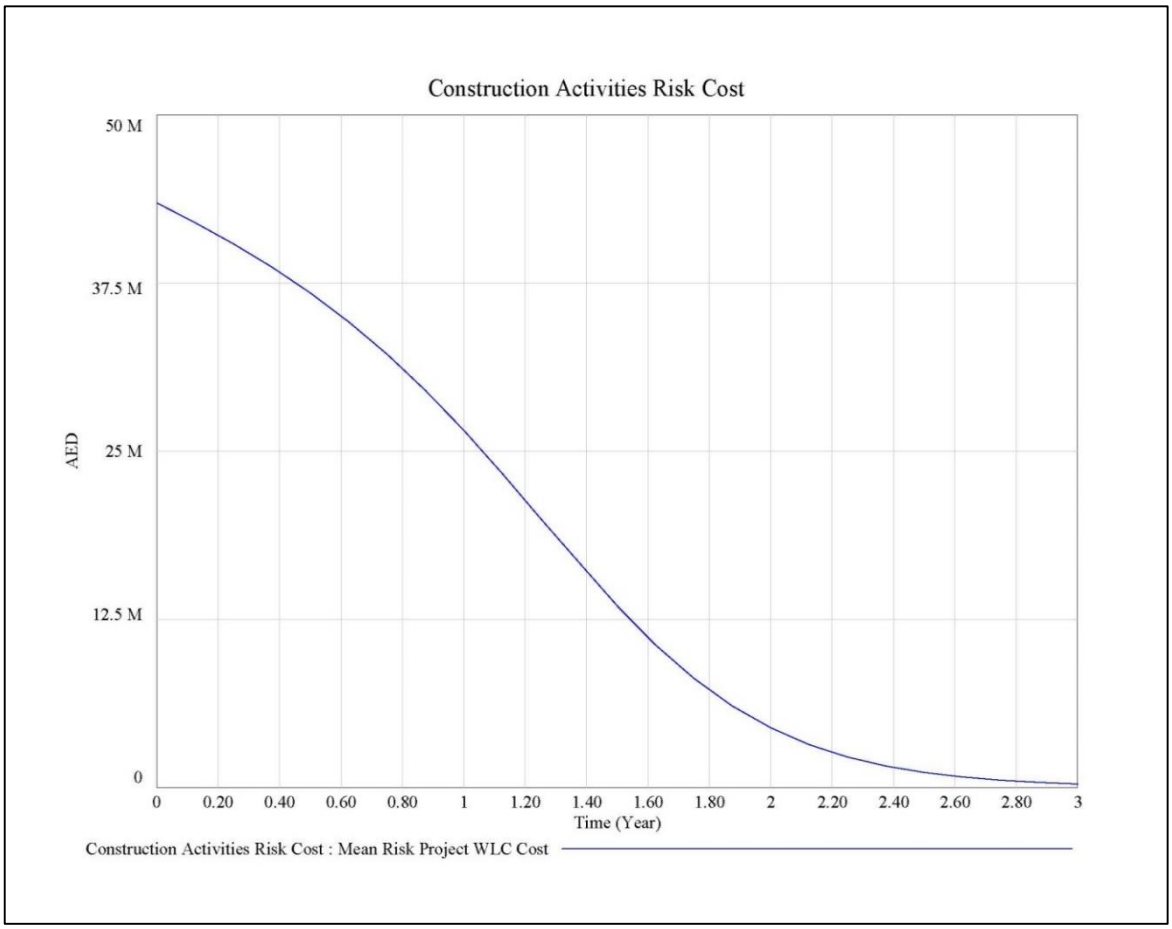


Figure 8-5: It is showing the Risk Cost S-Curve of the "**Construction Activities' Risks**" using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

B- Political Risks

In this system dynamics modelling validation, the political risk group has provided a decreasing S-Curve as expected from advanced mathematics. However, in Figure 8-6, the risk is at the highest point at the beginning of the project and showed a value of AED 13,299,400. If the full project's cash flow is spent at the beginning of the project, the risk group's risk cost only (i.e., political) will be the possibility of facing danger to lose AED 13,299,400. Therefore, the mathematical model minimizes the cash spent at the start of project construction using cost increasing cash flow S-Curve.

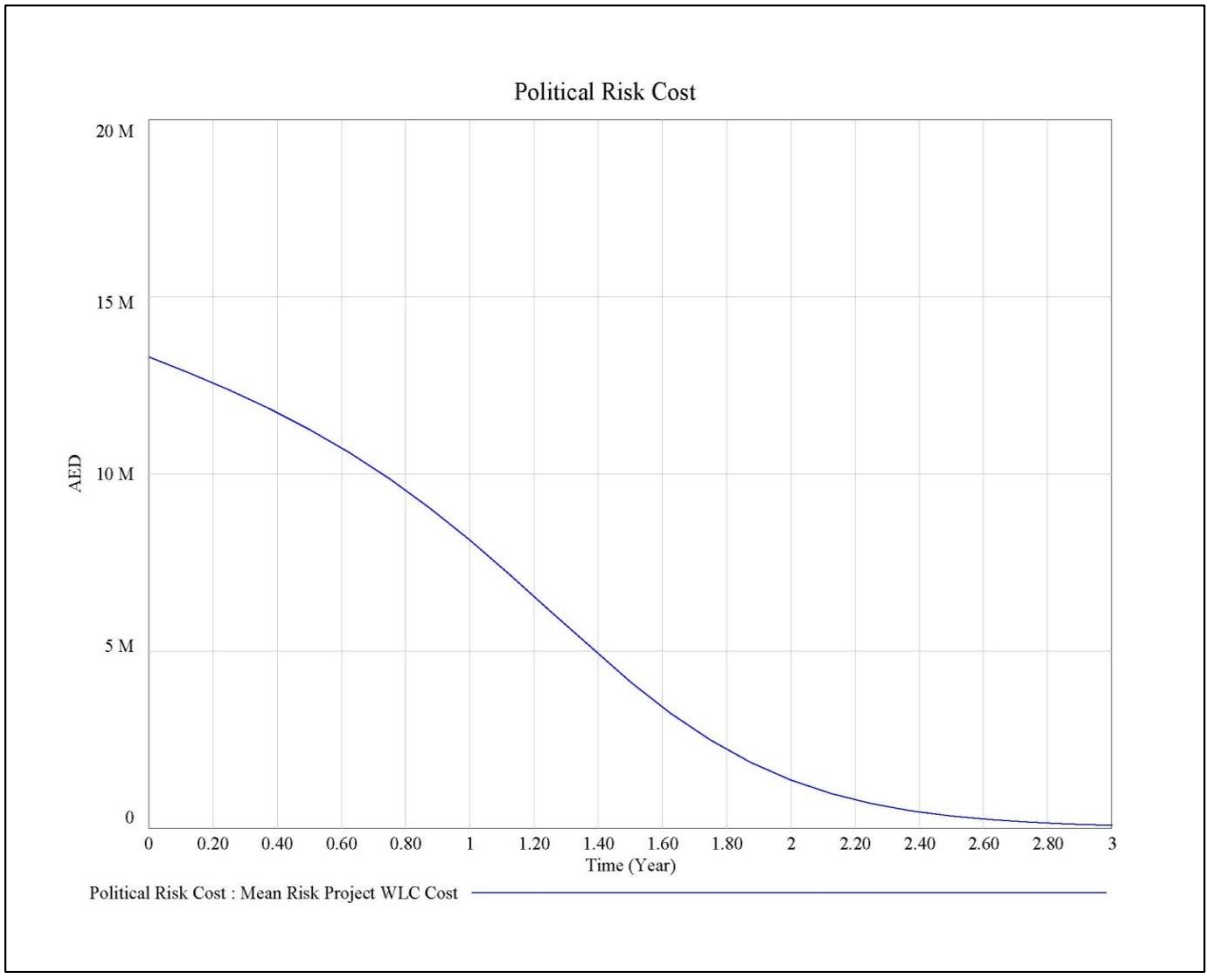


Figure 8-6: It is showing the Risk Cost S-Curve of the "**Political Risks**" using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

C- Legal Risks

In this system dynamics modelling validation, the legal risk group has provided a decreasing S-Curve as expected from advanced mathematics. However, in Figure 8-7, the risk is at the highest point at the beginning of the project with a value of AED 13,339,200. In other words, in case if the full project's cash flow is spent at the beginning of the project, the risk cost of this risk group only (i.e., Legal) will be the possibility of facing danger to lose AED 13,339,200. Therefore, the mathematical model minimizes the cash spent at the start of project construction using cost increasing cash flow S-Curve.

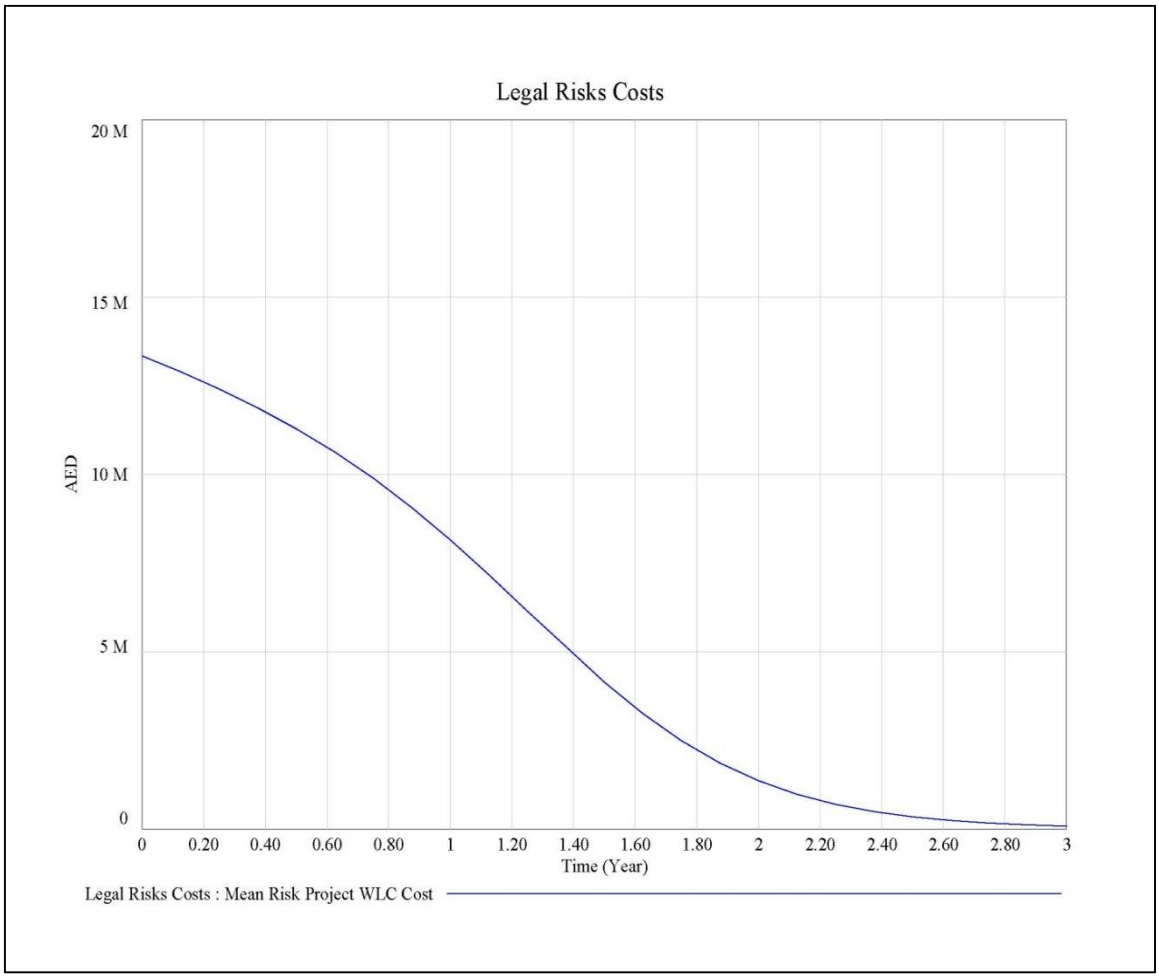


Figure 8-7: It is showing the Risk Cost S-Curve of the "**Legal Risks**" using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

D- Economic Change Risks

The Economic Change risk group in this system dynamics modelling validation has provided a decreasing S-Curve as expected from advanced mathematics. However, in Figure 8-8, the risk is at the highest point at the beginning of the project and showed a value of AED 3,015,150. In other words, in case if the full project's cash flow is spent at the beginning of the project, the risk cost of this risk group only (i.e., Economic Change) will be the possibility of facing danger to lose AED 3,015,150. Therefore, the mathematical model minimizes the cash spent at the start of project construction using cost increasing cash flow S-Curve.

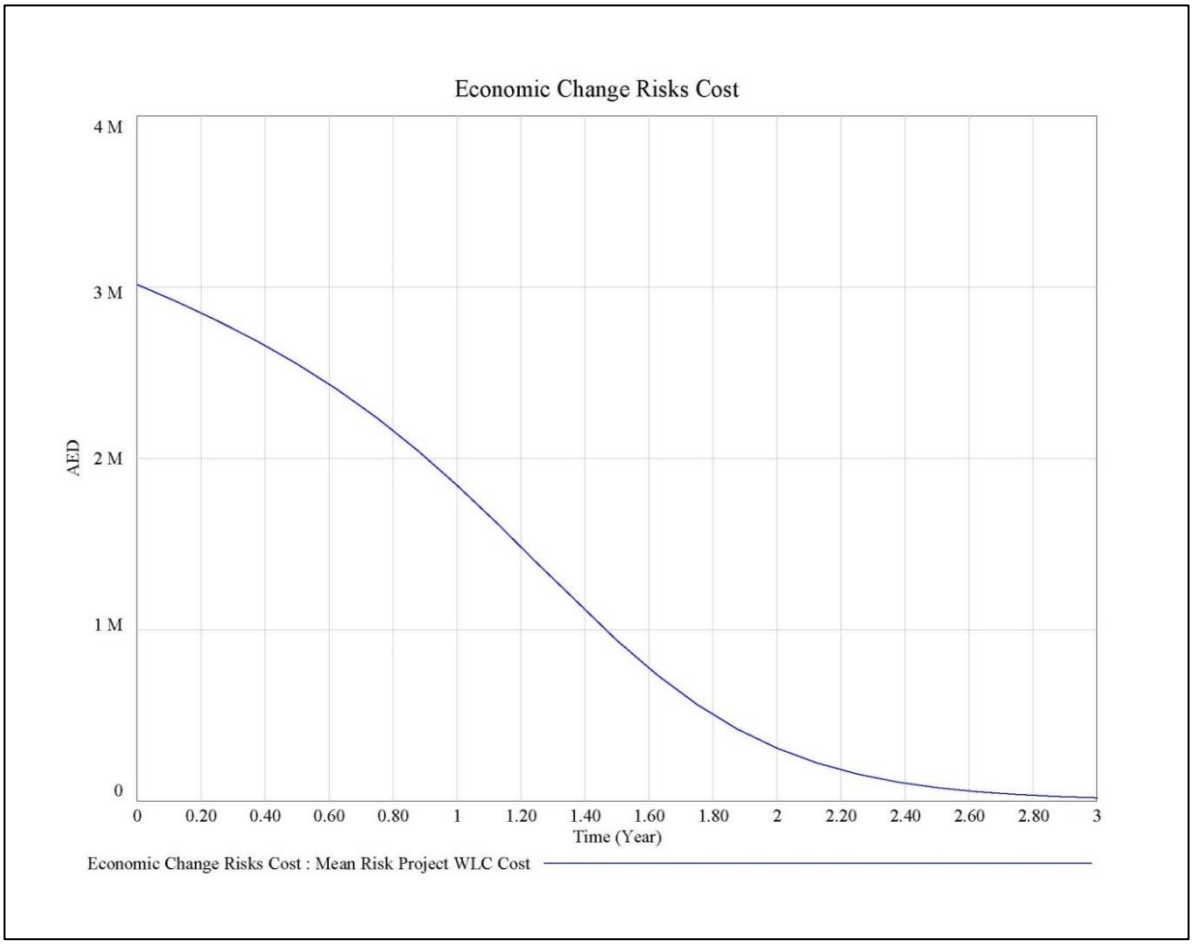


Figure 8-8: It is showing the Risk Cost S-Curve of the "**Economic Change Risks**" using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

E- Natural Forces Risks

The Natural Forces risk group in this system dynamics modelling validation has provided a decreasing S-Curve as expected from advanced mathematics. However, in Figure 8-9, the risk is at the highest point at the beginning of the project and showed a value of AED 7,797,830. In other words, in case if the full project's cash flow is spent at the beginning of the project, the risk cost of this risk group only (i.e., Natural Forces) will be the possibility of facing danger to lose AED 7,797,830. Therefore, the mathematical model minimizes the cash spent at the start of project construction using increasing cash flow S-Curve.

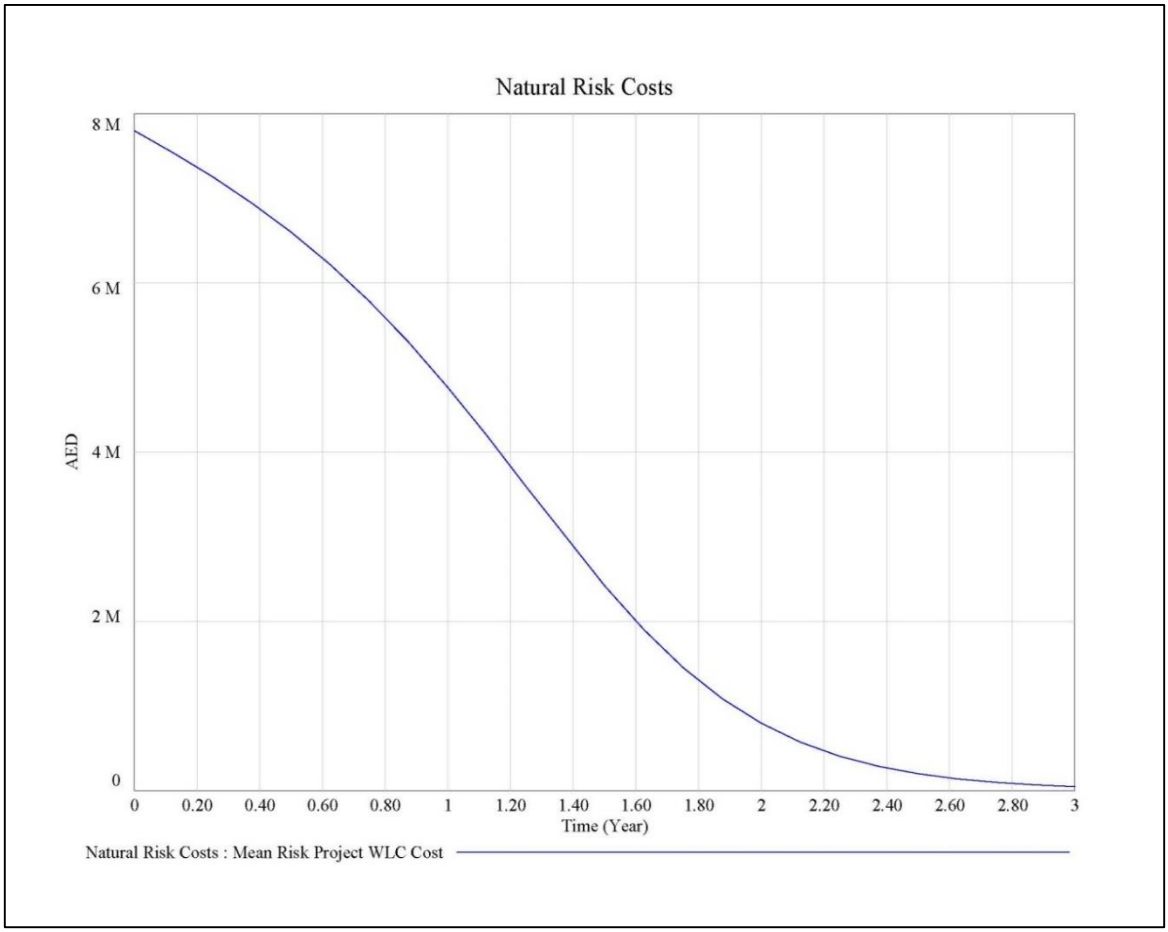


Figure 8-9: It is showing the Risk Cost S-Curve of the "**Natural Forces Risks**" using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

F- Market Risks

In this system dynamics modelling validation, the market risk group has provided a decreasing S-Curve as expected from advanced mathematics. However, in Figure 8-10, the risk is at the highest point at the beginning of the project and showed a value of AED 9,539,540. If the full project's cash flow is spent at the beginning of the project, the risk group's risk cost only (i.e., market) will be the possibility of facing danger to lose AED 9,539,540. Therefore, the mathematical model minimizes the cash spent at the start of project construction using increasing cash flow S-Curve.

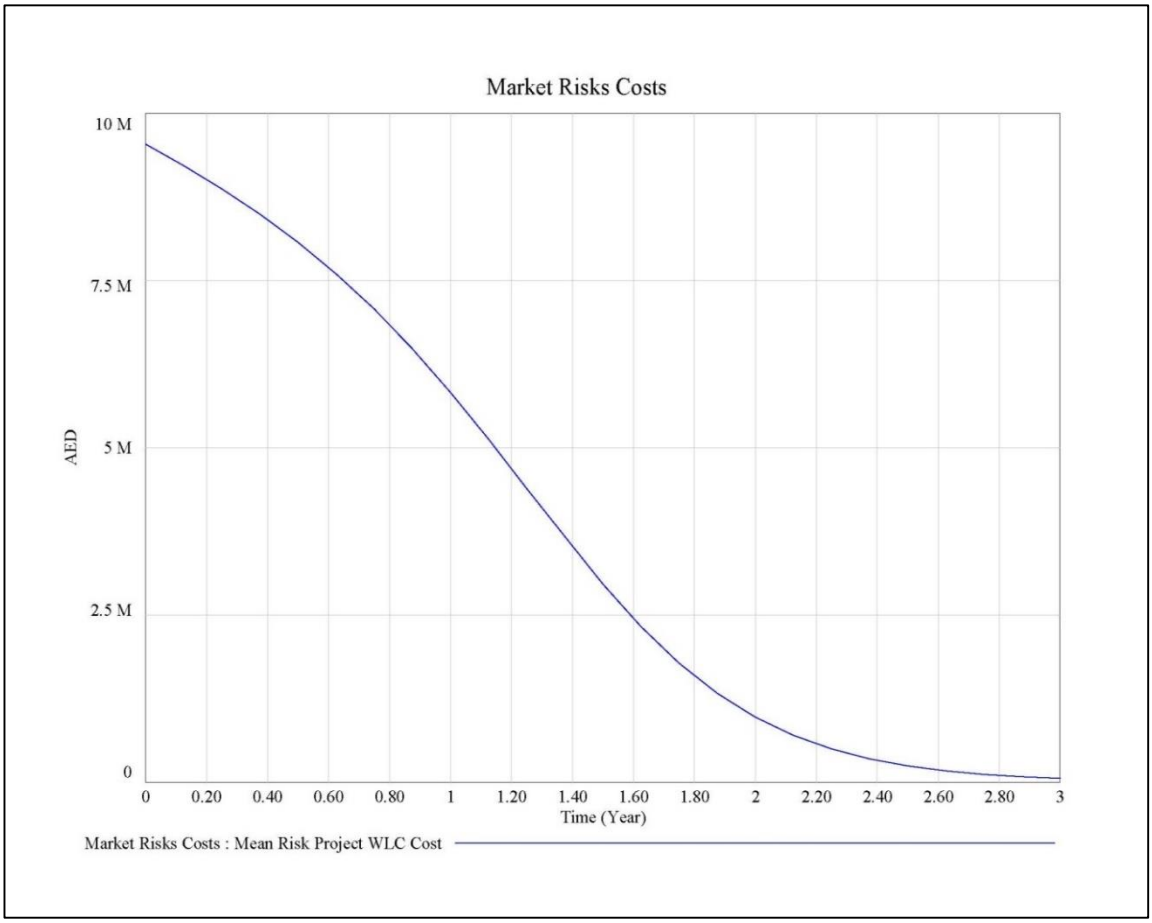


Figure 8-10: It is showing the Risk Cost S-Curve of the "**Market Risks**" using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

G- Project Selection Risks

The Project Selection risk group in this system dynamics modelling validation has provided a decreasing S-Curve as expected from developed mathematics. However, in Figure 8-11, the risk is at the highest point at the beginning of the project and showed a value of AED 13,101,500. In other words, in case if the full project's cash flow is spent at the beginning of the project, the risk cost of this risk group only (i.e., Project Selection) will be the possibility of facing danger to lose AED 13,101,500. Therefore, the mathematical model minimizes the cash spent at the start of project construction using increasing cash flow S-Curve.

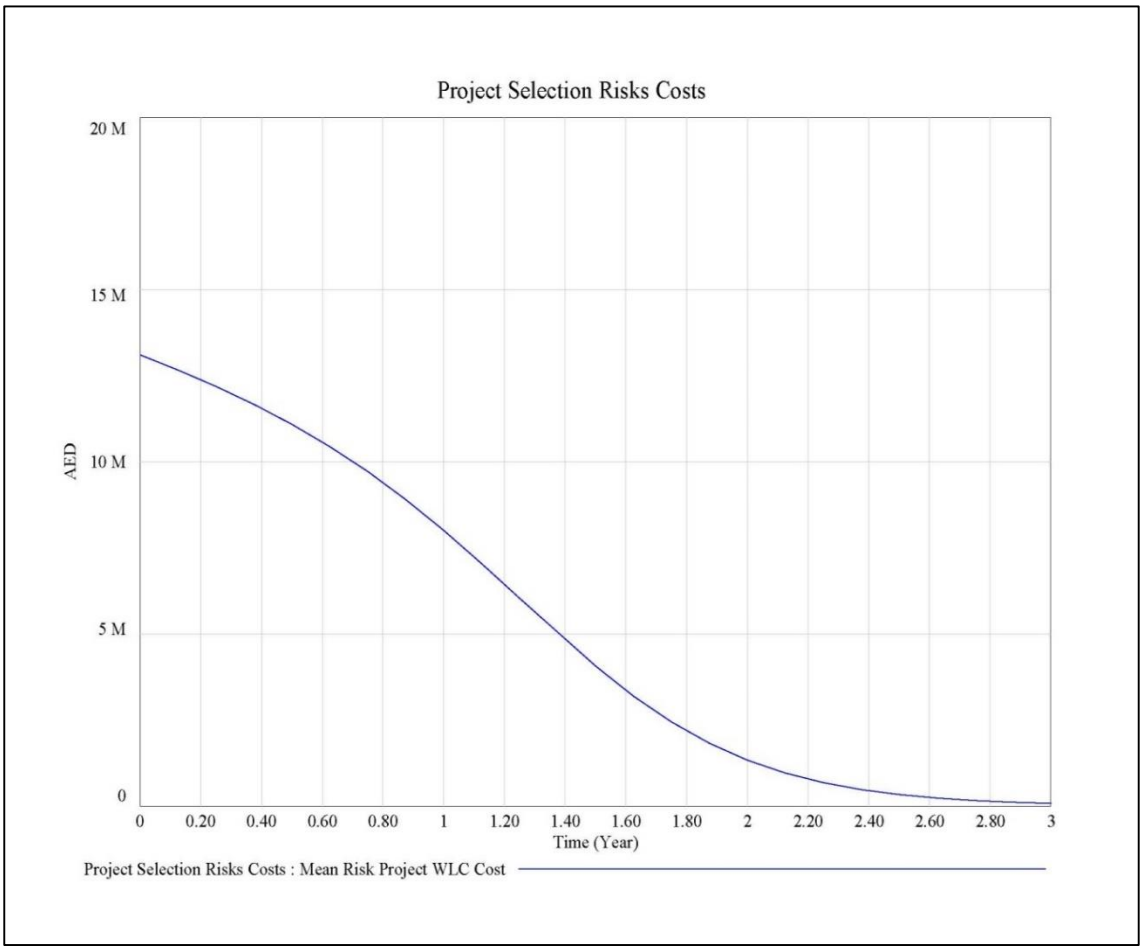


Figure 8-11: It is showing the Risk Cost S-Curve of the "**Project Selection Risks**" using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

H- Project Finance Risks

The Project Finance risk group in this system dynamics modelling validation has provided a decreasing S-Curve as expected from advanced mathematics. However, in Figure 8-12, the risk is at the highest point at the beginning of the project and showed a value of AED 15,171,400. In other words, in case if the full project's cash flow is spent at the beginning of the project, the risk cost of this risk group only (i.e., Project Finance) will be the possibility of facing danger to lose AED 15,171,400. Therefore, the mathematical model minimizes the cash spent at the start of project construction using increasing cash flow S-Curve.

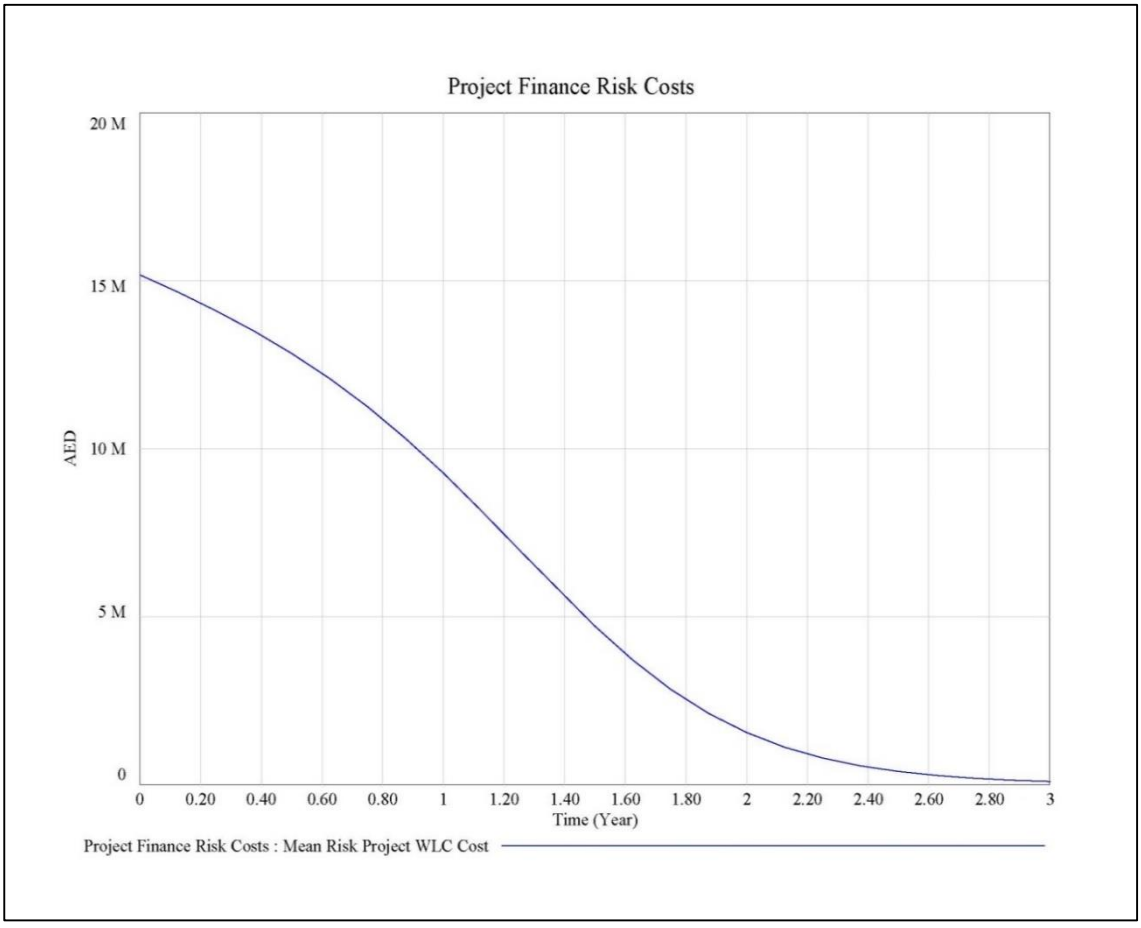


Figure 8-12: It is showing the Risk Cost S-Curve of the "**Project Finance Risks**" using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

I- Building Functionality and Serviceability Risks

The Building Functionality and Serviceability risk group in this system dynamics modelling validation has provided a decreasing S-Curve as expected from advanced mathematics. However, in Figure 8-13, the risk is at the highest point at the beginning of the project and showed a value of AED 10,831,200. In other words, in case if the full project's cash flow is spent at the beginning of the project, the risk cost of this risk group only (i.e., Building Functionality and Serviceability) will be the possibility of facing danger to lose AED 10,831,200. Therefore, the mathematical model minimizes the cash spent at the start of project construction using increasing cash flow S-Curve.

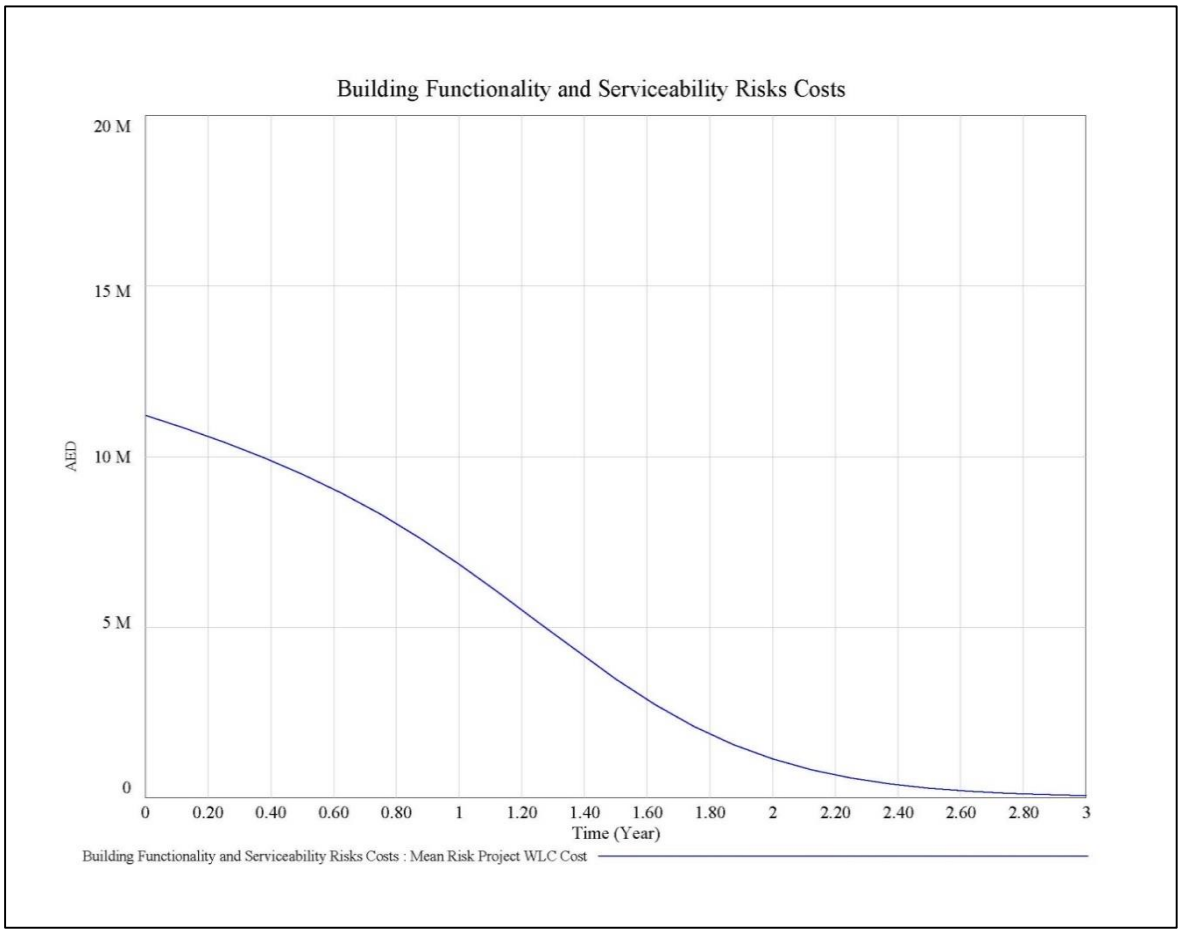


Figure 8-13: It is showing the Risk Cost S-Curve of the "**Building Functionality and Serviceability Risks**" using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

J- Stakeholders Relationship Risks

The Stakeholders Relationship risk group in this system dynamics modelling validation has provided a decreasing S-Curve as expected from advanced mathematics. However, in Figure 8-14, the risk is at the highest point at the beginning of the project and showed a value of AED 8,167,190. In other words, in case if the full project's cash flow is spent at the beginning of the project, the risk cost of this risk group only (i.e., Stakeholders Relationship) will be the possibility of facing danger to lose AED 8,167,190. Therefore, the mathematical model minimizes the cash spent at the start of project construction using increasing cash flow S-Curve.

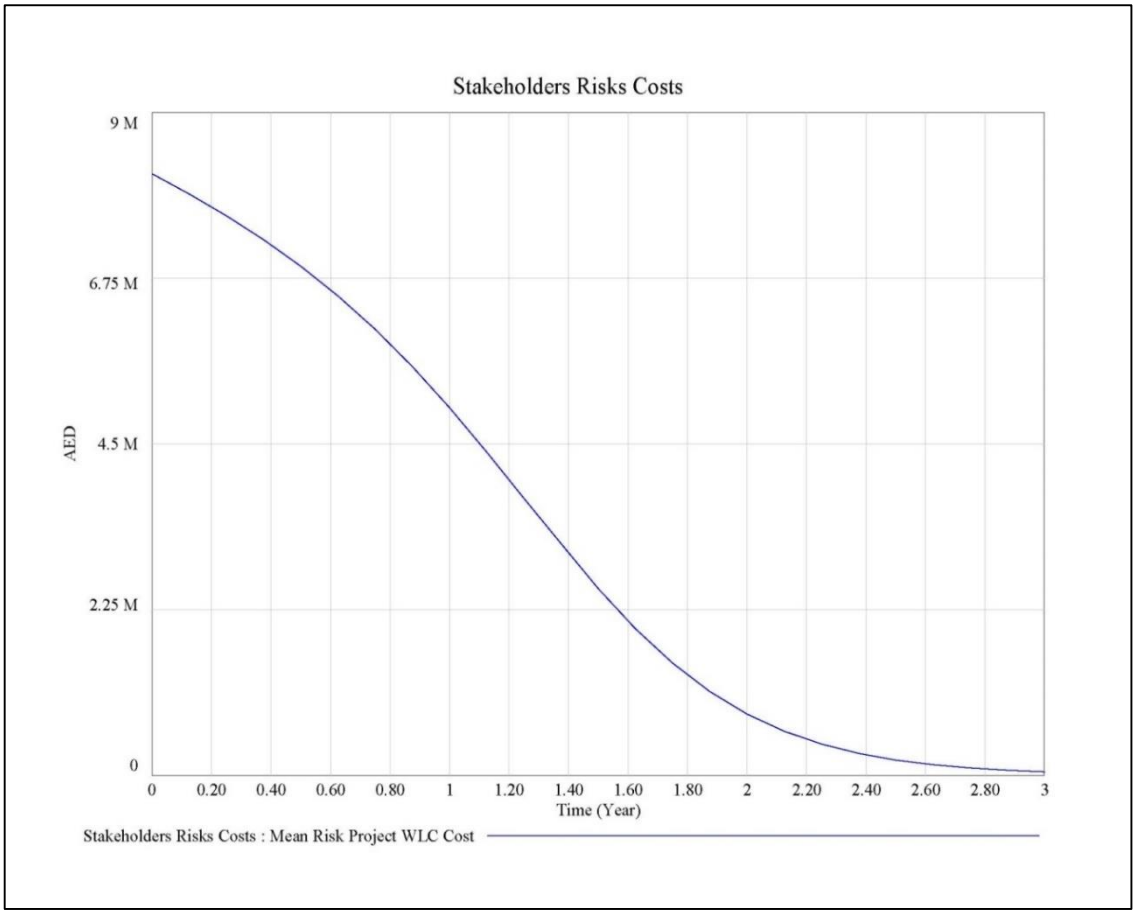


Figure 8-14: It is showing the Risk Cost S-Curve of the "**Stakeholders Relationship Risks**" using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

K- Knowledge Risks

The Knowledge risk group in this system dynamics modelling validation has provided a decreasing S-Curve as expected from developed mathematics. However, in Figure 8-15, the risk is at the highest point at the beginning of the project and showed a value of AED 13,923,800. In other words, in case if the full project's cash flow is spent at the beginning of the project, the risk cost of this risk group only (i.e., Knowledge) will be the possibility of facing danger to lose AED 13,923,800. Therefore, the mathematical model minimizes the cash spent at the start of project construction using increasing cash flow S-Curve.

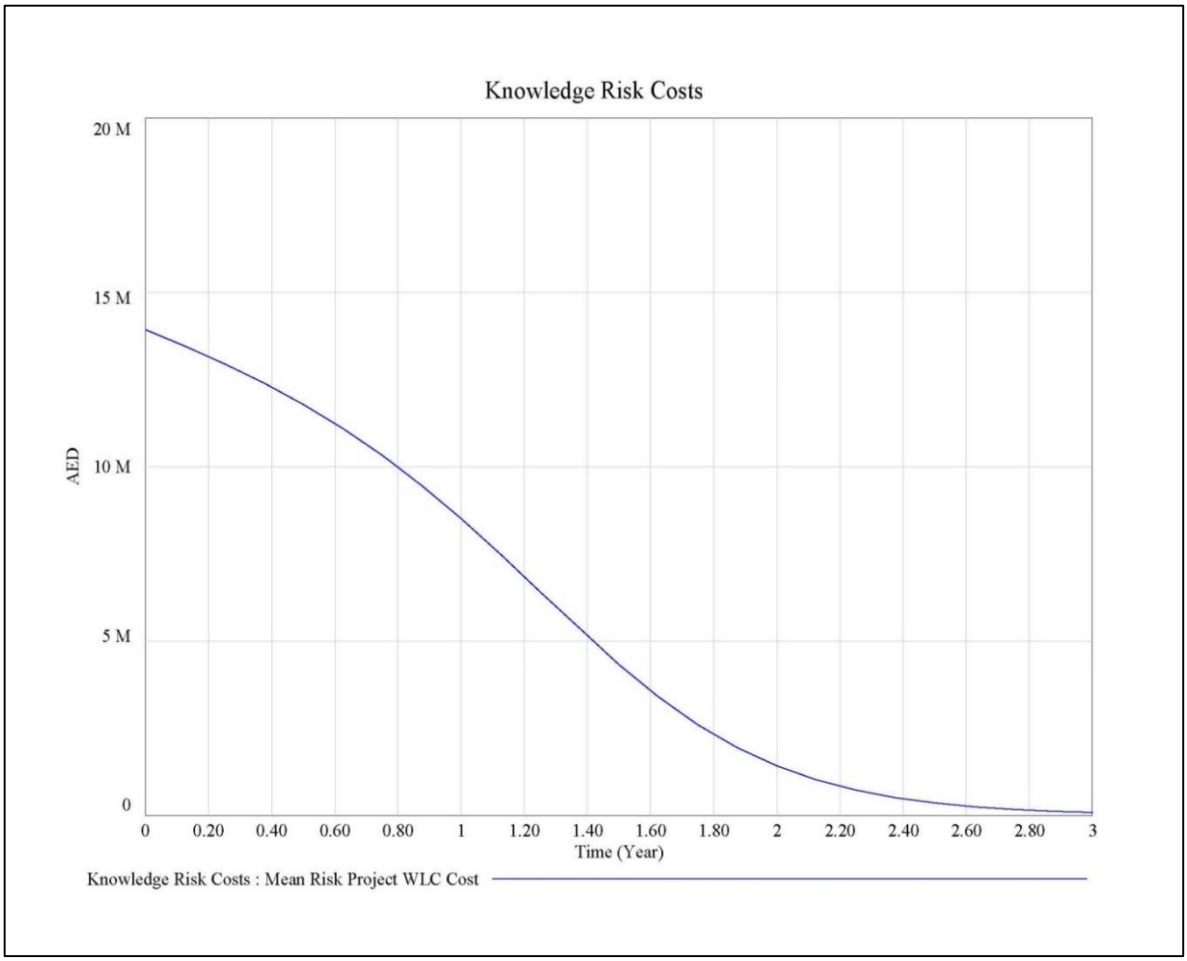


Figure 8-15: It is showing the Risk Cost S-Curve of the "**Knowledge Risks**" using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 3 years of execution time.

8.1.2 OPEX System Dynamics Model Validation

In the OPEX validation process, the system dynamics model is tested against having cost cash flow outputs starting after the project's construction completion (i.e., CAPEX = 3 years). In other words, it should equal zero from time step 0 to 3 years. It is also testing if the model can adapt to adjusting cash flow risks over the 57 years of operations. As a result, the model showed a successful allocation of cumulative cash flows over each time step of the operation period. It could adapt different adjusting risks and provided three curves. The first curve's highest value is equal to AED 13,007,800 for the minimum adjusting risks. The second curve's highest value is equal to AED 58,140,800 for the mean adjusting risks. The third curve's highest value is equal to AED 93,259,900 for maximum adjusting risks, as shown in Figure 8-16. The outputs are based on the DEMO construction cost equal to AED 400 Million.

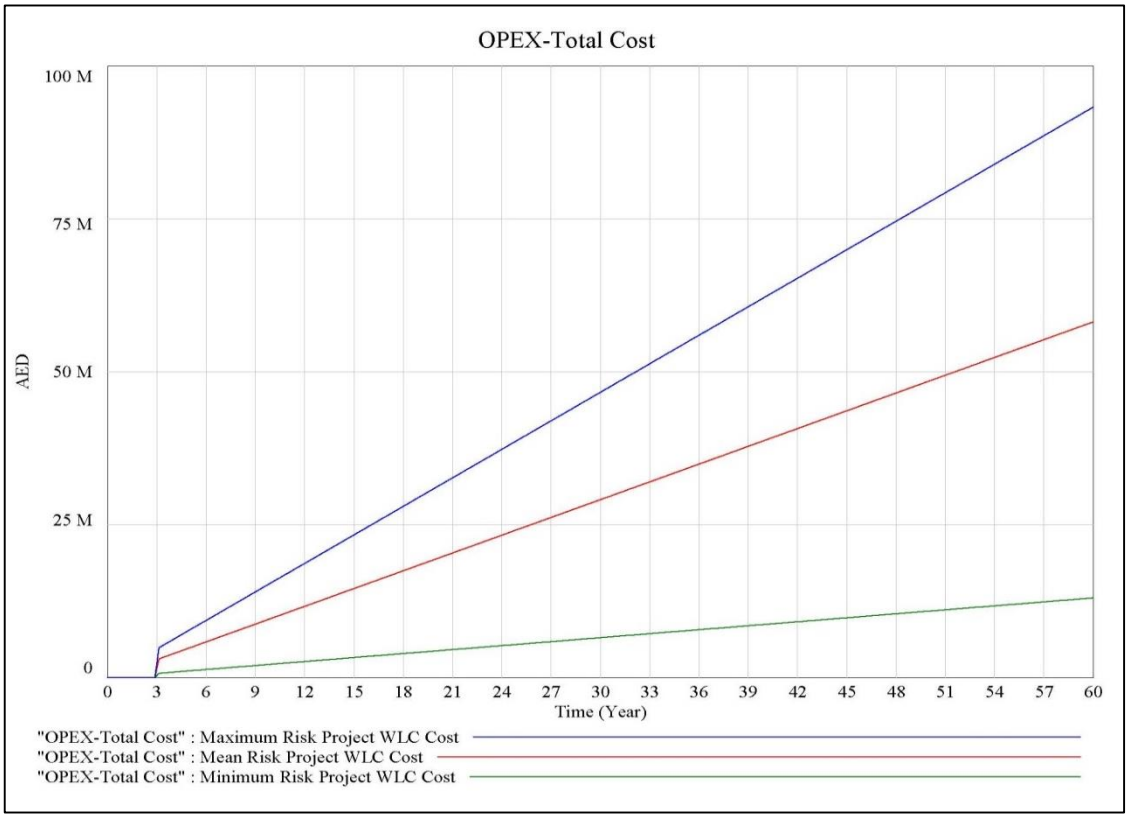


Figure 8-16: It is showing OPEX cost flow at minimum, mean, and maximum adjusting risks using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 57 years operation time.

8.1.3 TOTEX System Dynamics Model Validation

The validation of the final estimated cost system dynamics model (i.e., TOTEX) is investigating the model's functionality to integrate mathematically and graphically the final costs of capital expenditure based on increasing S-Curve from 0 to 3 years. Moreover, based on operational expenditures, linear relationship from 3 to 60 years. Moreover, based on equipment replacement, pulse costs impact every 25 years over the project's lifecycle. However, it is also investigating if the model will operate successfully while adapting three different adjusting risks simultaneously. The project's full lifecycle model results are equal to AED 533,180,000 for minimum adjusting risks, AED 578,957,000 for mean adjusting risks, and AED 614,721,000 for maximum adjusting risks, as shown in Figure 8-17. This is for project construction contract DEMO value equal to AED 400 million. Finally, a comparison between CAPEX and OPEX is made in Figure 8-18.

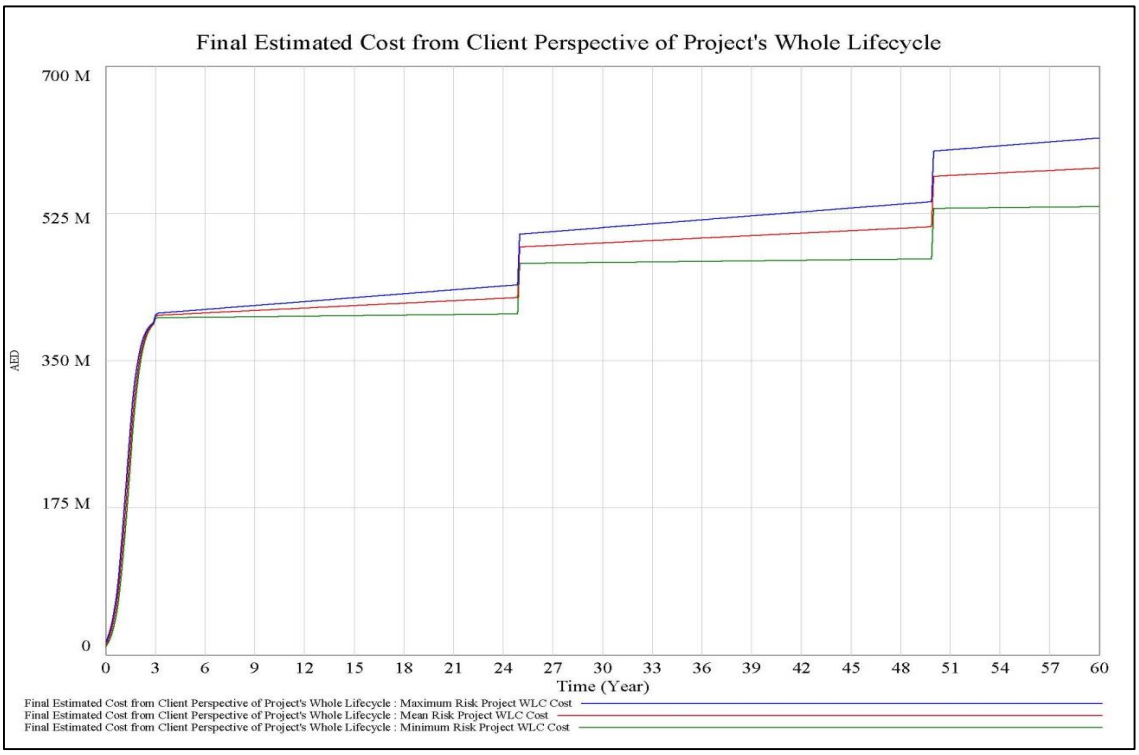


Figure 8-17: It is showing TOTEX cost flow at minimum, mean, and maximum adjusting risks using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 60 years projects whole lifecycle.

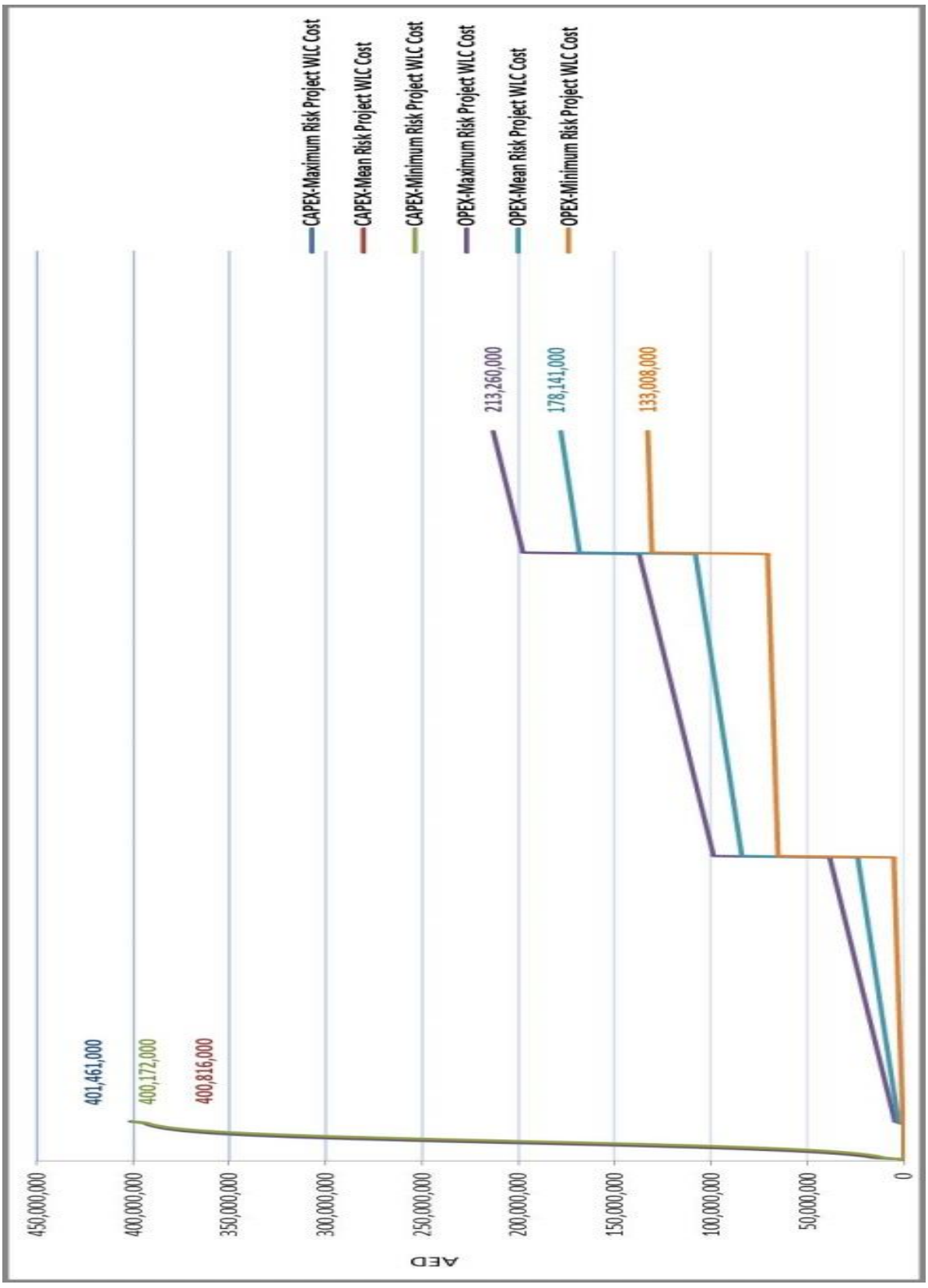


Figure 8-18: It is showing the comparison between adjusted OPEX and adjusted CAPEX Cash Flow S-Curve including equipment replacement cost, minimum adjusting risks, mean adjusting risks, and maximum adjusting risks using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 60 years projects whole lifecycle.

8.1.4 Net Present Value System Dynamics Model Validation

The net present value validation is divided into two stages. First, validating the net present value of OPEX modelled costs over the 57 years of operations (i.e., 3 to 60 years cash flow). This will be by providing, numerically, NPV detailed schedule for each time step and graphically as shown in Figure 8-19a. However, the resulted OPEX NPV is equal to AED 3,414,970 for minimum adjusting risks. Moreover, it is equal to AED 15,263,800 for mean adjusting risks. Moreover, it is equal to 24,483,700 for maximum adjusting risks. Therefore, the model simulated costs dynamics successfully and used the UAE EIBOR-Central Bank discount rate for calculating the accurate NPV, as explained previously in chapter 4.

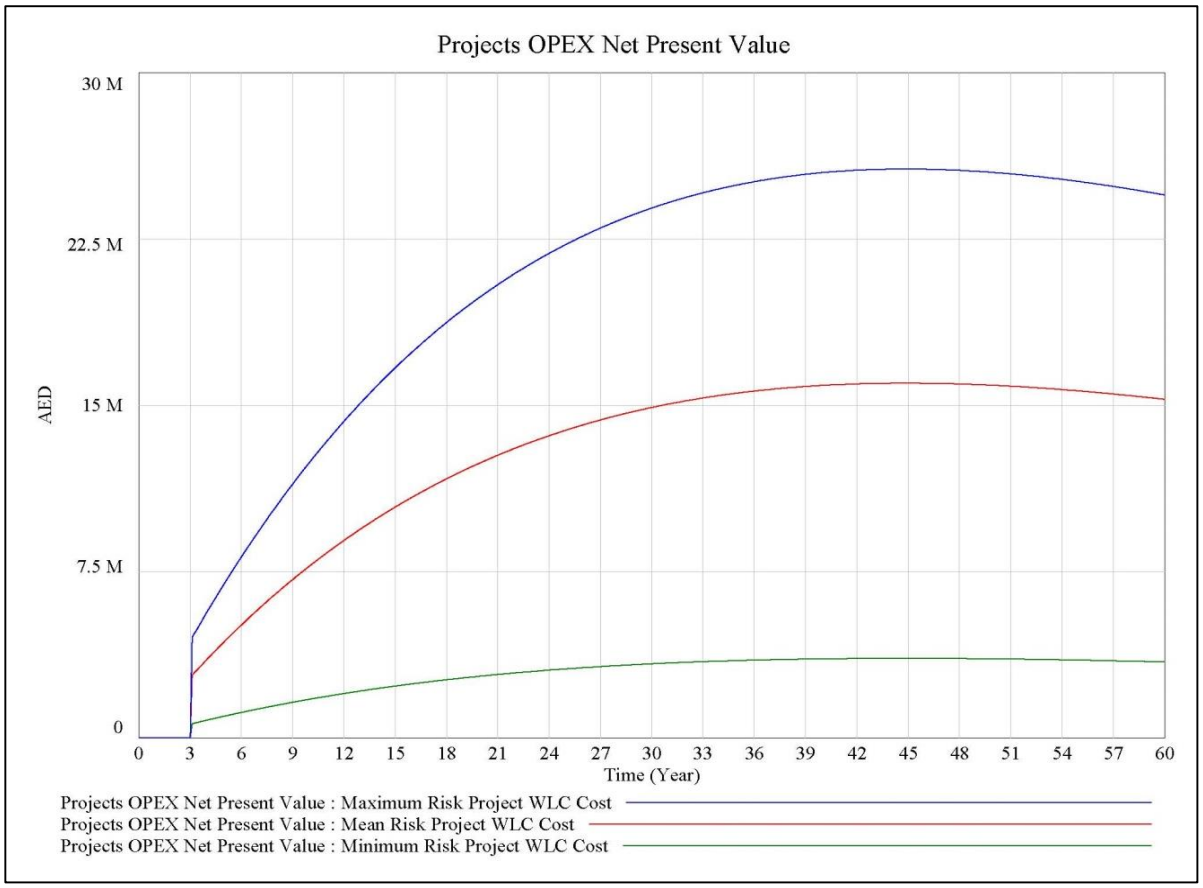


Figure 8-19a: It is showing OPEX NPV cost curve at the minimum, mean, and maximum adjusting risks using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 57 years operation time.

Second, calculating the project's whole lifecycle costs, NPV is about investigating if the model can adapt the net present value calculations, including the S-Curve equations and operation linear equations. Also, it should concurrently adapt the pulse impact lockup table equations. However, the project's whole lifecycle NPV was found equal to AED 435,091,000 for minimum adjusting risks. Furthermore, equal to AED 447,584,000 for mean adjusting risks. Moreover, equal to AED 457,448,000 for maximum adjusting risks. Therefore, NPV provided successfully numerical values for each time step and graphical charts shown in Figure 8-19b.

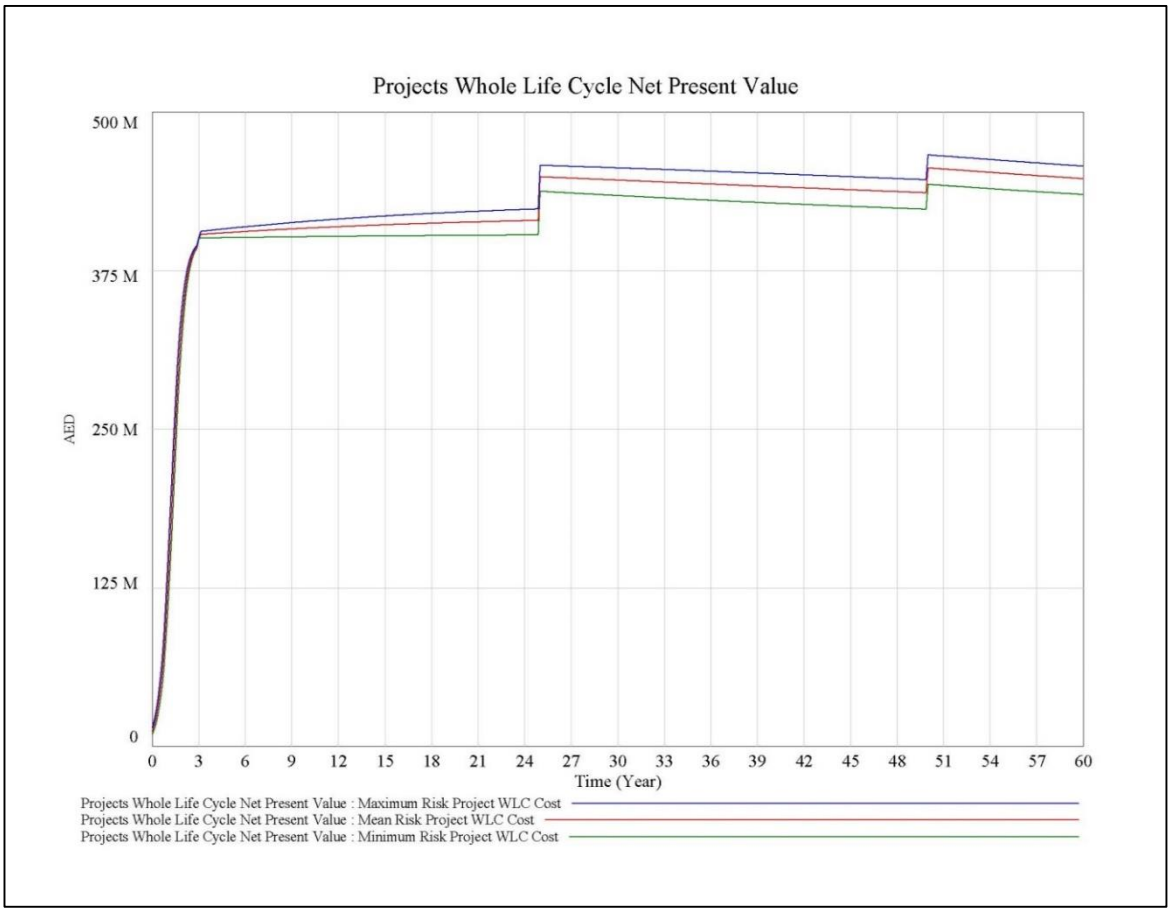


Figure 8-19b: It is showing the adjusted OPEX and CAPEX NPV Flow Curves including equipment replacement cost, minimum adjusting risks, mean adjusting risks, and maximum adjusting risks using the validation DEMO project cost. DEMO cost is assigned equal to AED 400 million over 60 years projects whole lifecycle.

8.1.5 Final Residential Project's Whole Lifecycle Cost Estimation Model

After validating each part of the system dynamics VENSIM model, the final simulation results are conducted to clarify how all parts interact with each other, as shown in Figures 8-20, 8-21, and 8-22. In Figure 8-20, the simulation is done only for the CAPEX lifecycle (i.e., 0 to 3 years only). Therefore, OPEX simulation will not reflect any acceptable curve outputs because the OPEX implementation lifecycle starts from 3 to 60 years.

In other words, the CAPEX curves in Figure 8-20 (i.e., 3 years simulation period) will be clearer than the same curves in Figure 8-22 (i.e., 60 years simulation period). So, putting Figure 8-20 and 8-22 shows the CAPEX outputs deference (i.e., like the difference between Figures 8-2 and 8-3). Nevertheless, it is necessary to change the period from 3 to 60 years in Figure 8-21.

For example, OPEX curves in Figure 8-20 are equal to zero, and the final cost estimation modelling is only reflecting CAPEX costs. Figure 8-21 shows how OPEX costs are reflected in three curves representing the minimum, mean, and maximum adjusting risks after including the operation stage (i.e., 3 to 60). The results will be captured using a simulation period equal to 60 years for the model shown in Figure 8-20, as shown in Figure 8-22.

Finally, by presenting Figures 8-20, 8-21, and 8-22, the validation process is fully completed, and the Final System dynamics Model for Residential Projects' Whole Lifecycle Cost Estimation is ready to move to the next stage (i.e., verification). In this research study's verification stage, the researcher will use real completed projects with costs between AED 500 million to AED 5 billion. Then, the system dynamics model accuracy will be checked at the end of this chapter by calculating the error found between the project model's outputs and project real-life actual data.

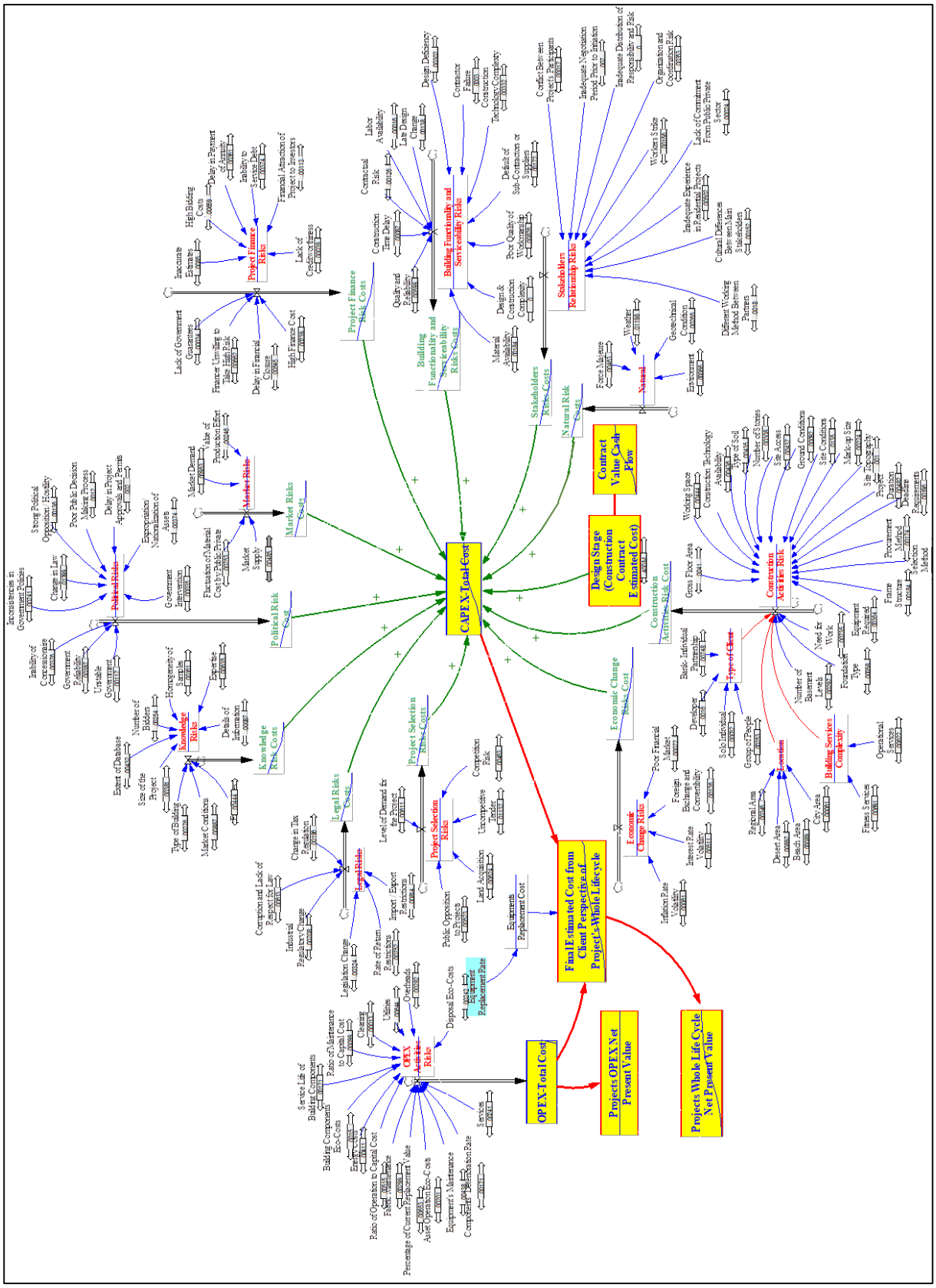


Figure 8-20: Final model validation simulation using the DEMO project cost. DEMO cost is assigned equal to AED 400 million over a simulation period equal to 3 years.

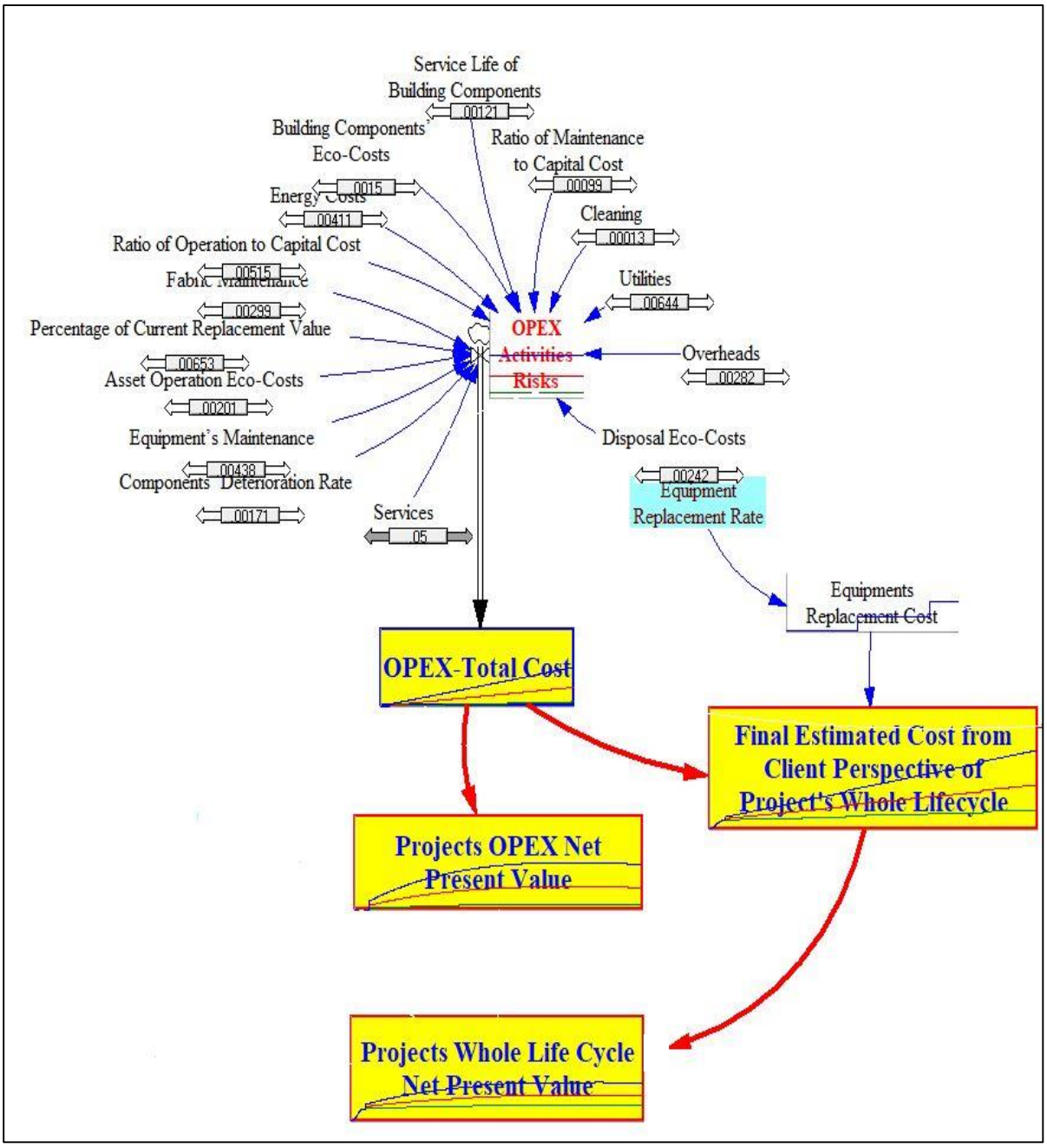


Figure 8-21: It is showing a bigger snapshot of OPEX and final estimated cost besides their impact on the NPV when assigning in the contract value as AED 400 million and change the project period from 3 years to 60 years.

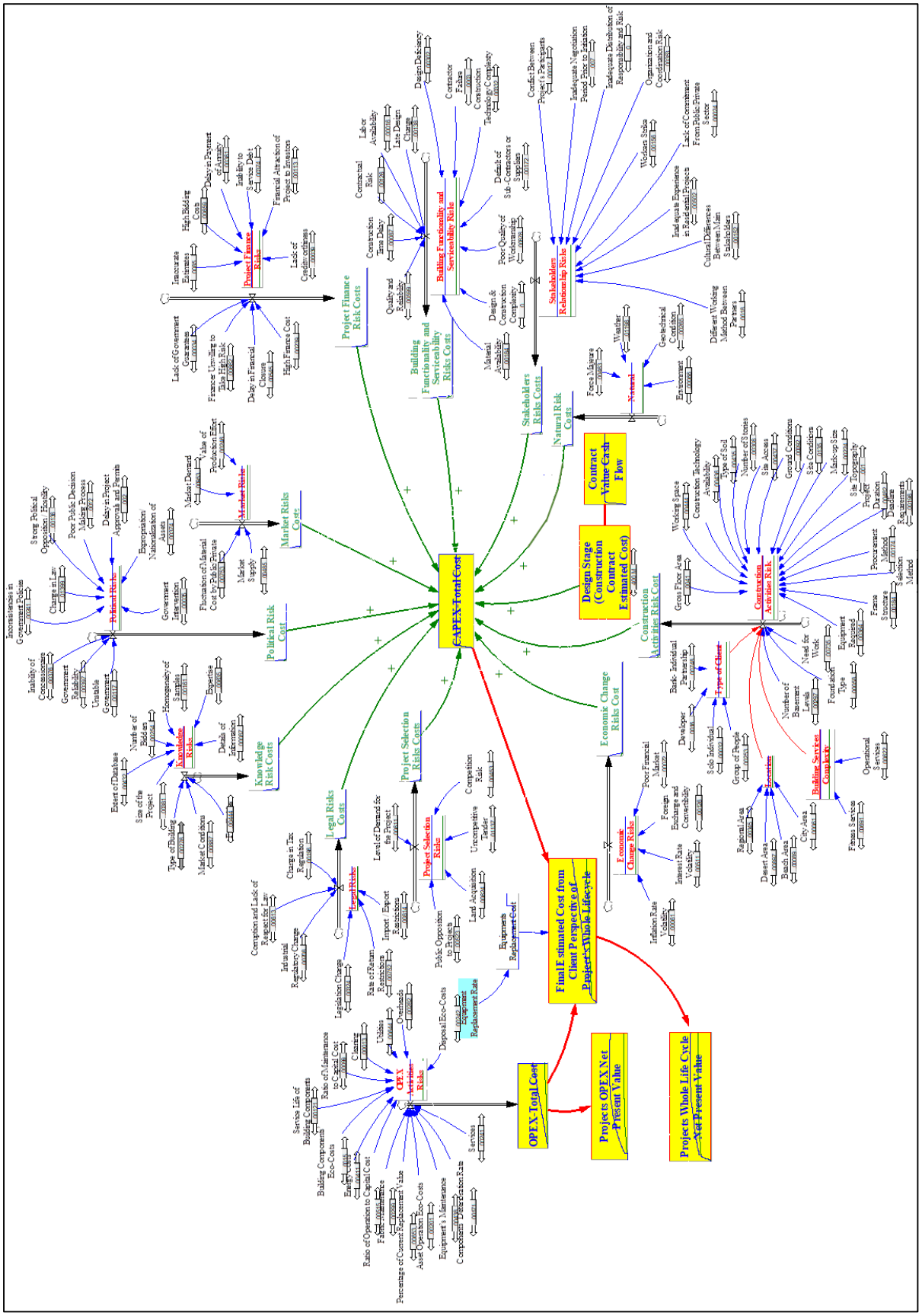


Figure 8-22: Final model validation simulation using the DEMO project cost. DEMO cost is assigned equal to AED 400 million over 60 years projects whole lifecycle.

8.2 System Dynamics Model Verification

After validating the system dynamics model, the verification process using actual projects data cash flow will be conducted to check its trustworthiness and applicability on real-world applications. Therefore, the verification process will be focusing on the most critical calculations. So, since OPEX and equipment change in the model is considered as functions of CAPEX (i.e., F(X), X=CAPEX)). Therefore, the CAPEX verification will be considered a verification of CAPEX, OPEX, and Equipment replacement. On the other hand, the project's whole lifecycle system dynamics model is built to cover 60 years lifecycle while the United Arab Emirates is less than 50 years old. Therefore, the accuracy of OPEX cannot be done using real data. However, OPEX verification will be considered done based on its validation and CAPEX validation and verification. This is because OPEX mathematics is based on functions of CAPEX. Next, in this part of the chapter, the verification process will be using the actual cash flow of 3 real housing projects completed in 2016, 2017, and 2019 as inputs of the developed and validated model. The researcher will then compare the model's outputs with the actual data to check its performance and accuracy. For project 1, a megaproject costing more than AED 4 billion (i.e., more than USD 1 billion) is executed over 3 years (completed in DEC 2016). For project 2, it is a large project and cost between AED 750 - 800 million (i.e., between USD 200 – 250 million) and it is executed over three years (completed in MAR 2019). For project 3, it is a large project and cost between AED 650 - 700 million (i.e., between USD 170 – 200 million) and it is executed over 3 years (completed in MAR 2017).

Finally, the details of projects' cash flow values and percentages following this research system dynamics model time steps (i.e., 0.125 years) is summarised in table 8-1 and 8-2.

Time (Year)	Estimated VENSIM Cash Flow Zero Risks	Estimated VENSIM Cash Flow Maximum Risks	Estimated VENSIM Cash Flow Mean Risks	Estimated VENSIM Cash Flow Minimum Risks	Actual Project Paid Cash Flow for Residential Housing Project 3	Actual Project Paid Cash Flow for Residential Housing Project 2	Actual Project Paid Cash Flow for Residential Housing Project 1	Deference Residential Housing Project 3 (Mean-Actual)	Deference Residential Housing Project 2 (Mean-Actual)	Deference Residential Housing Project 1 (Mean-Actual)
0	2.23%	2.24%	2.24%	2.23%	0.10%	3.00%	0.00%	2.14%	-0.76%	2.24%
0.125	3.10%	3.11%	3.11%	3.10%	0.10%	4.42%	3.51%	3.01%	-1.31%	-0.40%
0.25	4.29%	4.31%	4.30%	4.29%	2.87%	5.05%	5.72%	1.43%	-0.75%	-1.42%
0.375	5.91%	5.93%	5.92%	5.91%	4.35%	5.95%	8.21%	1.58%	-0.03%	-2.29%
0.5	8.09%	8.12%	8.11%	8.09%	6.34%	7.15%	10.28%	1.77%	0.96%	-2.17%
0.625	10.98%	11.02%	11.01%	10.99%	8.86%	9.25%	12.79%	2.15%	1.76%	-1.78%
0.75	14.74%	14.80%	14.77%	14.75%	12.23%	12.52%	16.58%	2.54%	2.25%	-1.81%
0.875	19.51%	19.58%	19.55%	19.51%	15.91%	17.76%	18.43%	3.64%	1.79%	1.12%
1	25.35%	25.44%	25.40%	25.36%	20.22%	28.51%	19.35%	5.18%	-3.11%	6.05%
1.125	32.25%	32.36%	32.31%	32.26%	34.51%	34.70%	20.76%	-2.20%	-2.39%	11.55%
1.25	40.01%	40.16%	40.09%	40.03%	39.14%	39.98%	35.39%	0.96%	0.11%	4.70%
1.375	48.31%	48.49%	48.41%	48.33%	44.04%	46.73%	42.52%	4.37%	1.68%	5.89%
1.5	56.71%	56.92%	56.82%	56.73%	49.08%	52.35%	55.25%	7.75%	4.47%	1.57%
1.625	64.74%	64.97%	64.87%	64.76%	55.56%	64.91%	75.56%	9.31%	-0.04%	-10.69%
1.75	72.01%	72.27%	72.16%	72.04%	61.83%	71.09%	82.72%	10.33%	1.06%	-10.56%
1.875	78.29%	78.57%	78.45%	78.32%	68.00%	77.28%	84.49%	10.45%	1.17%	-6.04%
2	83.48%	83.78%	83.65%	83.52%	72.36%	83.46%	89.76%	11.29%	0.19%	-6.11%
2.125	87.63%	87.95%	87.80%	87.66%	77.09%	86.00%	90.75%	10.72%	1.80%	-2.95%
2.25	90.85%	91.18%	91.03%	90.89%	80.33%	88.00%	91.44%	10.71%	3.03%	-0.41%
2.375	93.29%	93.63%	93.48%	93.33%	81.91%	88.50%	92.73%	11.57%	4.98%	0.75%
2.5	95.12%	95.47%	95.31%	95.16%	85.67%	89.65%	93.72%	9.64%	5.67%	1.59%
2.625	96.47%	96.82%	96.67%	96.51%	87.55%	95.83%	94.34%	9.12%	0.83%	2.33%
2.75	97.45%	97.81%	97.65%	97.50%	88.03%	97.00%	95.70%	9.62%	0.65%	1.95%
2.875	98.17%	98.53%	98.37%	98.21%	93.10%	101.00%	97.72%	5.27%	-2.63%	0.65%
3	100.00%	100.37%	100.20%	100.04%	100.097%	103.00%	100.00%	0.11%	-2.80%	0.20%

Table 8-1: It is detailing the verification data percentages including the model adjusting risks (i.e., minimum, mean, and maximum) by presenting all three verification projects and highlight the differences in cash flow between the mean adjusting risks percentages and each project cash flow percentage.

Saving Cash | Over Cash

Cost Description		Contract Value	Finish Cost
Actual Cost-Residential Housing Project 1		100%	100%
Actual Cost-Residential Housing Project 2		100%	103.262%
Actual Cost-Residential Housing Project 3		100%	100.097%
VENSIM Estimated Cost	Minimum Risk	100%	100.043%
	Mean Risk		100.204%
	Maximum Risk		100.365%

Table 8-2: it is showing model vs. actual cost summary including the percentages of costs at completion compared with contract value. (contract value is considered 100%).

Table 8-2 summarizes the results of verification modelling using the projects' actual contract value compared with the actually completed cost of each project. Based on these facts, the project's model outputs will be presented in detail, including comparing actual and modelling outputs. Also, this research is providing an analytical discussion for each project and its model performance. However, each project model will have six main graphical outputs as the following:

1- CAPEX Total Cost Cash Flow S-Curve in 3 years.

2- CAPEX Total Cost Cash Flow S-Curve in 60 years.

3- OPEX Total Cost Plot for over 60 years.

4- Final Estimated Cost from Client Perspective of Project's Whole Life Cycle.

5- Project's OPEX Net Present Value.

6- Project's Whole Life Cycle Net Present Value.

The comparison plotted graph between the Model's Cash Flow S-Curve and the actual Cash Flow S-Curve will be presented for a better understanding during the discussion.

8.2.1 Project 1

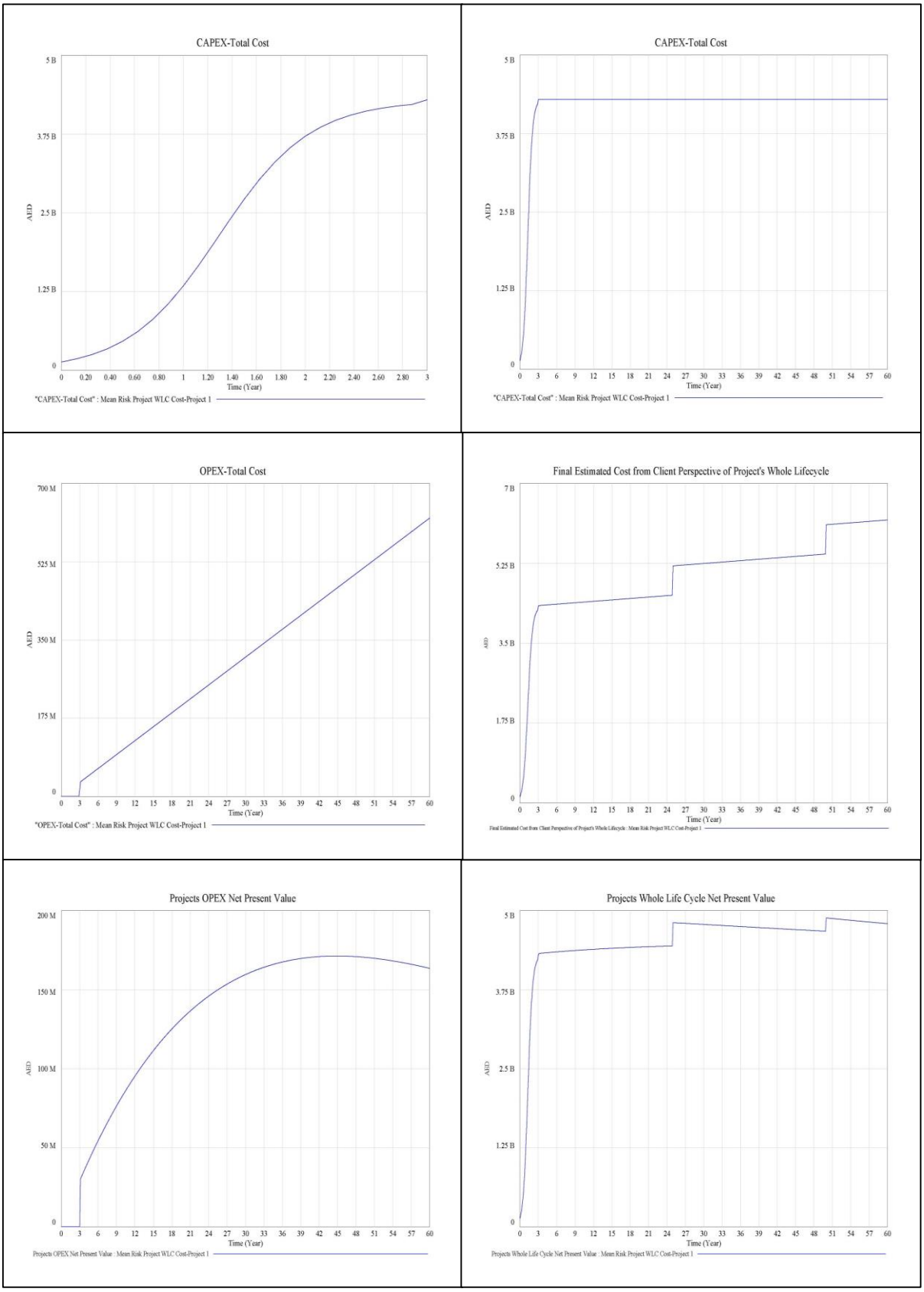


Figure 8-23: VENSIM System dynamics modelling results for Project 1 costs including CAPEX, OPEX, Total Estimated Costs, OPEX NPV, and Projects Whole Life Cycle NPV.

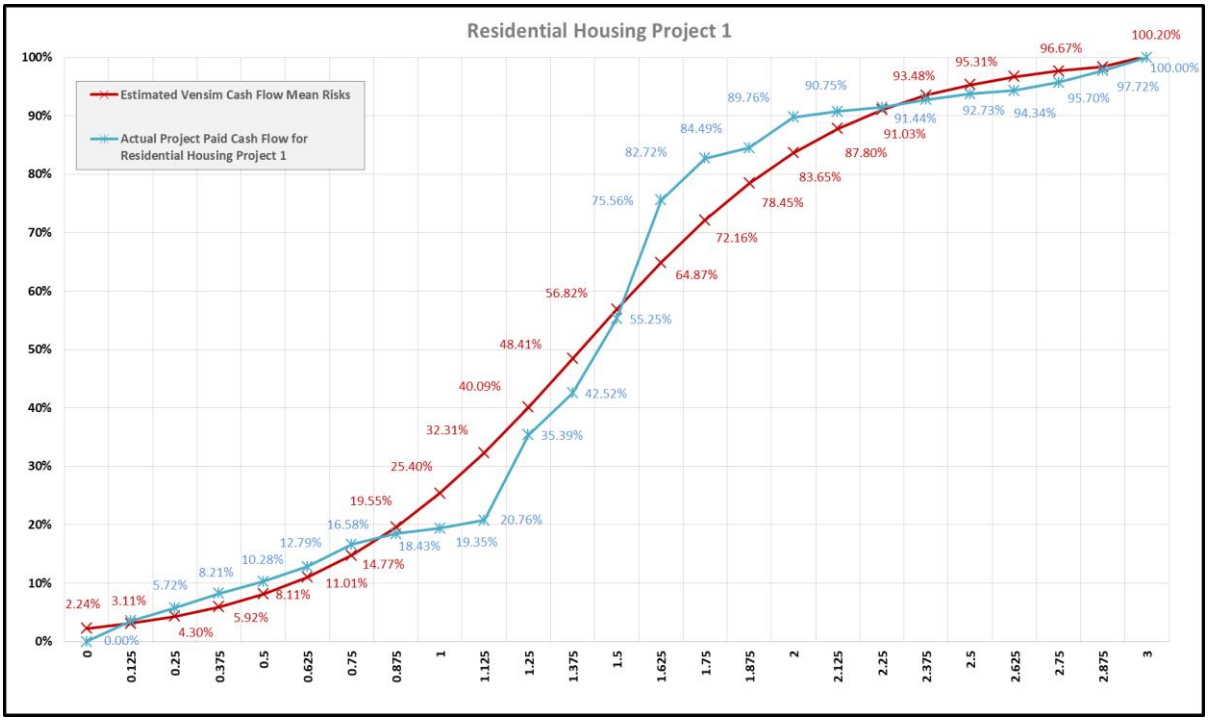


Figure 8-24: comparing project 1 model vs. actual cost cash flow in percentage during CAPEX stage.

Figure 8-23 and 2-24 related to project 1, the construction cash flow S-Curve model acts as a centre line of the actual cash flow curve. However, this project is considered a mega project (i.e., above USD 1 billion) and found its actual costs fluctuation around the modelled S-Curve. So, to study these cash flow trends, it was found that cash flow is deviating with about a range of ±10%. Nevertheless, it has been observed that the actual S-Curve is trending almost like a straight line at the beginning of the project. According to researchers, construction cost s-curve should relate to project's progress based on activities milestones and indirect overheads costs as shown in Figure 8-24a (Wang, Wang, et al. 2016; Koo, Hong & Hyun 2011). The activities from A1 to A5 represent a demonstration of discussion from literature to interpret cost results in Figure 8-24 (Wang, Wang, et al. 2016). The dummy activity shown in Figure 8-24a is the indirect costs included in CAPEX S-Curve (Wang, Wang, et al. 2016).

This means that the execution of project construction faced issues in completing overlapped tasks after the project's start from time step 0.875 to time step 1.5. This caused an

overflow of cash flow from time step 1.5 to time step 2.25 to compensate for the lower progress with more required activities. On the other hand, the delay in the start of the project caused an over cash flow, which will be a problem for the client in case if the fund is not available to pay for the approved and accepted progress, which may delay the project and make a cost issue ending with cash bleeding and unnecessary overcasts at the end of the project.

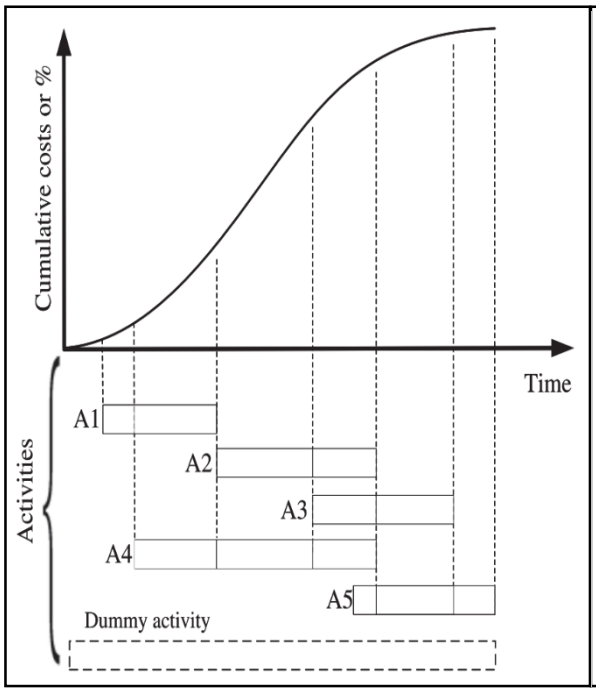


Figure 8-24a: Example of analysing progress vs. cost cash flow in percentage during construction stage (Wang, Wang et al. 2016).

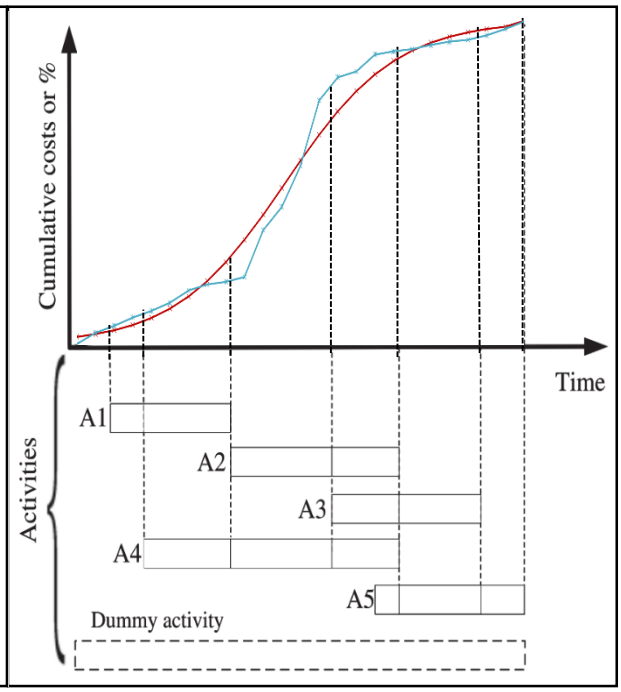


Figure 8-24b: adapted chart for progress vs. modelled and actual cost cash flow in percentage during CAPEX stage for project 1 (Wang, Wang et al. 2016).

Finally, this can be summarized in Table 8-3. Moreover, the risk of having fluctuating cash flows during mega projects can reach ±10%. Therefore, clients should cover themselves at the pre-construction stage by planning extra funds to include financing the difference between savings cash flows and over cash flows. It is required to avoid delay and failure in delivering the project (Teerajetgul, Chareonngam & Wethyavivorn 2009).

Time (Year)	Estimated VENSIM Cash Flow Zero Risks	Estimated VENSIM Cash Flow Maximum Risks	Estimated VENSIM Cash Flow Mean Risks	Estimated VENSIM Cash Flow Minimum Risks	Actual Project Paid Cash Flow for Residential Housing Project 1	Deference Residential Housing Project 1 (Mean-Actual)
0.00	95,579,391.53	95,928,495.26	95,774,373.49	95,620,490.67	0.00	95,774,373.49
0.13	132,759,551.61	133,244,455.87	133,030,381.10	132,816,638.22	150,350,499.00	-17,320,117.90
0.25	183,768,062.09	184,439,274.94	184,142,948.94	183,847,082.36	245,015,628.00	-60,872,679.06
0.38	253,179,494.23	254,104,232.34	253,695,980.40	253,288,361.42	351,674,529.00	-97,978,548.60
0.50	346,592,027.68	347,857,955.06	347,299,075.42	346,741,062.25	440,342,772.00	-93,043,696.58
0.63	470,446,803.36	472,165,110.31	471,406,514.84	470,649,095.49	547,858,371.00	-76,451,856.16
0.75	631,462,076.95	633,768,492.18	632,750,259.58	631,733,605.64	710,202,642.00	-77,452,382.42
0.88	835,511,018.54	838,562,722.53	837,215,461.01	835,870,288.27	789,447,207.00	47,768,254.01
1.00	1,085,890,487.31	1,089,856,702.32	1,088,105,703.91	1,086,357,420.22	828,855,315.00	259,250,388.91
1.13	1,381,244,353.39	1,386,289,348.39	1,384,062,091.87	1,381,838,288.46	889,252,524.00	494,809,567.87
1.25	1,713,874,170.85	1,720,134,096.26	1,717,370,474.16	1,714,611,136.75	1,515,927,111.00	201,443,363.16
1.38	2,069,488,539.04	2,077,047,345.93	2,073,710,295.66	2,070,378,419.11	1,821,339,948.00	252,370,347.66
1.50	2,429,136,787.49	2,438,009,209.61	2,434,092,226.54	2,430,181,316.31	2,366,628,225.00	67,464,001.54
1.63	2,773,004,238.82	2,783,132,636.80	2,778,661,167.47	2,774,196,630.65	3,236,605,044.00	-457,943,876.53
1.75	3,084,577,673.46	3,095,844,093.42	3,090,870,211.92	3,085,904,041.86	3,543,397,675.00	-452,527,463.08
1.88	3,353,437,367.52	3,365,685,797.50	3,360,278,379.75	3,354,879,345.58	3,619,120,701.00	-258,842,321.25
2.00	3,575,836,590.59	3,588,897,333.73	3,583,131,297.23	3,577,374,200.32	3,844,860,624.00	-261,729,326.77
2.13	3,753,460,115.41	3,767,169,628.48	3,761,117,174.04	3,755,074,103.26	3,887,267,175.00	-126,150,000.96
2.25	3,891,388,293.77	3,905,601,589.51	3,899,326,725.89	3,893,061,590.74	3,916,823,256.00	-17,496,530.11
2.38	3,996,171,312.31	4,010,767,328.02	4,004,323,501.78	3,997,889,665.97	3,972,080,277.00	32,243,224.78
2.50	4,074,456,874.53	4,089,338,828.27	4,082,768,766.56	4,076,208,890.99	4,014,486,828.00	68,281,938.56
2.63	4,132,219,452.44	4,147,312,383.99	4,140,649,180.13	4,133,996,306.81	4,041,044,466.00	99,604,714.13
2.75	4,174,447,544.77	4,189,694,714.43	4,182,963,417.76	4,176,242,557.21	4,099,299,930.00	83,663,487.76
2.88	4,205,111,005.01	4,220,470,172.96	4,213,689,431.46	4,206,919,202.74	4,185,826,428.00	27,863,003.46
3.00	4,283,490,000.00	4,299,135,447.23	4,292,228,319.60	4,285,331,900.70	4,283,490,000.00	8,738,319.60

Table 8-3: It is detailing the verification data percentages including the model adjusting risks (i.e., minimum, mean, and maximum) while presenting verification project 1 and highlight the differences in cash flow between the mean adjusting risks percentages and project 1 cash flow percentage. Colour legend is shown below.

Saving Cash | Over Cash

8.2.2 Project 2

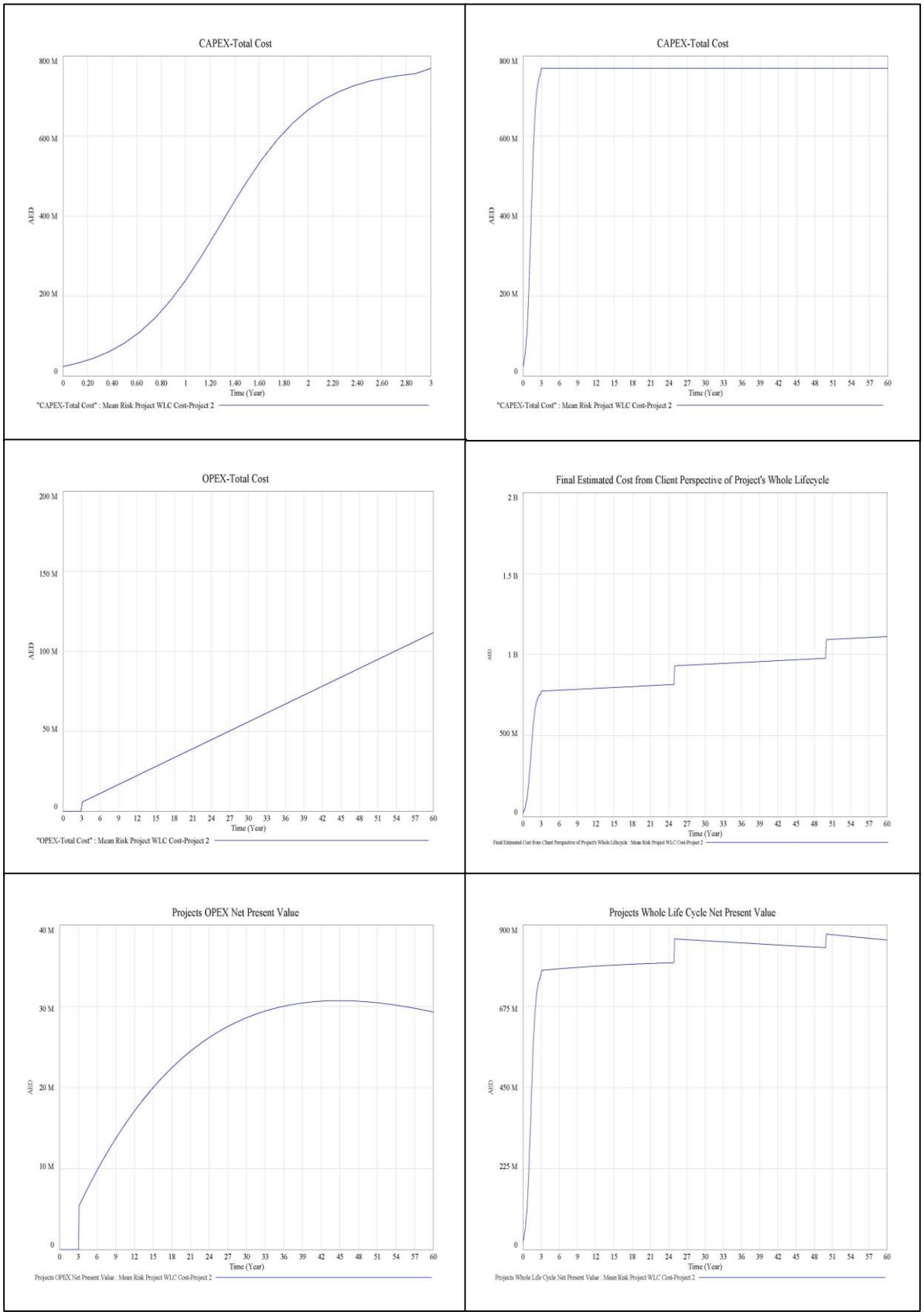


Figure 8-25: VENSIM System dynamics modelling results for Project 2 costs including CAPEX, OPEX, Total Estimated Costs, OPEX NPV, and Projects Whole Life Cycle NPV.

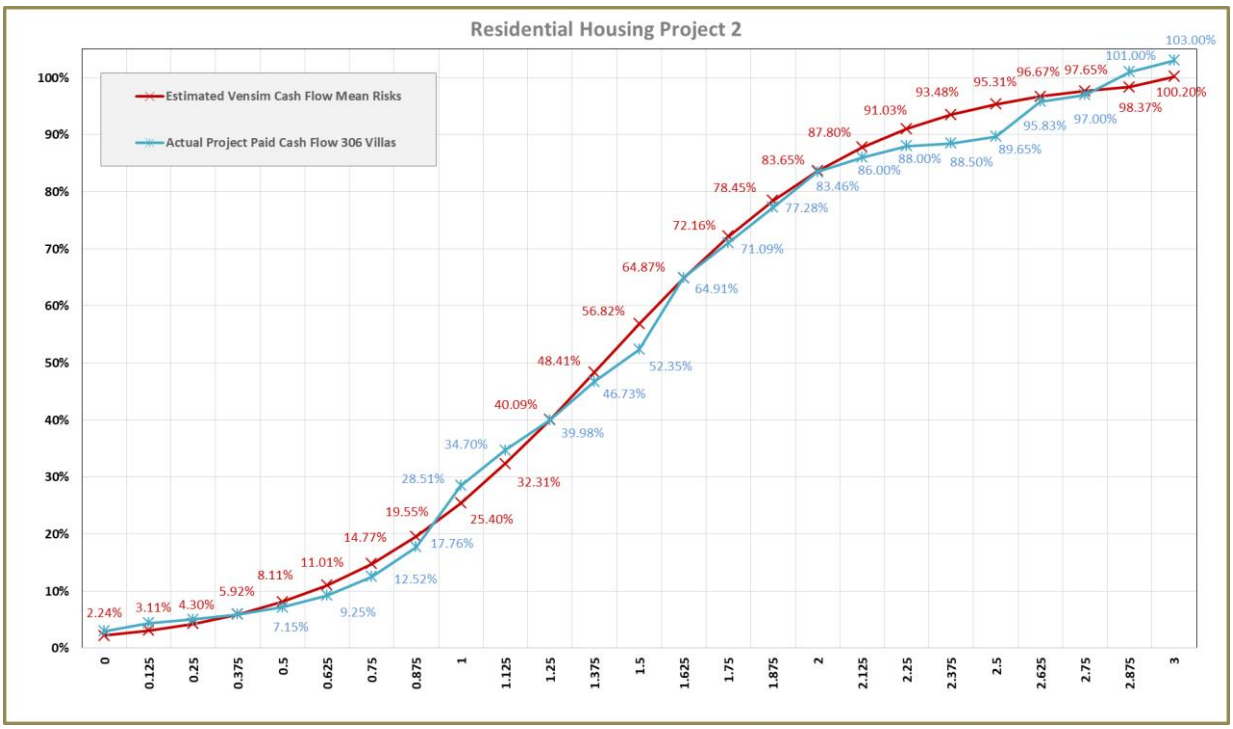


Figure 8-26: comparing project 2 model vs. actual cost cash flow in percentage during CAPEX stage.

Figures 8-25 and 2-26 relate to project 2, the construction cash flow S-Curve model acts as a centre line of the actual cash flow curve. However, this project is considered a large project (i.e., between USD 200 – 250 million) and found its actual costs fluctuation around the modelled S-Curve. So, to study these cash flow trends, it was found that cash flow is deviating with about a range of ±3%. Nevertheless, it has been observed that the actual S-Curve is trending almost like a straight line at the beginning of the project. According to researchers, construction cost s-curve should relate to project's progress based on activities milestones and indirect overheads costs as shown in Figure 8-26a (Wang, Wang, et al. 2016; Koo, Hong & Hyun 2011). The activities from A1 to A5 represent a demonstration of discussion from literature to interpret cost results in Figure 8-26a (Wang, Wang, et al. 2016). The dummy activity shown in Figure 8-26a is the indirect costs included in CAPEX S-Curve (Wang, Wang, et al. 2016). This means that the execution of project construction faced issues in completing overlapped tasks after the project's start from time step 0.5 to time step 0.875, from time step

1.25 to time step 1.675, and from time 2 to time step 2.75. On the other hand, the delay in the start of the project caused an overflow of cash flow from time step 0.875 to time step 1.25 and from time step 2.75 to time step 3, as shown in Figures 8-26 8-26a. This can cause a problem for the client if the fund is not available to pay for the approved and accepted progress. The project's delay made a cost issue ending with cash bleeding and unnecessary over costs at the end of the project equal to 103%.

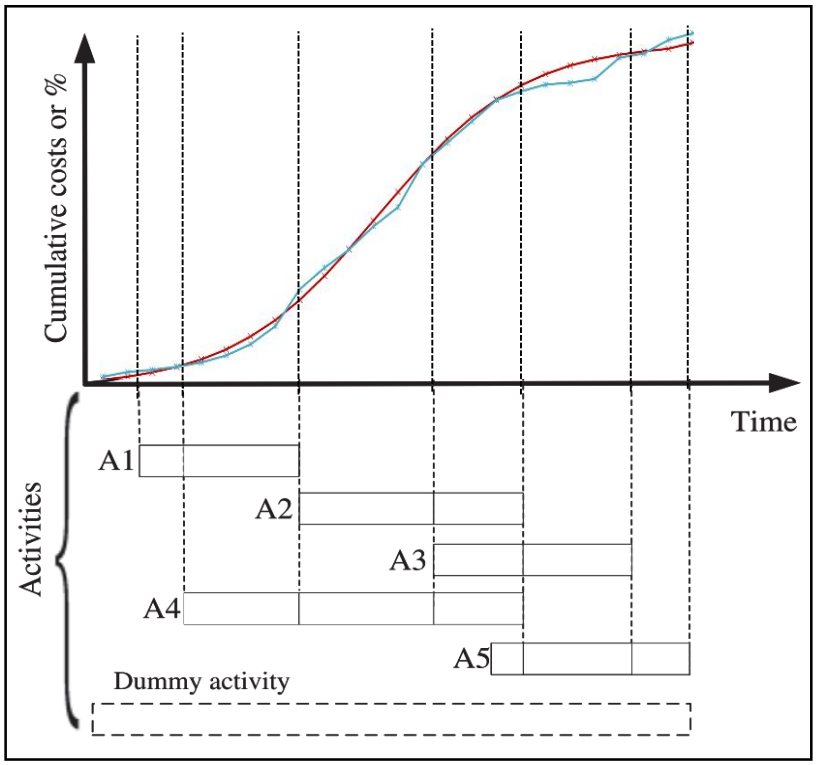


Figure 8-26a: adapted chart for progress vs. modelled and actual cost cash flow in percentage during CAPEX stage for project 2 (Wang, Wang et al. 2016).

Finally, this can be summarized in Table 8-4, and the risk of having fluctuation cash flows during large-sized projects can reach ±3%. Furthermore, the frequent reduction in progress and cash flows during project execution was found to cause a final cost at the end of the project.

Time (Year)	Estimated VENSIM Cash Flow Zero Risks	Estimated VENSIM Cash Flow Maximum Risks	Estimated VENSIM Cash Flow Mean Risks	Estimated VENSIM Cash Flow Minimum Risks	Actual Project Paid Cash Flow for Residential Housing Project 2	Deference Residential Housing Project 2 (Mean-Actual)
0.00	17,129,052.77	17,191,616.64	17,163,996.04	17,136,418.27	23,029,690.32	-5,865,694.28
0.13	23,792,214.30	23,879,115.36	23,840,750.41	23,802,444.95	33,930,410.40	-10,089,659.99
0.25	32,933,593.56	33,053,883.51	33,000,778.09	32,947,755.01	38,766,645.37	-5,765,867.28
0.38	45,373,012.41	45,538,737.34	45,465,573.35	45,392,522.80	45,675,552.47	-209,979.11
0.50	62,113,736.42	62,340,606.85	62,240,448.45	62,140,445.33	54,887,428.60	7,353,019.85
0.63	84,310,100.67	84,618,043.31	84,482,093.27	84,346,354.01	71,008,211.82	13,473,881.45
0.75	113,166,102.73	113,579,441.92	113,396,961.58	113,214,764.15	96,110,574.27	17,286,387.31
0.88	149,734,290.00	150,281,194.49	150,039,747.95	149,798,675.74	136,335,766.69	13,703,981.25
1.00	194,605,501.93	195,316,298.53	195,002,497.16	194,689,182.30	218,858,823.67	-23,856,326.52
1.13	247,536,702.66	248,440,830.47	248,041,677.54	247,643,143.45	266,376,751.37	-18,335,073.83
1.25	307,148,231.95	308,270,090.87	307,774,814.34	307,280,305.69	306,909,006.33	865,808.01
1.38	370,878,887.50	372,233,522.64	371,635,480.43	371,038,365.42	358,725,809.55	12,909,670.88
1.50	435,332,466.13	436,922,517.97	436,220,544.37	435,519,659.09	401,868,096.08	34,352,448.28
1.63	496,957,923.53	498,773,062.35	497,971,717.70	497,171,615.44	498,272,938.62	-301,220.92
1.75	552,795,878.97	554,814,965.91	553,923,582.56	553,033,581.19	545,752,483.49	8,171,099.07
1.88	600,978,984.28	603,174,060.02	602,204,981.41	601,237,405.24	593,232,028.37	8,972,953.04
2.00	640,835,777.34	643,176,430.02	642,143,082.32	641,111,336.72	640,711,573.25	1,431,509.08
2.13	672,668,191.02	675,125,111.59	674,040,434.13	672,957,438.34	660,184,455.84	13,855,978.29
2.25	697,386,689.52	699,933,894.40	698,809,358.36	697,686,565.79	675,537,582.72	23,271,775.64
2.38	716,165,150.29	718,780,943.50	717,626,127.19	716,473,101.30	679,375,864.44	38,250,262.75
2.50	730,194,927.05	732,861,964.03	731,684,524.71	730,508,910.87	688,191,118.12	43,493,406.58
2.63	740,546,721.82	743,251,568.73	742,057,437.14	740,865,156.92	735,670,663.00	6,386,774.14
2.75	748,114,537.55	750,847,025.90	749,640,691.20	748,436,226.80	744,626,653.68	5,014,037.52
2.88	753,609,822.88	756,362,382.76	755,147,186.92	753,933,875.11	775,332,907.44	-20,185,720.52
3.00	767,656,344.00	770,460,208.80	769,222,362.94	767,986,436.23	790,686,034.32	-21,463,671.38

Table 8-4: It is detailing the verification data percentages including the model adjusting risks (i.e., minimum, mean, and maximum) while presenting verification project 2 and highlight the differences in cash flow between the mean adjusting risks percentages and project 2 cash flow percentage. Colour legend is shown below.

Saving Cash	Over Cash

8.2.3 Project 3

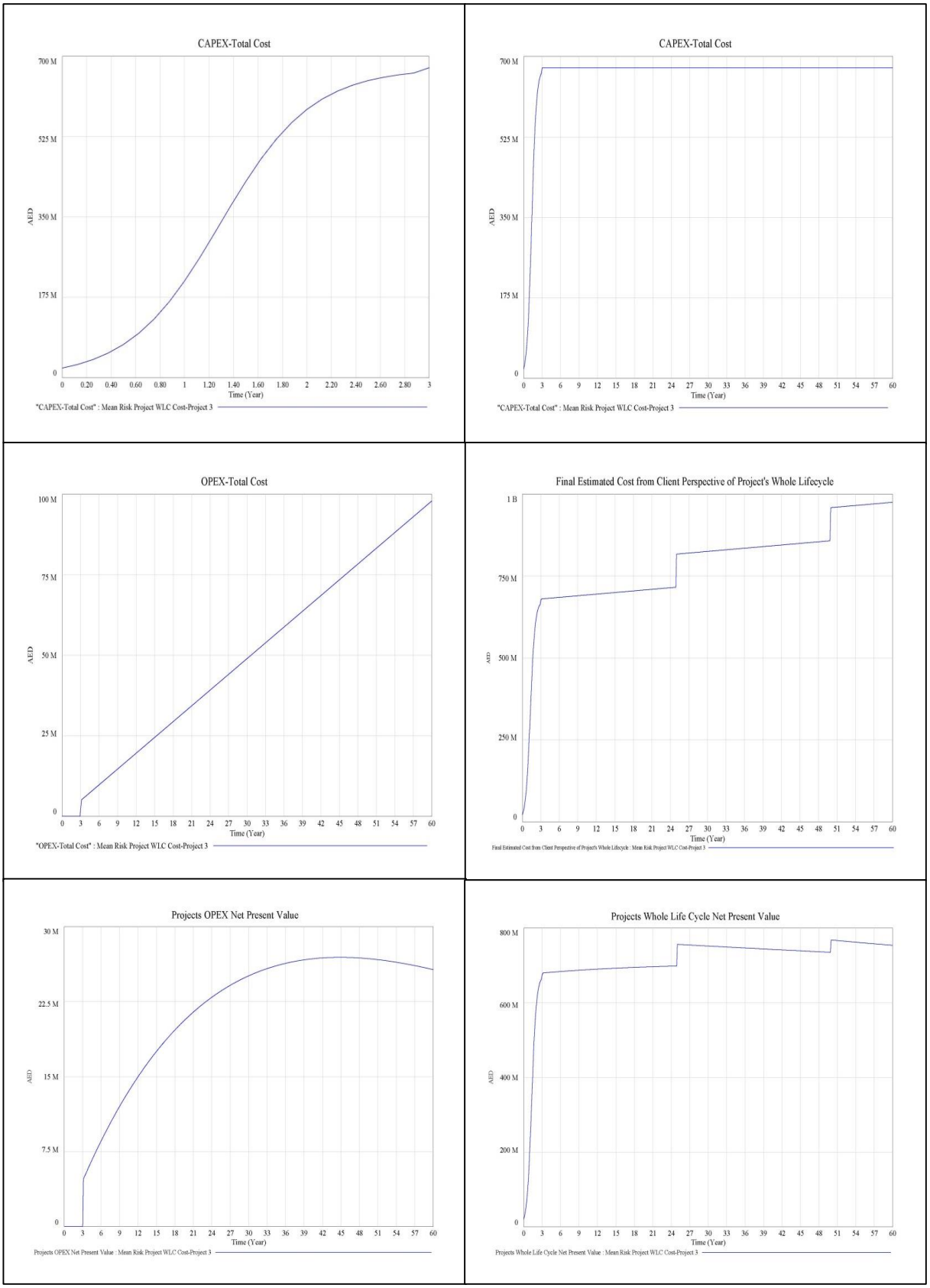


Figure 8-27: VENSIM System dynamics modelling results for Project 3 costs including the CAPEX, OPEX, Total Estimated Costs, OPEX NPV, and Projects Whole Life Cycle NPV.

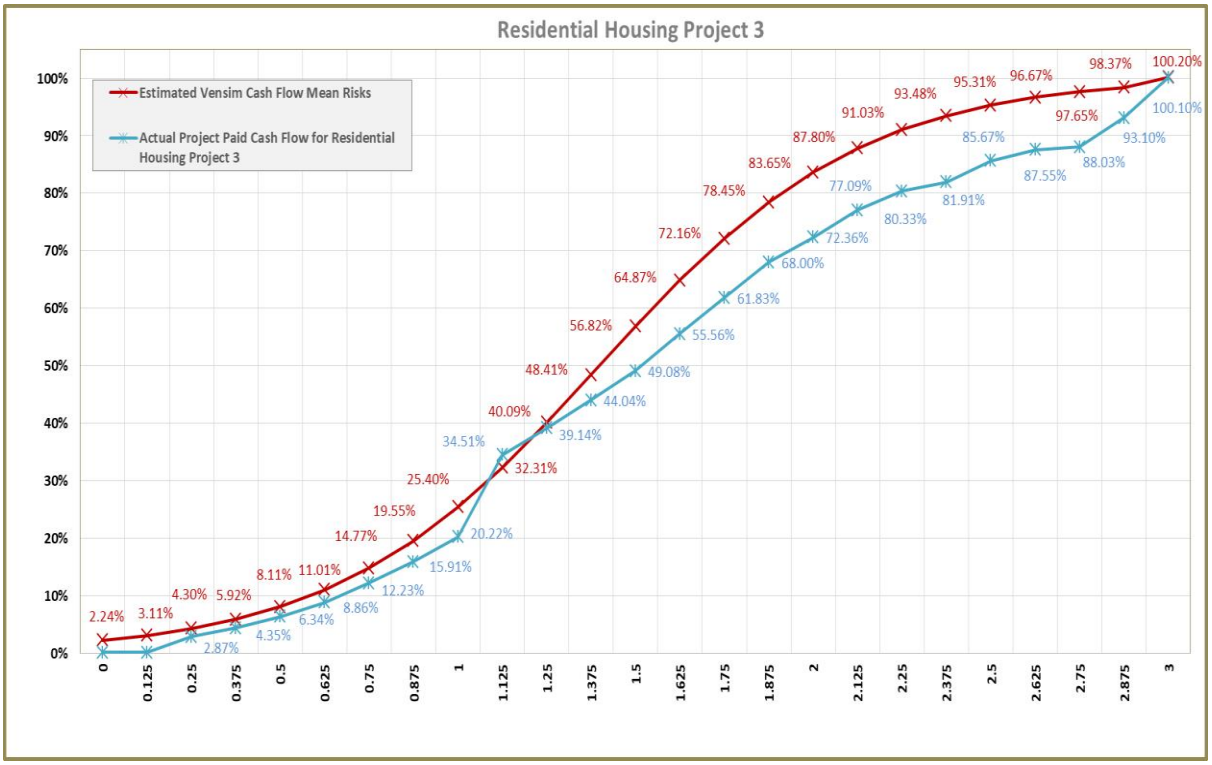


Figure 8-28: comparing project 3 model vs. actual cost cash flow in percentage during CAPEX stage.

Figure 8-27 and 2-28 related to project 2, the construction cash flow S-Curve model act as a centre line of the actual cash flow curve. However, this project is considered a large project (i.e., between USD 170 – 200 million) and found its actual costs fluctuation around the modelled S-Curve. So, to study these cash flow trends, it was found that cash flow is deviating from about -2.2% to +11.5%. Nevertheless, it has been observed that the actual S-Curve is trending almost like a straight line at the beginning of the project. According to researchers, construction cost s-curve should relate to project's progress based on activities milestones and indirect overheads cost as shown in Figure 8-28a (Wang et al. 2016; Koo, Hong & Hyun 2011). The activities from A1 to A5 represent a demonstration of discussion from literature to interpret cost results in Figure 8-28a (Wang et al. 2016). The dummy activity shown in Figure 8-28a is the indirect costs included in CAPEX S-Curve (Wang et al. 2016). Nevertheless, it has been observed that the actual S-Curve is lower than the modelled cash flow for the whole period

except time step 1.125. This time step is above the modelled value. On the other hand, at the end of the project, the final actual costs were 100.1%. Finally, this can be summarized in table 8-5, and the risk of having fluctuation cash flows during large-sized projects can reach -2.2% to +11.5%.

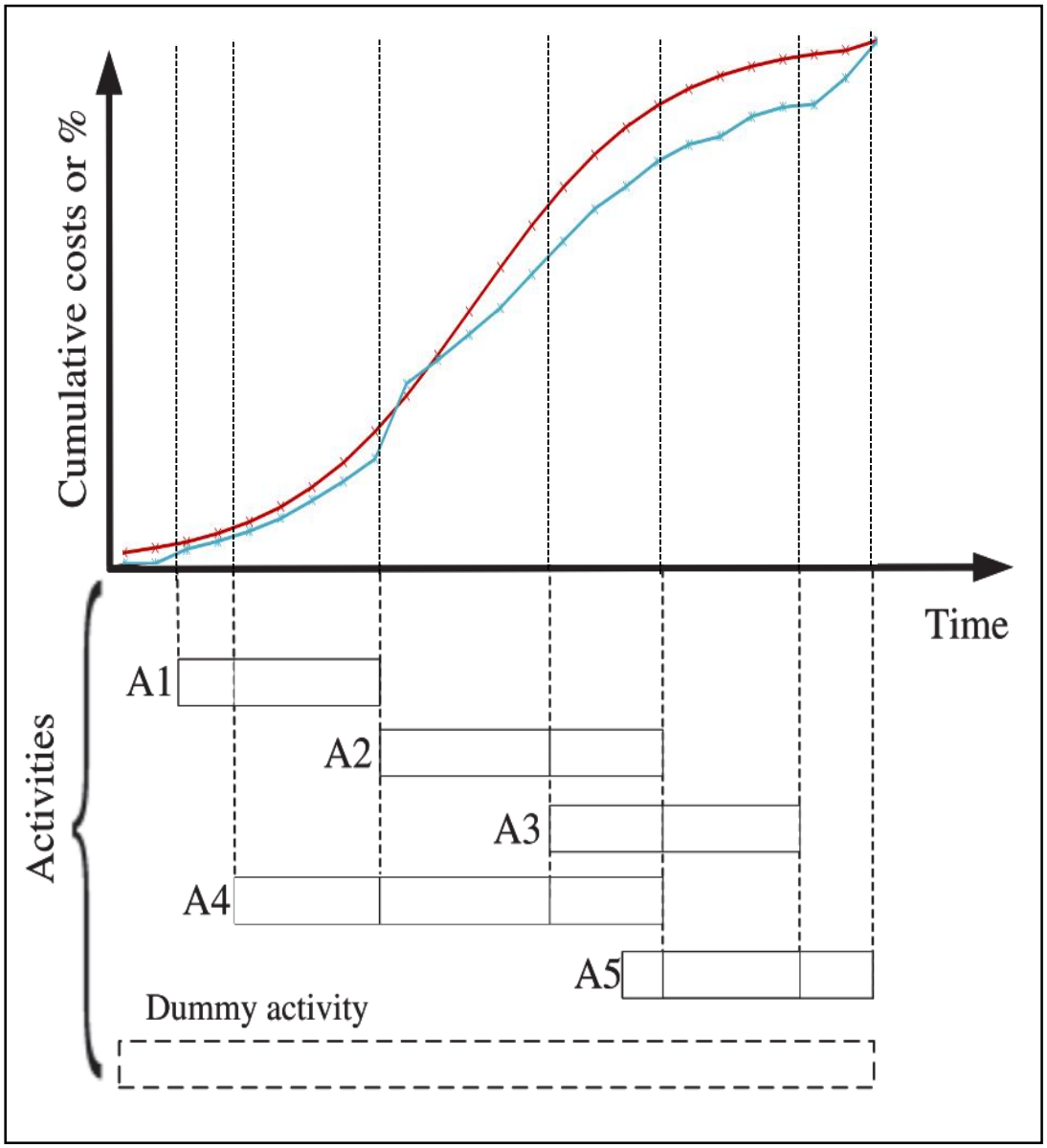


Figure 8-28a: adapted chart for progress vs. modelled and actual cost cash flow in percentage during CAPEX stage for project 3 (Wang, Wang et al. 2016).

Time (Year)	Estimated VENSIM Cash Flow Zero Risks	Estimated VENSIM Cash Flow Maximum Risks	Estimated VENSIM Cash Flow Mean Risks	Estimated VENSIM Cash Flow Minimum Risks	Actual Project Paid Cash Flow for Residential Housing Project 3	Deference Residential Housing Project 3 (Mean-Actual)
0.00	15,032,429.77	15,087,335.72	15,063,095.93	15,038,893.72	653,483.18	14,409,612.75
0.13	20,880,009.84	20,956,274.08	20,922,605.06	20,888,988.25	653,483.18	20,269,121.88
0.25	28,902,469.91	29,008,036.18	28,961,430.95	28,914,897.97	19,314,806.98	9,646,623.97
0.38	39,819,284.32	39,964,724.26	39,900,515.66	39,836,406.61	29,285,478.18	10,615,037.48
0.50	54,510,917.38	54,710,018.51	54,622,119.65	54,534,357.08	42,691,988.78	11,930,130.87
0.63	73,990,411.73	74,260,661.71	74,141,352.17	74,022,227.61	59,669,077.58	14,472,274.59
0.75	99,314,393.75	99,677,139.57	99,516,995.11	99,357,098.94	82,372,565.38	17,144,429.73
0.88	131,406,577.38	131,886,539.90	131,674,646.79	131,463,082.20	107,171,722.12	24,502,924.67
1.00	170,785,482.39	171,409,276.36	171,133,884.77	170,858,920.15	136,220,706.09	34,913,178.68
1.13	217,237,820.89	218,031,282.03	217,680,986.05	217,331,233.15	232,507,103.28	-14,826,117.23
1.25	269,552,805.23	270,537,346.85	270,102,692.95	269,668,712.93	263,663,620.78	6,439,072.17
1.38	325,482,728.29	326,671,553.96	326,146,713.06	325,622,685.87	296,673,091.89	29,473,621.17
1.50	382,047,087.52	383,442,514.50	382,826,463.58	382,211,367.77	330,628,804.38	52,197,659.20
1.63	436,129,492.00	437,722,454.97	437,019,196.16	436,317,027.68	374,284,175.58	62,735,020.58
1.75	485,132,793.85	486,904,741.38	486,122,464.75	485,341,400.96	416,523,381.31	69,599,083.44
1.88	527,418,211.29	529,344,606.31	528,494,144.44	527,645,001.12	458,091,709.18	70,402,435.26
2.00	562,396,470.18	564,450,623.29	563,543,758.98	562,638,300.66	487,464,767.58	76,078,991.40
2.13	590,332,546.36	592,488,735.98	591,536,824.75	590,586,389.35	519,330,493.78	72,206,330.97
2.25	612,025,461.76	614,260,884.76	613,273,993.70	612,288,632.71	541,150,808.94	72,123,184.76
2.38	628,505,409.39	630,801,025.40	629,787,560.43	628,775,666.72	551,855,921.69	77,931,638.74
2.50	640,817,919.41	643,158,506.86	642,125,187.97	641,093,471.12	577,151,308.59	64,973,879.38
2.63	649,902,638.22	652,276,407.61	651,228,439.60	650,182,096.36	589,799,002.04	61,429,437.56
2.75	656,544,141.40	658,942,168.87	657,883,491.44	656,826,455.38	593,073,054.40	64,810,437.04
2.88	661,366,795.16	663,782,437.38	662,715,983.42	661,651,182.88	627,188,903.18	35,527,080.24
3.00	673,694,000.00	676,154,667.34	675,068,335.76	673,983,688.42	674,347,483.18	720,852.58

Table 8-5: It is detailing the verification data percentages including the model adjusting risks (i.e., minimum, mean, and maximum) while presenting verification project 3 and highlight the differences in cash flow between the mean adjusting risks percentages and project 3 cash flow percentage. Colour legend is shown below.

Saving Cash	Over Cash

8.3 Cash Flow Range and Final Model Accuracy

In this part of chapter 8, cash flow tolerance possibility estimation based on the chosen verification projects 1, 2, and 3 are analyzed as per summary table 8-6. According to previous research, construction projects' cash flow estimation studies approach area method analysis, as shown in Figure 8-29 (Konior & Szóstak 2020). This approach is achieved by plotting previous similar projects S-Curves and create an area that includes all potted points (Konior & Szóstak 2020). It is then merged with the estimated cash flow to create an updated area, including actual and estimated cash flows (Konior & Szóstak 2020). This area is used to identify construction projects' cash flow S-Curve range in each time step (Konior & Szóstak 2020). Researchers stated that there are other methods and models for cash flow estimation (Konior & Szóstak 2020). They are too complicated and do not help plan or support construction project management (Konior & Szóstak 2020). Therefore, this research study approaches the cash flows-curve area method to provide "*the easy-to-apply*" cash flow model (Konior & Szóstak 2020, p. 19). This will support planning and managing the project (i.e., monitoring and control (Konior & Szóstak 2020). It is proved that this approach is a helpful tool (i.e., model) for both investors (i.e., clients) and contractors (Konior & Szóstak 2020).

This research will include the maximum absolute value from actual and estimated curves at each time step. The highest limit contains all three projects and mean risk modelled curves shown in Figures 8-30, 8-31, 8-32, and 8-33. However, the final total tolerance range for better housing projects cash flow planning is shown in Figure 8-34. Nevertheless, those curves are based on three verification projects only, and it is recommended to increase it to above 30. Then, validate it using SPSS to exclude the outlier projects. As more projects enter the process, the created area range in Figures 8-33 and 8-34 will be more accurate and include all similar projects' cash flow possibilities.

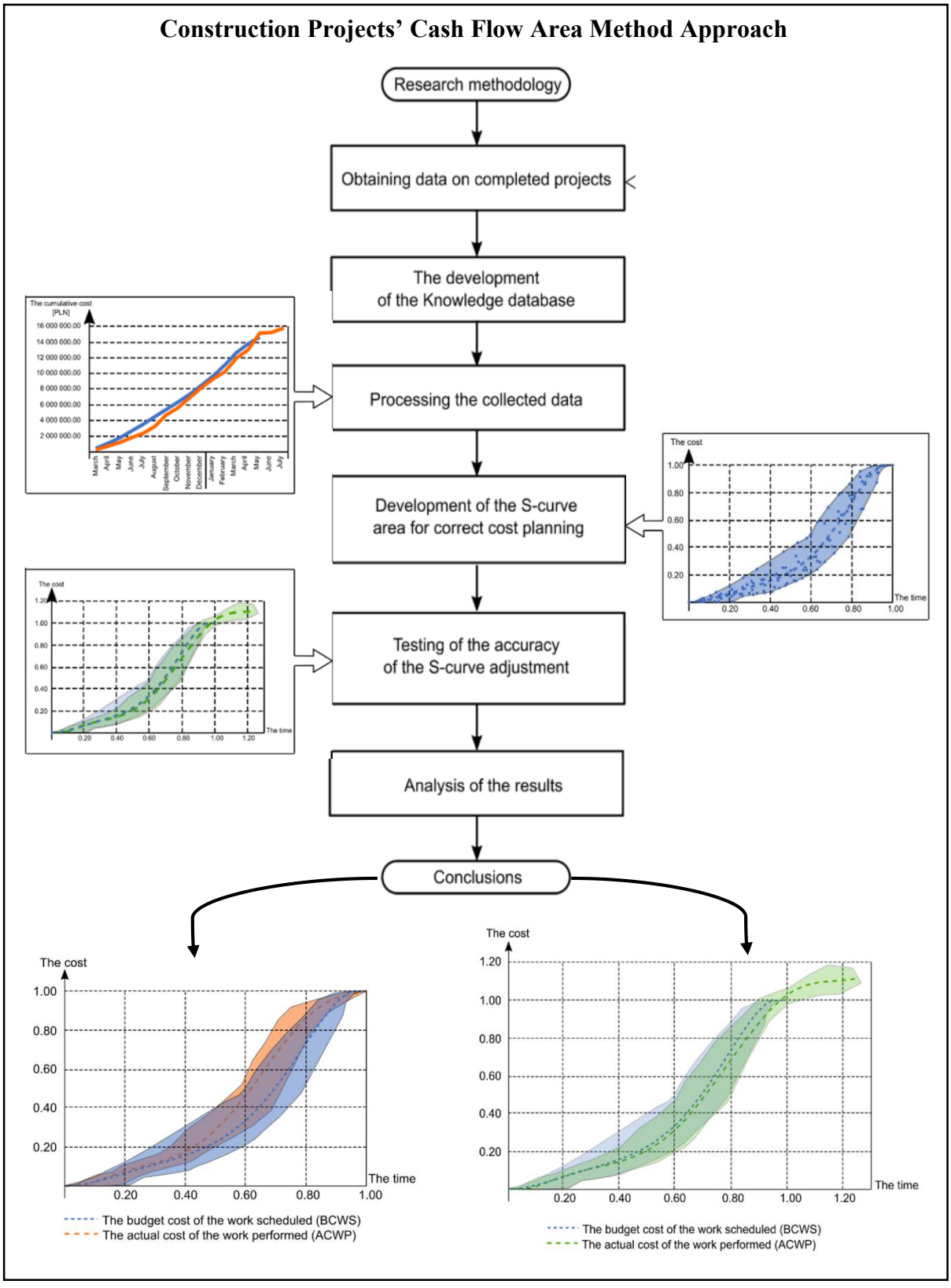


Figure 8-29: Construction projects' cash flow area method approach for accurate estimation in each time step over project's duration (Konior & Szóstak 2020).

Project 3 MAX S-Curve Error	Project 3 MIN S-Curve Error	Project 3 Error of Each Time Step Cash Flow	Project 2 MAX S-Curve Error	Project 2 MIN S-Curve Error	Project 3 Error of Each Time Step Cash Flow	Project 1 MAX S-Curve Error	Project 1 MIN S-Curve Error	Project 3 Error of Each Time Step Cash Flow	Maximum S-Curve Tolerance	Minimum S-Curve Tolerance	Total Fluctuation of Each Time Step Cash Flow
4.37%	0.10%	4.28%	3.00%	1.47%	1.53%	4.47%	0.00%	4.47%	4.47%	0.00%	4.47%
6.11%	0.10%	6.02%	4.42%	1.79%	2.63%	3.51%	2.70%	0.81%	6.11%	0.10%	6.02%
5.73%	2.87%	2.86%	5.05%	3.55%	1.50%	5.72%	2.88%	2.84%	5.73%	2.87%	2.86%
7.50%	4.35%	3.15%	5.95%	5.90%	0.05%	8.21%	3.64%	4.57%	8.21%	3.64%	4.57%
9.88%	6.34%	3.54%	9.07%	7.15%	1.92%	10.28%	5.94%	4.34%	10.28%	5.94%	4.34%
13.15%	8.86%	4.30%	12.76%	9.25%	3.51%	12.79%	9.22%	3.57%	13.15%	8.86%	4.30%
17.32%	12.23%	5.09%	17.02%	12.52%	4.50%	16.58%	12.96%	3.62%	17.32%	12.23%	5.09%
23.18%	15.91%	7.27%	21.33%	17.76%	3.57%	20.66%	18.43%	2.23%	23.18%	15.91%	7.27%
30.58%	20.22%	10.36%	28.51%	22.29%	6.22%	31.45%	19.35%	12.10%	31.45%	19.35%	12.10%
34.51%	30.11%	4.40%	34.70%	29.92%	4.78%	43.86%	20.76%	23.10%	43.86%	20.76%	23.10%
41.05%	39.14%	1.91%	40.21%	39.98%	0.23%	44.80%	35.39%	9.41%	44.80%	35.39%	9.41%
52.79%	44.04%	8.75%	50.09%	46.73%	3.36%	54.30%	42.52%	11.78%	54.30%	42.52%	11.78%
64.57%	49.08%	15.50%	61.30%	52.35%	8.95%	58.40%	55.25%	3.15%	64.57%	49.08%	15.50%
74.18%	55.56%	18.62%	64.91%	64.83%	0.08%	75.56%	54.18%	21.38%	75.56%	54.18%	21.38%
82.49%	61.83%	20.66%	73.22%	71.09%	2.13%	82.72%	61.59%	21.13%	82.72%	61.59%	21.13%
88.90%	68.00%	20.90%	79.62%	77.28%	2.34%	84.49%	72.40%	12.09%	88.90%	68.00%	20.90%
94.94%	72.36%	22.59%	83.84%	83.46%	0.37%	89.76%	77.54%	12.22%	94.94%	72.36%	22.59%
98.52%	77.09%	21.44%	89.61%	86.00%	3.61%	90.75%	84.86%	5.89%	98.52%	77.09%	21.44%
101.74%	80.33%	21.41%	94.06%	88.00%	6.06%	91.44%	90.62%	0.82%	101.74%	80.33%	21.41%
105.05%	81.91%	23.14%	98.47%	88.50%	9.97%	94.24%	92.73%	1.51%	105.05%	81.91%	23.14%
104.96%	85.67%	19.29%	100.98%	89.65%	11.33%	96.91%	93.72%	3.19%	104.96%	85.67%	19.29%
105.78%	87.55%	18.24%	97.50%	95.83%	1.66%	98.99%	94.34%	4.65%	105.78%	87.55%	18.24%
107.27%	88.03%	19.24%	98.31%	97.00%	1.31%	99.61%	95.70%	3.91%	107.27%	88.03%	19.24%
103.64%	93.10%	10.55%	101.00%	95.74%	5.26%	99.02%	97.72%	1.30%	103.64%	93.10%	10.55%
100.31%	100.10%	0.21%	103.00%	97.41%	5.59%	100.41%	100.00%	0.41%	103.00%	97.41%	5.59%

Table 8-6: It is showing verification projects used for this research model and how much cost cash flow can fluctuate each time step including project 1, 2 and 3. The total possible fluctuation in percentage for the model is included based on verification S-Curves' maximum and minimum yield points.

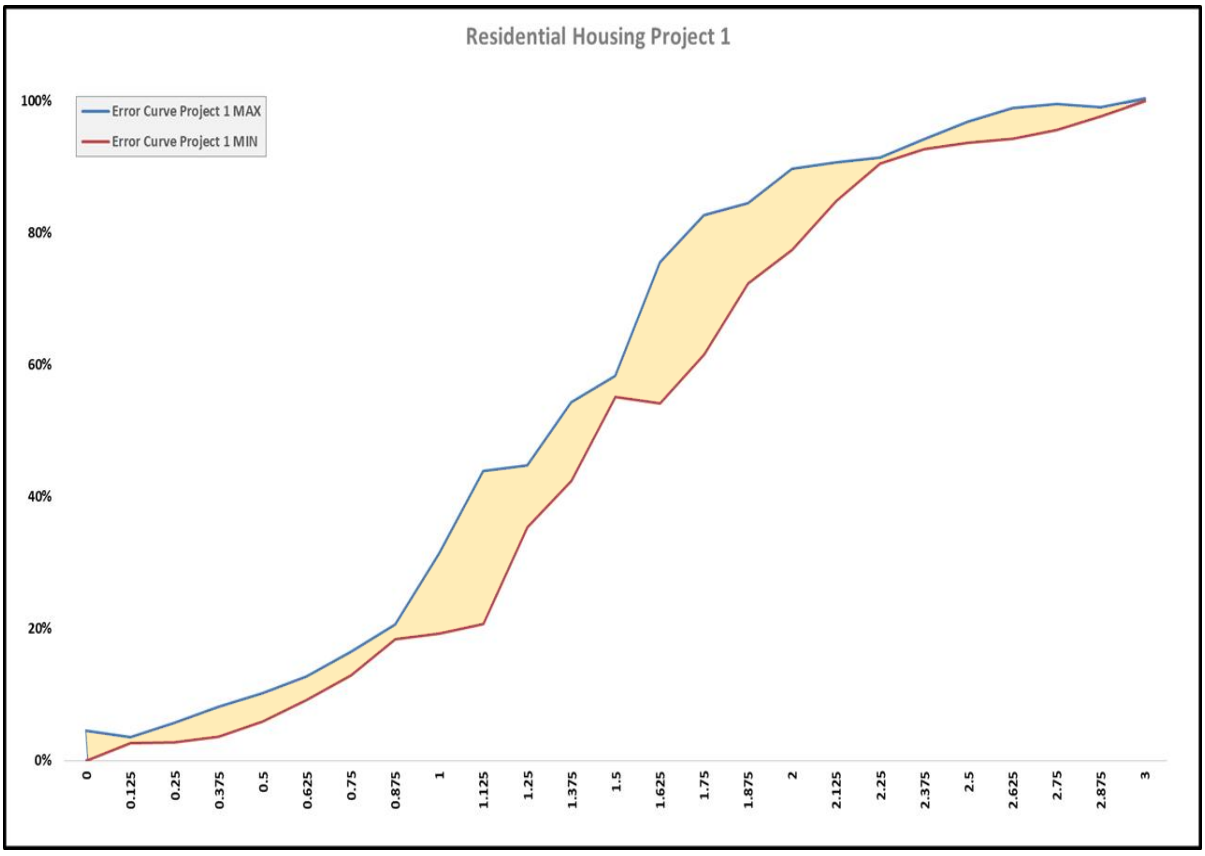


Figure 8-30: Cash flow area method range of verification project 1 (i.e., within the highlighted area).

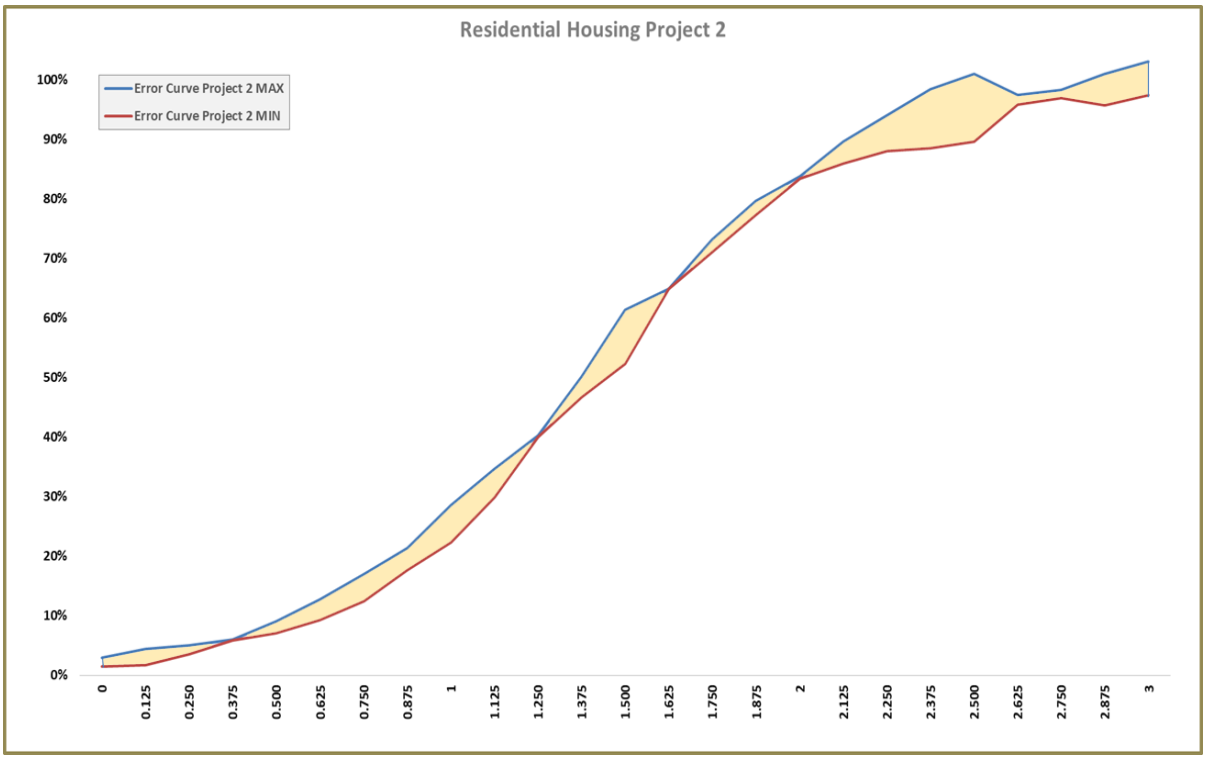


Figure 8-31: Cash flow area method range of verification project 2 (i.e., within the highlighted area).

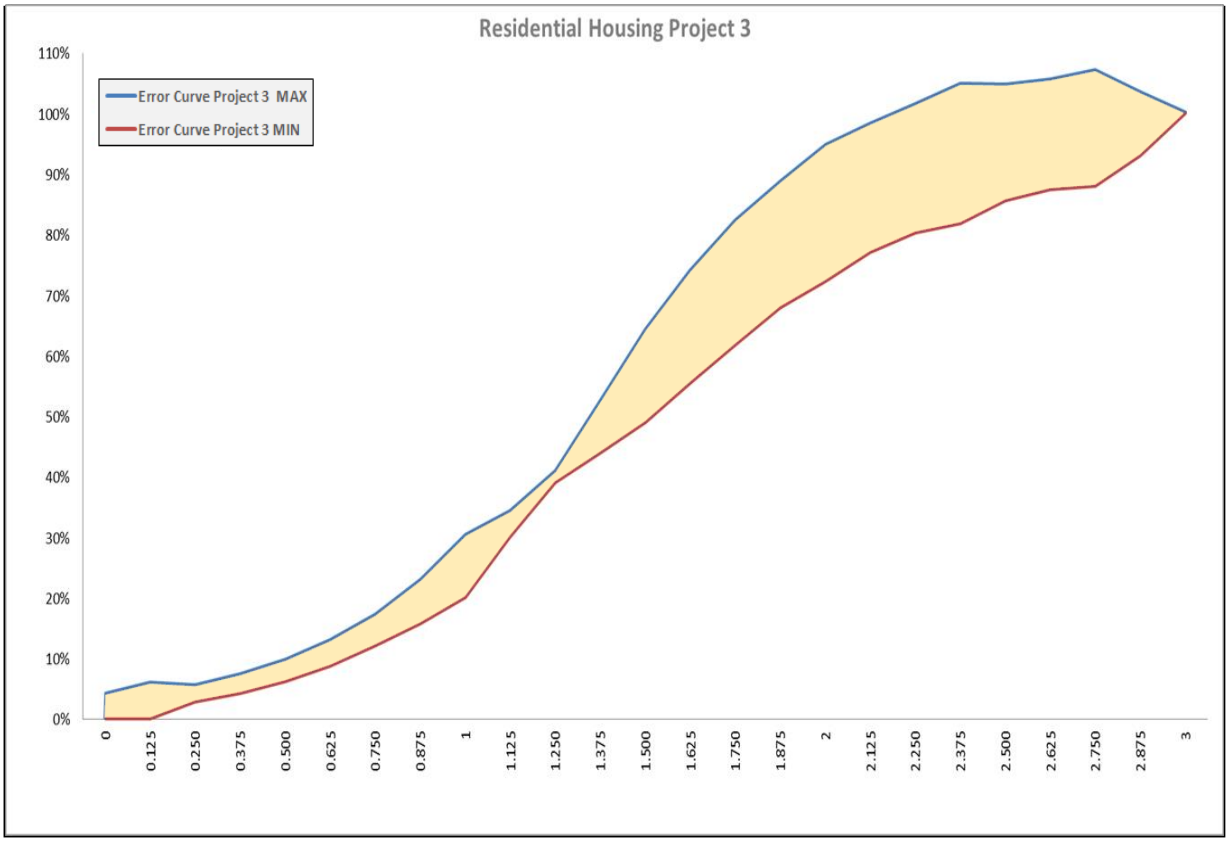


Figure 8-32 Cash flow area method range of verification project 3 (i.e., within the highlighted area).

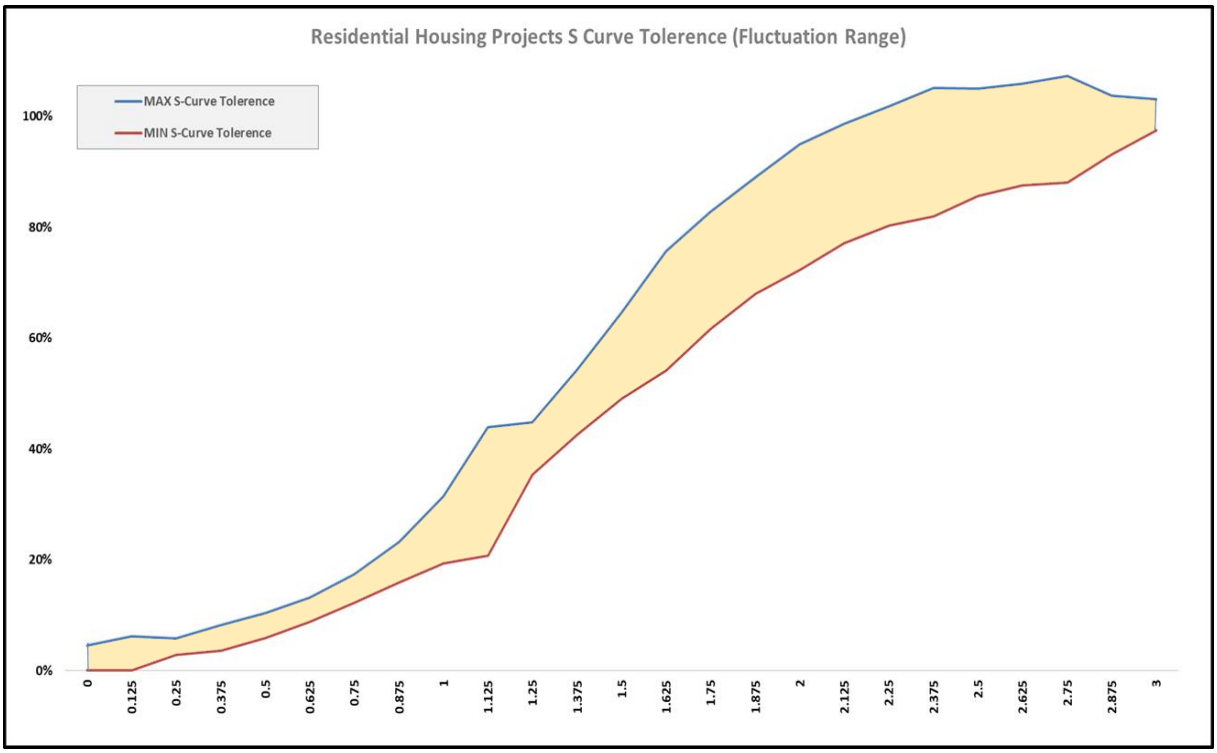


Figure 8-33: Cash flow area method range of all verification projects 1,2, & 3 (i.e., within the highlighted area).

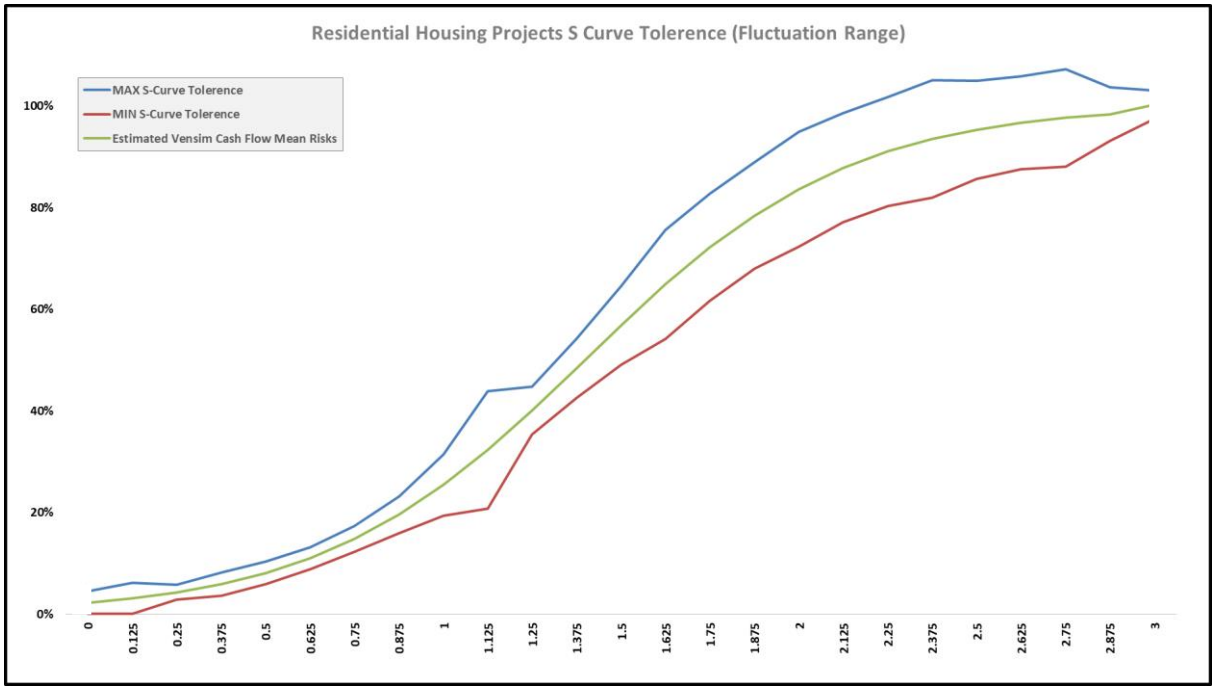


Figure 8-34: Cash flow area range of total verification projects 1, 2 and 3 including maximum limits, minimum limits and estimated VENSIM cash flow mean risks S-Curve.

Next, in table 8-7, error calculations of the final model's cost estimation based on the verification projects (i.e., three projects) are detailed to reach a final model accuracy equal to **96.728%.** Therefore, this accuracy can change and be more précised if the verification projects are increased to reach above 30 projects to validate the accuracy by grouping the projects with similar challenges and using SPSS to exclude outliers (Konior & Szóstak 2020). This will finalize the accuracy of system dynamics cost modelling accuracy. Nevertheless, the equations used to calculate error and accuracy of this research model are equations 4-64 to 4-67 (Koo, Hong & Hyun 2010; Xu & Moon 2013; Shahandashti & Ashuri 2013; Odeyinka, Lowe & Kaka 2013; Huang et al. 2015; Hyari, Al-Daraiseh & El-Mashaleh 2016; Murillo-Hoyos, Volovski & Labi 2016). Measuring accuracy error is commonly used in quantitative and modelling research after validating forecasting systems using real data (Koo, Hong & Hyun 2010; Xu & Moon 2013; Shahandashti & Ashuri 2013; Odeyinka, Lowe & Kaka 2013; Huang et al. 2015; Hyari, Al-Daraiseh & El-Mashaleh 2016; Murillo-Hoyos, Volovski & Labi 2016).

$$Error = A_t - F_t \quad \text{Equation 4-64}$$

$$MAD = \frac{\sum_{n=0}^{t} |A_t - F_t|}{\mathrm{T}} \quad \text{Equation 4-65}$$

$$MSE = \frac{\sum_{n=0}^{t} (A_t - F_t)^2}{\mathrm{T}} \quad \text{Equation 4-66}$$

$$MAPE = \frac{\sum_{n=0}^{t} [A_t - F_t]}{\mathrm{A_t}} * \mathrm{T} \quad \text{Equation 4-67}$$

MAD = Mean Absolute Deviation.

MSE = Mean Squared Error.

MAPE = Mean Absolute Percentage Error.

A_t = Actual Value at t time.

F_t = Forecast Value at t time.

T = The number of time periods.

However, using mean absolute deviation and mean square error have been proved very effective in calculating system dynamics and mathematical modelling error percentage (Koo, Hong & Hyun 2010; Xu & Moon 2013; Shahandashti & Ashuri 2013; Odeyinka, Lowe & Kaka 2013; Huang et al. 2015; Hyari, Al-Daraiseh & El-Mashaleh 2016; Murillo-Hoyos, Volovski & Labi 2016).

SN	Project	Actual Cost	Forecast Cost with Mean Risks	Error Actual-Forecast	Absolute Error	Squared Error	Absolute % Error	Final Model Accuracy
1	Residential Housing Project 1	100%	100.204%	-0.204%	0.00204	0.0000041616	0.204%	99.796%
2	Residential Housing Project 2	103.262%	100.204%	3.058%	0.030582723	0.000935303	2.962%	97.038%
3	Residential Housing Project 3	100.097%	100.204%	-0.107%	0.001066264	0.00000113692	0.107%	99.893%
4	Total	-	-	-	0.033688987	0.000940601	3.272%	96.728%

Table 8-7: Error calculation table including the System dynamics VENSIM model and all three verification projects 1, 2 and 3 to get the final estimation cost modelling accuracy which is equal to **96.728%.**

8.4 Discussion

In this part of chapter 8, a detailed discussion for system dynamics model cash flow and final estimation values will be performed to highlight the main outputs and conduct further results interpretation. The final model's accuracy will then be discussed to highlight this research analysis's main points and results.

8.4.1 Cash Flow Discussion

The cash flow fluctuation range percentage does not indicate that all points should be on the same curve concerning cash flow discussion. However, it means that it will be within the identified area. For example, if one or two points reach the minimum or the maximum cost curve points at (t) time point, it does not mean that the remaining points will be falling on the same curve for the remaining of the project's expenditure. Thus, according to researchers, the cash at a certain time point should be as planned except if there is an unexpected issue or challenge (Kazaz, Birgonul & Ulubeyli 2005; Doloi 2012; Yana & Wibowo 2015). In other words, researches showed that if the cash spent is more than the planned, estimated curve, and then it will be because of either faster performance in execution, quality reworks, or too many design changes/variation (Kazaz, Birgonul & Ulubeyli 2005; Doloi 2012; Yana & Wibowo 2015). On the other hand, if the cash spent at (t) time point found below the planned, estimated cost, it will mean that the project is probably experiencing (1) low performance in execution, (2) challenges in solving quality issues, (3) getting approvals of design changes/variations, or (4) an issue related to project's resources (Chapman 1998; Howell & Koskela 2000; Love et al. 2002; Peng & Lai 2012; Odeyinka, Lowe & Kaka 2013; Kubba 2017). This means that the possible actual curves will be falling within the maximum and the minimum curves

highlighting the identified area. On the other hand, other researchers did not include cash flow fluctuation percentage during the project's execution for specific projects (i.e., specifically residential housing projects) (Konior & Szóstak 2020). For example, researchers estimated the S-Curve of construction at the pre-construction based on assuming no addition or deduction causing fluctuation or retention (Odeyinka, Lowe & Kaka 2013). Researchers also agreed that the only fluctuation reason for changing S-Curve values over the project's time steps is because of the BOQ (Bill of Quantity) and material price changes. However, this is included in the dynamical regression and analysis of material price fluctuation from the clients', consultants', and contractors' perspectives (Hwang 2011; Perera & Imriyas 2004; Memon et al. 2010; Abdul-Rahman et al. 2013; Memon & Abdul-Rahman 2014). Researchers also included inflation, resources costs, and budget availability fluctuations as the main reasons for changing construction cash flow through project execution from clients', consultants', and contractors' perspectives (Hwang 2011; Bovsunovskaya 2016). Thus, this research S-Curve predicts cash flow for each time step using system dynamics and actual fluctuation using actual projects' verification data to include all possible issues within the estimated range.

8.4.2 Final Cost Estimation and Error Discussion

Results showed that this project's accuracy is considered high accuracy (i.e., low error) model for residential projects cost estimation. This includes large-projects and mega-projects. It is acceptable and provides an accurate estimated cost at the pre-construction stage from the client's perspective (i.e., **96.728%** accuracy). However, this is due to the following:

1- In the 1970s, researchers reached a maximum accuracy of cost estimation modelling equal to 90% (i.e., error = 10%) and were considered acceptable based on mathematical and information modelling according to Beeston (1974) (Hardcastle, 1992).

2- Then, in 1980s, cost estimation modelling included small projects with accuracy equal to 98% (i.e., error = 2%), medium projects with accuracy equal to 93% (i.e., error = 7%), and large projects with accuracy equal to 88% - 90% (i.e., error = 10% - 12%) based on mathematical and information modelling according to Flanagan and Norman (1983) (Hardcastle, 1992).

3- Based on the artificial neural network approach, the accuracy of construction cost modelling found in the best research outputs equal to 92.5% (i.e., error = 7.5) (Gunaydın & Dogan, 2004).

4- Then, in the early 2000s, an artificial neural network approach was used to investigate two design parameters to control cost estimation using a prediction model with accuracy equal to 93% (i.e., error = 7%) (Gunaydın & Dogan, 2004).

5- In 2011, the artificial neural network was tested in Egypt and found outputs with accuracy equal to 80% (i.e., error = 20%), and the researcher proved that it is acceptable and considered high based on Egypt's risks and challenges. Moreover, based on testing the model using only five projects (ElSawy, Hosny & Abdel-Razek 2011).

6- In 2014, researchers in the United Kingdom used an artificial neural network to estimate construction costs using many historical data projects (i.e., 1,600 projects) to end up with a model accuracy equal to 96.33% (i.e., error = 3.67%) (Ahiaga-Daghui 2014).

7- In 2014 and 2015, researchers used system dynamics modelling to model risks that are impacting construction costs and reached an accuracy equal to 98% (i.e., error = 2%) (Boateng 2014; Alzahrani 2015)

8- In 2019, researchers used a system dynamics approach to technical model criteria in construction, impacting cost estimation and control and limited their research with further works to determine output accuracy (Al Aryani 2019).

9- Finally, based on points 1 to 8, it has been found that the system dynamics approach is the highest modelling accuracy outputs from all used approaches of studying costs. According to the researcher's best knowledge, there is no previous research using system dynamics in cost modelling and estimation (i.e., this is the first research). However, this research's accuracy level (i.e., **96.728%** accuracy) is higher than the highest accuracy level in other cost modelling and estimation studies (i.e., artificial neural network approach with accuracy equal to 96.33%).

10- In other words, the highest cost risk modelling accuracy was found to be 98%, and the highest cost prediction was found to equal 96.33% (Boateng 2014; Ahiaga-Daghui 2014). This proves that these research outputs have a better achievement, as shown in Figures 8-35 and 8-36.

1970-1979	1980-1989	1990-1999	2000-2009	2010-2019	2020 - Present
Accuracy = 90% **Error** = ±10%	**Accuracy** = 98% Small, 93% Medium, 88% - 90% Large **Error** = ± 2%, 7%, 10%	**Accuracy** = 92.5% **Error** = ± 7.5%	**Accuracy** = 93% **Error** = ± 7%	**Accuracy** = 80%, 96.33% **Error** = ±20%, 3.67%	**Accuracy = 96.728%** **Error = ±3.272%**

Figure 8-35: Cost Estimation Accuracy Achievement over the last 50 years (i.e., from 1970 – 2020).

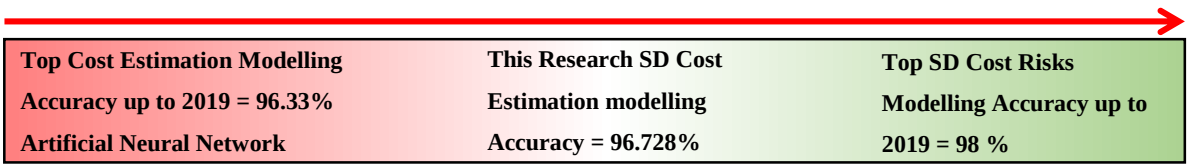


Figure 8-36: Showing System dynamics (SD) Cost Estimation and Modelling Performance in PM Field.

8.5 Summary

In conclusion, after validating each part of the system dynamics model and after verifying the model's outputs by using three actual housing projects, it has been proved that the research is completed successfully to deliver the following outputs:

1- Cost's adjusting risk values and their interaction with each other. Moreover, they interact with the estimated project's whole life cycle costs (including CAPEX and OPEX).

2- Providing the estimated CAPEX cost with accuracy equal to 96.728%.

3- Provide a detailed S-Curve estimation for construction cash flow.

4- Provide OPEX cost estimation annually and at every time steps. This is including the cost of equipment replacement for over 60 years.

5- Provide the final project costs and cash flow for each time step at the pre-construction stage through the project's whole lifecycle until the end of the project.

6- Provide the net present value (NPV) for the final estimated cost and each time step of the project's lifecycle. This is including operational expenditure NPV value for the 57 years separately.

Finally, concerning cash flow tolerance/fluctuation range, project managers need to consider the possibility of each time step range while setting their risk management system, including identification, assessing, and controlling cost risks, in order to ensure that estimated cost will remain as per the modelled values.

Chapter 9
CONCLUSION

"Research is to see what everybody else has seen, and to think what nobody else has thought".

(Boncz et al. 2017, p.8)

9.0 Introduction

This chapter will summarize the thesis to include this research's successful progress, outputs, and impacts on the project management body of knowledge. However, this is going to be through several summary points. First, this chapter will review system dynamics and costs research gaps, aims, and objectives. Then, answering the research questions. Then, discussing the research contribution (i.e., So what?). This will include the theoretical contribution and practical contribution discussions. Then, discussing the research outputs recommendations. Finally, the summary will sum up discussing the limitations of this research study and discussing further research requirements.

Therefore, by including all research key elements and contributions summary, this thesis will reach its successful completion and add system dynamics cost modelling and estimation approach to project management bodies of knowledge to improve the theory and practice of projects.

9.1 Research Gaps, Aims, Objectives, and Questions

In order to provide a more accurate conclusion for this research study, it is essential to have a summary of why this research was initiated and progressed from its start to end. Therefore, the missing research gaps of previous studies included the following:

1- No research modelled and analysed projects (i.e., construction and operational costs) using system dynamics approaches (i.e., VENSIM).

2- The underestimation and costs overrun were not covered in previous research, including both capital and operational expenditures.

3- Most previous research included infrastructure studies when it comes to cost modelling. However, they ignored residential projects TOTEX (i.e., CAPEX and OPEX).

4- Pre-construction stage costs estimation did not include residential buildings studies.

5- There is no cost modelling for residential construction projects in the United Arab Emirates.

6- There are no previous data outputs of cost risks (i.e., variables description types and numerical values) related to buildings, construction, or operation in the United Arab Emirates.

7- There is no previous cost model that can be generalized to a region that includes the United Arab Emirates. So, the research window is open for this study.

8- Previous research focused on modelling risks from the client perspective and focused on modelling costs from contractors' perspective—no cost models for residential buildings project's whole lifecycle from a client perspective in the United Arab Emirates.

9- Finally, all previous research recommended to proceed with further research in cost modelling, including their developed model, and investigate it under deferent circumstances (i.e., region, variables, client perspective, etc.). Also, they recommended developing a new cost model using other approaches.

Therefore, based on the research gaps mentioned above, this research aims to approach system dynamics to model residential project's whole life cycle costs at the pre-construction stage from the client perspective in the United Arab Emirates. There are six sub-objectives to ensure that research questions have been answered successfully to meet this research aim and objective. This study aims to simulate (i.e., imitate the character of) costs behaviour in a dynamical model over the project's whole life cycle.

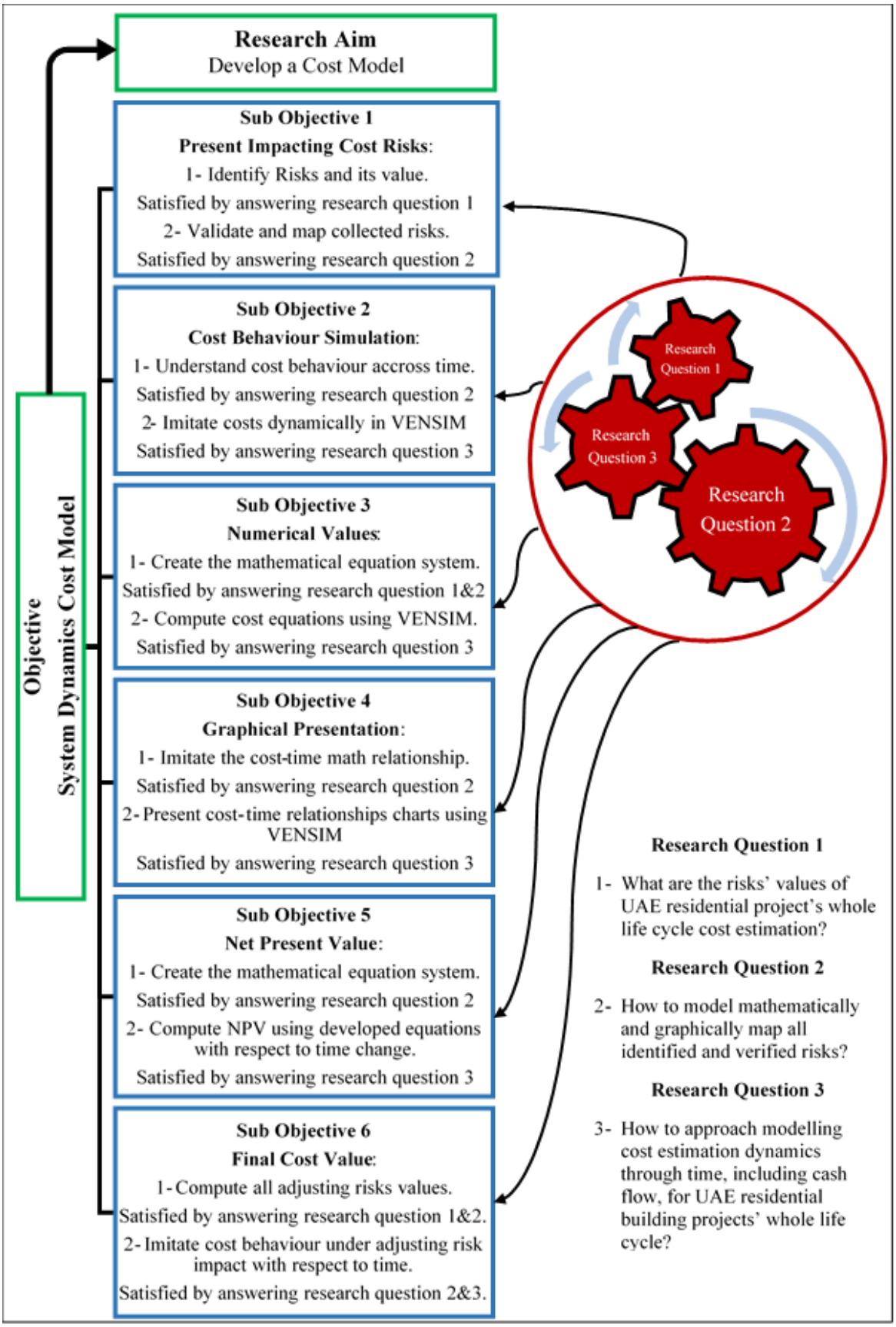


Figure 9-1: adapted figure 1-1 showing how research questions are answered to meet this research aim and objective. This is using sub objectives controls to measure its accomplishment.

However, in this chapter, it is time to review and ensure that the study's aim have been successfully met and satisfied through this research journey, as shown in Figure 9-1. The best way of accomplishing this task is by reviewing and explaining how each research question satisfied each sub-objective, as shown in Figure 9-1. Moreover, explain its contribution to the aim (i.e., cost estimation modelling). The research questions are acting like gear as one unit due to the overlap in answering them, as shown in Figure 9-1 and as explained in chapter 4 conclusion. These research study questions are listed as the following:

1- What are the risks' values of the UAE residential project's whole life cycle cost estimation?

2- How to model mathematically and graphically map all identified and verified risks?

3- How to approach modelling cost estimation dynamics through time, including cash flow, for UAE residential building projects' whole life cycle?

First, the initial point is to have a conceptual model, that is grouping the variables (i.e., costs risks) and identifying their relationship. However, this is done with the second objective, mapping the identified variables together in stock and flow form of system dynamics, as shown in chapter 3. The first sub-objective is accomplished successfully as required by identifying each group and each cost risks in those groups while mapping their system dynamics relationships in detailed Figures. The second and third sub-objectives measure the probability and impact of each cost variable to identify each cost variable's risk value. However, this is done through the survey questioner data collection, which has been designed to collect all measurements from experts based on the Project Management Institute Risk Matrix (i.e., PMI Probability vs Impact Risk Matrix) as explained and detailed in chapter 4 and chapter 5. Then, simulating collected data in the Monte Carlo modelling system to investigate the difference between what is covered by bidders and the actual risks should be added as adjusting risks in

the system dynamics model. However, the software programs used for completing these sub-objectives are SPSS and Microsoft Excel, as shown in chapter 5 and chapter 6. After that, the outputs of the SPSS and Monte Carlo simulations are extracted to develop the mathematical relationship between each group's variables. However, the mathematical relationship found representing stock and flow in system dynamics concept, as shown in chapter 7. Sub objectives four to six are built on the second and third sub-objectives to present data in charts or extract a certain time step (i.e., 0 to 60 years). In other words, they are based on investigating the mathematical modelling time relationships between variables through the project's whole lifecycle, starting from the contract value, on including six different mathematical calculation models and present them graphically as the following:

1- First, the CAPEX mathematical relationship calculation is about creating the stock and flow numerical equations after identifying each adjusting risks group's stock and flow variables. However, the risk relationship mathematical interaction is based on risks of decreasing S-Curve. The impact of the risks on the contract value costs is based on the increased cash flow S-Curve. Nevertheless, these mathematical relationships are active from the start of the CAPEX model stage until the end of the CAPEX model stage (i.e., from time step 0 to 3 years).

2- The impacts of operational expenditures (i.e., OPEX) are mathematically based on stock and flow calculations. It is related to OPEX adjusting risks and based on linear behaviour through time constantly as annual payments of the maintenance and operations costs from year 3 (i.e., after CAPX end) until year 60 (i.e., the model time frame = projects whole lifecycle).

3- Next, the equipment replacement mathematical model is based on replacing equipment every 25 years. However, this mathematical model has been entered into VENSIM

system dynamics cost modelling as a pulse impact variable, and it is not active except when its timestep of replacement occurs.

4- After that, the project's lifecycle's final estimated costs will be based on the summation of CAPEX, OPEX, and equipment pulse impact concerning their relationship with time.

5- The model also included the operational net present value of operational expenditures (i.e., OPEX-NPV) for the cost cash flow over 57 years of expected modelled operations (i.e., 3 to 60 years). This NPV Equation has been implemented using UAE Central Bank discount rate EIBOR shown in chapter 4 and 7.

6- Finally, the final cost estimation of the project's whole life cycle, including CAPEX, OPEX, and equipment replacement, is also considered in a separate mathematical model from timestep 0 to 60 years. Nevertheless, NPV mathematical equation has been implemented in this part of the model, and it is using the United Arab Emirates Central Bank discount rate EIBOR shown in chapter 4 and 7.

At this point of conclusion, it is important and mandatory to summarize this thesis progress from start to finish. First, starting from chapter 2 (i.e., literature review), the existing cost models related to construction have been summarised, and the accuracy of construction project management costs models was found to be between 80% and 96.33%. These models were using information and knowledge models, hypothesis and paradigm models, pure mathematical models, Correlated Cost Risk Analysis Model (i.e., CCRAM), Fuzzy Models, case-based models, and Artificial Neural Networks models (Hardcastle 1992; Baloi & Price 2003; Zeng et al. 2007; Dikmen, Birgonul & Han 2007; Nasirzadeh, Khanzadi & Rezaie 2014; Wang et al. 2016; Cui 2005; Isaksson 2002; Boateng 2014; Ahiaga-Dagbui 2014). It was found that risk models reached a higher accuracy limit (i.e., 98%) (Boateng 2014). Thus, this research

reviewed existing cost models. However, Meta Theory methodology, Analytical-Network-Process models, ANOVA models, and System dynamics models are found to be the most effective cost models of previous research (Hardcastle 1992; Baloi & Price 2003; Zeng et al. 2007; Dikmen, Birgonul & Han 2007; Nasirzadeh, Khanzadi & Rezaie 2014; Wang et al. 2016; Cui 2005; Isaksson 2002; Boateng 2014; Ahiaga-Dagbui 2014). As a result, from reviewing and searching between models of the highest accuracy, it was found that system dynamics VENSIM modelling is the most accurate modelling approach for similar research studies. For example, researchers used it to model construction profitability in 2014, modelling risks in 2015, and modelling the resilience of technical aspects in 2019 (Boateng 2014; Alzahrani 2015; Al Aryani 2019). Finally, this research study found that using system dynamics approach to model the cost has a higher possibility to raise the accuracy level above 96.33% resulted from the ANN modelling approach (Hardcastle 1992; Baloi & Price 2003; Zeng et al. 2007; Dikmen, Birgonul & Han 2007; Nasirzadeh, Khanzadi & Rezaie 2014; Wang et al. 2016; Cui 2005; Isaksson 2002; Boateng 2014; Ahiaga-Dagbui 2014).

Utilizing the system dynamics model is mandatory to measure cost risks in the United Arab Emirates of residential building projects to obtain valid outputs from the final model's simulation. After searching for previous studies in the United Arab Emirates, which include any confirmed and applicable risks of UAE building's construction industry, it has been found that there are no such studies available in UAE. Therefore, construction risks from empirical and published studies (i.e., more than 225 studies) were collected and listed in the structured face-to-face survey interviews with experts working in related industries as explained in chapters 4 and 5. Using SPSS correlation analysis and regression, this research checked the linear relationships between collected data (i.e., risk and probability and impact) and checked the outliers, autocorrelation, and validated risks values. Finally, to compute risk values from

the client perspective, this research study is interested in the missing risks weightages that are not covered due to contractors' errors in calculating contract values. Risks are covered in the contract value from the contractor's perspective; nevertheless, to get the error of these risks and use its impact in the VENSIM system dynamics cost model, the validated survey data has been used as mean, minimum, and maximum values to create a Monte Carlo simulating model including 10,000 random value for each risk as explained in chapters 4 and 7. The adjusted mean and the error between the mean and the adjusted mean were computed to find the adjusting mean risk feed into the final model. Based on the same concept, minimum and maximum risks' error was found and prepared to be used in the final system dynamics cost model, as explained in chapters 4 and 6.

The interaction of system dynamics performance through the project's whole lifecycle concerning cost over time is detailed in graphs, Figures, and tables as resulted from the model simulations. However, the graphs and tables detail the performance of the model's elements dynamical interaction in each time step and how it is shaped and changed from the start of the project until the end of its operational time frame (i.e., total 60 years). The expected outputs are including estimated cash flows of CAPEX and OPEX Curves separately. The total estimated cost (i.e., TOTEX) and NPV for the project's whole life cycle curve are presented numerically and graphically in charts. The net present value curves of OPEX are provided separately as an output from this research system dynamics model simulation. However, all provided graphs, Figures, and tables include three curves for the same outputs to reflect the impact of minimum, mean, and maximum adjusting risks in each Figure. So, from the final provided validated and verified outputs, this research aim, objectives, and research questions are met successfully to contribute to the project management body of knowledge. However, this research contribution will be summarized in the following part of this chapter.

9.2 The Research Contribution

The research contribution is the added knowledge significance and importance to the field of project management cost modelling. Therefore, this research contribution is going to be presented through two main parts. First, the theoretical part is how cost estimation and modelling theoretical development added to the body of knowledge and create a future research base. Second, the practice part is about the applications and advantages of the developed model in the residential projects industry's practical field in the United Arab Emirates.

9.2.1 Theoretical Contribution

Eight main theoretical contributions resulted from this research study related to project management cost estimation and modelling. However, the first contribution is modelling cost estimation to include residential projects' whole lifecycle, including CAPEX, OPEX, equipment replacement, and Net Present Value in one model. Moreover, obtain all their outputs from one simulation. The second contribution is using a new approach that was not used before in cost estimation and modelling (i.e., System dynamics Modelling Approach). The third point is providing the research outputs of the residential project whole life cycle with cost estimation and modelling approach in the United Arab Emirates, which was not done before this research according to the author's latest knowledge. Fourth, this study provides a new cost estimation modelling approach for residential building projects from the clients' perspective. This is a significant theoretical contribution. However, most cost estimation research outputs approach contractors' perspective when the study is at the pre-construction stage. Furthermore, most previous research focused on modelling costs from clients' perspectives related to infrastructure construction projects. The infrastructure cost modelling approach is based on

price/unit instead of a lump sum buildings contract value. Previous infrastructure cost modelling used a price/unit approach to control possible clients' variations and estimate the end cost after predicting all possible variations. On the other hand, this research is based on the estimated actual cost of residential buildings projects and investigate the cost change reasons to feed them in the developed system dynamics model. Besides, the fifth theoretical contribution point is that this research study provided a structured, systematic approach to calculate and estimate costs based on identified risks' errors which rather than collecting the specific reasons of one or more projects and investigate project's cost change through progress reaching to the end based on one reason. However, this approach will make the model applicable to all residential buildings' whole life cycle after satisfying the related recommendations mentioned in this chapter. The sixth theoretical contribution is about providing a detailed estimated cash flow through projects' whole lifecycle time for each time step between 0 to 60 years. The seventh theoretical contribution provides the construction cash flow fluctuation measurement using the area method approach for each time step, as explained in chapter 8. This is not provided in previous residential project cash flow research studies. Moreover, researchers recommend conducting this analysis for housing projects (Konior & Szóstak 2020). Finally, the eight theoretical contributions are based on having the final research output system dynamics cost model adjustable whenever it is required to adopt new risks or remove invalid risks as required including its minimum, mean, and maximum adjusting risks value for all resulting curves and tables of the model's simulation after adding/removing risks.

9.2.2 Practice Contribution

There are five main practice contributions from this research study outputs. However, the significance of practice contribution points is about the ability to estimate, as a client, the cost of the whole project lifecycle at each time step. Therefore, this gives a better judgment based on financing and risk management systems used at the planning stage (Ibn-Homaid & Tijani 2015; Konior & Szóstak 2020). First, provided CAPEX cost value in the model adds to project management practice by estimating the residential project's actual investment cost based on existing risks (i.e., minimum, mean, or maximum risks) and how these costs will vary when risks change. However, the fluctuation of each time step S-Curve is representing how critical is cash flow at a specific time step based on the cash flow area methodology. This will support risk management systems and ensure that it is good enough or implement more monitoring and controlling actions from the client perspective according to each timestep's estimated fluctuation range as required. Second, provided OPEX cost value covers the full operation and maintenance expenses of residential projects investments based on construction MEP system costs at the CAPEX stage. Thus, clients can enhance their decisions related to construction and operational-related factors such as the quality level, energy consumption, and environmentally friendly factors (Hoffma et al. 2017; Baloi & Price 2003; Marzouk & Azab 2014). These factors can cause cost overrun on long-term investments after starting the operation stage (Hoffma et al. 2017; Baloi & Price 2003; Marzouk & Azab 2014). Third, equipment replacement costs and its pulse impact intervals are provided in the pre-construction stage model based on what should happen after starting the project’s operation. This will give the ability to adjust those costs or change its time intervals as needed by the business investors. Fourth, this study's developed system dynamics model provides the total expenditure view of residential project investments. It is done by providing the estimated cost of the project’s whole

lifecycle and details its output data using tables and curves for each timestep between 0 to 60 years at the pre-construction stage. Finally, the fifth practice contribution provides the net present value (NPV) for OPEX separately and for the project's whole lifecycle estimated costs in the same s cost model of this study. This will determine the entire investment future cash flow current value at present to make more accurate decisions related to maximizing profitability.

9.3 Limitations and Future Research

The limitations of this research have been collected and summarized as the following:

1- Based on these research outputs as explained and justified previously, it is recommended to keep collecting risks data from experts following time intervals (i.e., every five years or other time intervals required) to ensure covering all possible risks' updates. This is required to adopt any change in how engineering experts approach managing residential projects risks, including CAPEX and OPEX.

2- From the client's perspective, it is recommended to consider covering adjusting values based on what contractors and consultants may miss in built environment projects. Researching from client perspectives are considering the errors of other stakeholders' analysis. However, this is because they are already doing their part accurately as per their latest knowledge, and it is possible to find errors in their decision analysis, which can impact the project's success and failure.

3- These research outputs (i.e., system dynamics PWLC cost modelling) is restricted to residential projects in the United Arab Emirates. This is because it is built, validated, and verified using the UAE residential project industry's data solely. It is recommended to investigate existing modelling approaches, such as this research outputs, in new

regions where the chosen approach is not known within its industry. For instance, researchers conducted a stochastic cost estimation model of hotel construction projects in Malaysia, although it is done in major countries such as the United States, United Kingdom, and Belgium (Konior & Szóstak 2020). Also, this research agrees with other published literature to approach cost modelling in the same way for different types of projects, including residential buildings (excluding UAE if using this research cost model), hotel buildings, commercial buildings, industrial buildings, and infrastructure projects (Konior & Szóstak 2020; Hardcastle 1992; Baloi & Price 2003; Zeng et al. 2007; Dikmen, Birgonul & Han 2007; Nasirzadeh, Khanzadi & Rezaie 2014; Wang et al. 2016; Cui 2005; Isaksson 2002; Boateng 2014; Ahiaga-Dagbui 2014). This can be done, as explained, for the same project type in many regions.

4- This research study is achieved from the client's perspective. However, according to the researcher's best knowledge, there is no cost estimation and modelling using system dynamics VENSIM modelling in previous research. Therefore, it is recommended to use this approach to model costs from the contractor's and consultant's perspective regarding risk values and mathematical equation systems. Also, as explained in the previous point, the system dynamics cost modelling approach can investigate cost modelling from contractor's and consultant's perspectives, including different projects in different regions.

5- As explained in Chapters 3 and 4, demolition is not included within this research model's calculations separately. This is because many published literature declared that the demolition process is a part of reinvestment activities. Therefore, this research study considers demolition as a part of construction CAPEX activities and will be treated like construction wastes as justified earlier. However, building projects' demolition is a

huge argument that requires many investigations about it. This research discussed only related arguments to the topic and recommended further research to approach demolishing, including different perspectives. These perspectives include, but not limited to, considering demolitions as a part of the CAPEX process (not for residential projects in UAE). Furthermore, it includes demolition as a profitable process (i.e., a project for contractors and salvage value for clients). Furthermore, demolition as a transition stage shifted to many years due to converting the building to a historic property.

6- This research study developed a system dynamic cost modelling approach for regular and normal residential buildings in the UAE. It does not include special building considerations such as historical buildings converting possibilities, although the final model can adapt to these changes. Therefore, further research will be required for special projects such as the Head of state buildings (e.g., Al Watan Palace = Presidential Palace in UAE) and other important buildings (e.g., Octagon Building = Egyptian Ministry of defence).

7- This research developed the final model for residential projects WLC without including private, public, and public-private projects' experts to collect data risk values. This caused an argument, as explained in chapter 5 related to the inability to concessionaire risk. The risk proved essential for building construction projects except that it is clearly mentioned in a PPP (i.e., public-private-projects) study to allocate inability to concessionaire risk to private projects only. This research has justified its data because most of the chosen experts are from the public sector. Therefore, future research is recommended to investigate distinguishing between private, public, and public-private residential projects when collecting data from experts.

8- The estimated cost and cash flow resulting from this research system dynamics model are based on adjusting risks, as explained before. Therefore, data collection is based on risk values gathering for identified risks. Instead, it is recommended to use similar projects' historical data including CAPEX, OPEX, and equipment replacement for developing a stochastic model using VENSIM systems dynamics where cash flow values are controlled, dynamically, by lessons learned and best practices variables result in previous similar projects. As explained in chapter 8, researchers agreed that the stochastic area range of cash flow over time is the most supportive and easy to understand method for industry professionals related to planning and managing projects. As explained in points 1 and 2 of this research limitations, this investigation can be done from the client's, contractor's, and consultant's perspectives, including different types of projects in different regions.

9- This dynamical research model's used mathematical model is based on estimating OPEX life cycle costs using published articles percentages of CAPEX costs. Instead, future research is recommended to investigate the change of having a stochastic estimation model to identify OPEX life cycle costs and risks and embrace it into this research cost model.

10- The used mathematical model in this dynamical research model is based on estimating MEP (i.e., Mechanical, Electrical, and Plumbing System) costs and O&M (i.e., operation and maintenance) costs using published literature percentages of construction costs. Therefore, it is recommended to develop a stochastic approach from real separated MEP CAPEX data and real O&M data related to the residential project. I should be at least 30 sets to conduct a more accurate estimation, as explained earlier.

11- This study's system dynamics model is covering 60 years project's whole life cycle and three years of CAPEX construction time as justified in chapters 3 and 4. So, the operational stage is equal to 57 years. Therefore, to verify the model's OPEX outputs, it must have actual data for residential buildings' operational expenditures in the United Arab Emirates. Unfortunately, this is not available because the United Arab Emirates age is less than 50 years old. Also, no housing / residential project's data was found that operated long enough to replace and change its equipment (i.e., MEP- Mechanical, Electrical, and Plumbing System). As a result, the OPEX part of this research model is only developed and validated. Therefore, further research using real data is recommended to verify OPEX accuracy.

12- The model development is based on a specific time range. Therefore, it is not possible to change the CAPEX time frame (i.e., Construction execution period) unless the mathematical modelling of the decreasing S-Curve of CAPEX cost risks and the increasing S-Curve of payments the cash flow is changed to adapt to new time frames as explained in chapter 7. The model can be fully functional and accurate on any residential project with a construction period equal to 3 years.

13- CAPEX S-Curve in this research model, is analysed using three projects real housing projects. This is by identifying the yield absolute maximum points upper or lower the mean risk S-Curve. It will create a stochastic approach by developing a mirror area around the model's mean S-Curve values. Moreover, each time step will possibly move up and down within the identified area limits, as explained in chapter 8. However, this research agrees with previous researchers to increase the number of projects, in future research, to be more than 30 and establish a more accurate stochastic cash flow estimation.

14- This research system dynamics model is based solely on the stock and flow VENSIM dynamical approach. Therefore, it is recommended to investigate cost modelling response against causal loops dynamical approach. Variables and outputs scenarios may vary as applicable. However, as mentioned in points 1 and 2 of this research limitations, this investigation can be done from the client's, contractor's and consultant's perspectives, including deferent types of projects in deferent regions.

15- The collected data was based on experts' face-to-face survey interviews and Monte Carlo stochastic modelling. It is recommended to investigate the model response after using published tables sample size for data collection. Experts identified risk values against previous historical completed projects (i.e., at least 30 projects) to calculate each risk error and adjust risk value feed into the system dynamics cost model.

16- Finally, this research included, in Monte Carlo simulation, 10,000 iterations as the minimum required iterations. However, according to the researcher's best knowledge, no one used system dynamics for cost modelling in previous research. It is recommended to investigate the impact of changing the Monte Carlo iterations number on the developed system dynamics cost modelling accuracy.

9.4 Summary

In conclusion, it is essential to declare that this research aim and objective have been met successfully. The completed research has achieved an empirical study to develop a new cost model for residential projects' whole life cycle approaching system dynamics. The research contribution was significant, and the delivered outputs have introduced a project management field with many future research possibilities. Research questions have been

satisfactory answered. Furthermore, it was explained how each research question is related to other questions to provide this research with acceptable outputs contributing to meet the study aim and objective systematically. This chapter summarises the key achievements and highlights the significant elements of this thesis. However, this chapter started with clarifying how the completed aim and objective filled the research gap. It has described how research questions act like a gear unit impacting each other and overlapping before delivering final outputs. The main objective has been divided into several sub-objectives to ensure that research questions are answered in a constructive approach to deliver a significant contribution. Therefore, the first research question successful answer is essential to identify risks used in deriving errors operating the final system dynamics cost model. However, its answer cannot be completed without a validation process. Therefore, the second research question answer must start before finalizing the first research question, developing mathematical and statistical models to validate answers to the first research question. This research will then answer the second research question by developing all required mathematical modelling equations to provide a systematic analysis approach through the final simulation processes. Again, it cannot be finalized without start answering the third research question. This is due to the mandatory engagement between the basic mathematics of the chosen system dynamics approach (i.e., VENSIM software programme) and the developed mathematical equation systems. The second research question is then fully answered, and the third research question starts progressing by developing a system dynamics model and validating it using DEMO methods. Then, the final model is verified using three real housing projects. Finally, this chapter discussed the theoretical and practical contributions and ended with 16 practical limitations and future research recommendation points. All model parts are based on CAPEX as justified earlier, and CAPEX accuracy was found equal to 96.728%.

REFERENCES

"Cite all relevant references in the review section of a thesis, dissertation, or journal article."

(Galvan 2002, p. 92)

Abanda, F. H., Kamsu-Foguem, B. and Tah, J. H. M. (2017). BIM - New Rules of Measurement ontology for construction cost estimation, *Engineering Science and Technology, an International Journal*, vol. 1(1), pp. 1–17.

Abanda, F. H., Tah, J. H. M. and Cheung, F. K. T. (2013). Mathematical modelling of embodied energy, greenhouse gases, waste, time-cost parameters of building projects: A review, *Building and Environment*. vol. 59(1), pp. 23–37.

Abdallah, A. (2007). Managerial and economic optimisations for prefabricated building systems, *Ukio Technologinis ir Ekonominis Vystymas*, vol. 13(1), pp. 83–91.

Abdelsalam, H. M. E. and Gad, M. M. (2009). Cost of quality in Dubai: An analytical case study of residential construction projects, *International Journal of Project Management*, vol. 27(5), pp. 501–511.

Abdul-Rahman, I. A., Memon, A. H., Azis, A. A. A. and Abdullah, N. H. (2013). Modeling causes of cost overrun in large construction projects with partial least square-sem approach: Contractor's perspective, *Research Journal of Applied Sciences, Engineering and Technology*, vol. 5(6), pp. 1963–1972.

Abudayyeh, O., Temel, B., Al-Tabtabai, H. and Hurley, B. (2001). Intranet-based cost control system, *Advances in engineering software*, vol. 32(2), pp. 87–94.

Abu Dhabi-Government (2015). *Housing Projects Cost and Time guidelines*. Abu Dhabi Government Executive Council, pp.6-9.

Abu Dhabi-Government (2016a). *National Agenda | UAE Vision 2021*. [online] Available at: https://www.vision2021.ae/en/national-priority-areas [Accessed 21 Dec. 2016].

Abu Dhabi-Government (2016b). *The Abu Dhabi Economic Vision 2030 | About IPIC | IPIC - International Petroleum Investment Company*. [online] Available at: http://www.ipic.ae/english/about-ipic/abu-dhabi-2030-vision [Accessed 21 Dec. 2016].

Abu Dhabi-Government (2016c). Abu-Dhabi-Economic-Vision-2030, [online] Available at: http://www.tdic.ae/TDICWSAssets /En/pdf/Abu-Dhabi-Economic-Vision-2030.pdf [Accessed 21 Dec. 2016].

Abu Dhabi-Government (2016d). *Abu Dhabi Urban Planning Council - Abu Dhabi Vision 2030*. [online] Available at: http://www.upc.gov.ae/abu-dhabi-2030.aspx?lang=en-US [Accessed 21 Dec. 2016].

Abu Dhabi-Government (2016e). Plan Abu Dhabi 2030, [online] Available at: https://dot.abudhabi.ae/wcms/forms/PlanAbuDhabi2030.pdf [Accessed 21 Dec. 2016].

Abu Dhabi-Government (2016f). *SCO - The Scholarship Co-ordination Office - Abu Dhabi, Unites Arab Emirates*. [online] Available at: http://www.sco.ae/quotes.htm [Accessed 23 Dec. 2016].

Abu Dhabi-Government 2016g. *Annual Economic Report 2016*. [online] Economy.gov.ae. Available at: <https://www.economy.gov.ae/Publications/MOE%20Anual%20Repoert%20English%202016.pdf> [Accessed 1 November 2016].

Acebes, F., Pajares, J., Galán, J. M. and López-Paredes, A. (2013). Beyond Earned Value Management: A Graphical Framework for Integrated Cost, Schedule and Risk Monitoring', *Procedia - Social and Behavioral Sciences*, vol. 74(1), pp. 181–189.

Adams, R. and Bentley, D. (2012). *Capital Expenditure Forecasting Methodology*.

Adeli, H. and Karim, A. (1997). Scheduling/Cost Optimizaion and Neural Dynamics Model for Construction, *Journal of Construction Engineering and Management*, vol. 1(1), pp. 450–458.

Adeli, H. and Kim, H. (2001). Cost optimization of composite floors using neural dynamics model, *Communications in Numerical Methods in Engineering*, vol. 17(11), pp. 771–787.

Adey, B. T., Herrmann, T., Tsafatinos, K., Lüking, J., Schindele, N. and Hajdin, R. (2012). Methodology and base cost models to determine the total benefits of preservation interventions on road sections in Switzerland, *Structure and Infrastructure Engineering*, vol. 8(7), pp. 639–654.

Agyapong-Kodua, K., Ajaefobi, J. O., Weston, R. H. and Ratchev, S. (2012). Development of a multi-product cost and value stream modelling methodology, *International Journal of Production Research*, vol. 50(22), pp. 6431–6456.

Agyapong-Kodua, K. and Weston, R. H. (2011). Systems approach to modelling cost and value dynamics in manufacturing enterprises, *International Journal of Production Research*, vol. 49(8), pp. 2143–2167.

Alhamadi, A. (2020). The impacts of the introduction of Value-Added Tax in the UAE Research Project, *Abu Dhabi University Research Project*, pp. 1–44.

Ahiaga-Dagbui, D. D., Olubukola, T., Smith, S. D. and Sam, W. (2013). A NEURO-FUZZY HYBRID MODEL FOR PREDICTING FINAL COST OF WATER INFRASTRUCTURE PROJECTS', *Procs 29th Annual ARCOM Conference*, pp. 181–190.

Ahiaga-Dagbui, D. D. and Smith, S. D. (2012). NEURAL NETWORKS FOR MODELLING THE FINAL TARGET COST OF WATER PROJECTS, *Procs 28th Annual ARCOM Conference*, pp. 307–316.

Ahiaga-Dagbui, D. D. and Smith, S. D. (2014a). Dealing with construction cost overruns using data mining, *Construction Management and Economics*, vol. 32 (7–8), pp. 682–694.

Ahiaga-Dagbui, D. D. and Smith, S. D. (2013). MY COST RUNNETH OVER: DATA MINING TO REDUCE CONSTRUCTION COST OVERRUNS, *Procs 29th Annual ARCOM Conference*, pp. 559–568.

Ahiaga-Dagbui, D. D. and Smith, S. D. (2014b). EXPLORING ESCALATION OF COMMITMENT IN CONSTRUCTION PROJECT MANAGEMENT: CASE STUDY OF THE SCOTTISH PARLIAMENT PROJECT, *Procs 30th Annual ARCOM Conference*, pp. 1–11.

Ahiaga-Dagbui, D. D., Tokede, O., Morrison, J. and Chirnside, A. (2020). Building high-performing and integrated project teams, *Engineering, Construction and Architectural Management*, vol. 27(10), pp. 3341–3361.

Ahiaga-Dagbui, D. and Juffermans, T. (2019). DEVELOPING COLLABORATIVE AND LESS ADVERSARIAL PROJECT TEAMS, *THE BUILDING ECONOMIST*, vol. 3(March), pp. 43–47.

Ahiaga-Dagbui, D (2014). *RETHINKING CONSTRUCTION COST OVERRUNS: An artificial neural network approach to construction cost estimation*. PhD Thesis. Edinburgh: The University of Edinburgh, School of Construction Project Management.

Ahiaga-Dagbui, D. and Smith, S. D. (2014). Rethinking construction cost overruns: cognition, learning and estimation, *Journal of Financial Management of Property and Construction*, vol. 19(1), pp. 38–54.

Ahmed, A. kulabi and Avetisyan, H. (2016). Reducing Time and Cost of Construction Projects by Improving the Properties of Precast Normal-weight Wall Panels, *Procedia Engineering*, vol. 145(1), pp. 1066–1073.

Aiyetan, A. O., Smallwood, J. J. and Shakantu, W. (2012). A linear regression modelling of the relation- ship between initial estimated and final achieved construction time in South Africa, *Acta Structilia*, vol. 19(1), pp. 39–57.

Akintoye, A. and Fitzgerald, E. (2000). A survey of current cost estimating practices in the UK, *Construction Management and Economics*, vol. 18(2), pp. 161–172.

Akinyemi, B., Ojiako, U., Maguire, S., Steel, G. and Anyaegbunam, A. (2009). Nigerian Banks and the Perception of Risk in PPP Project Delivery, *Journal of Finance and Management*, vol. 8(2), pp. 1–20.

Akter, M. N., Mahmud, M. A. and Oo, A. M. T. (2017). Comprehensive economic evaluations of a residential building with solar photovoltaic and battery energy storage systems: An Australian case study, *Energy and Buildings*, vol. 138(1), pp. 332–346.

Alaryani, M.M (2019). *Using System Dynamics to Measure resilience for flexible pavement under the impact of climate change*. PhD Thesis. British University in Dubai, FACULTY OF ENGINEERING, School of Engineering and IT.

Al Enezy Osama, van Hassel Edwin, Sys Christa, V. T. (2017). Developing a cost calculation model for inland navigation, *Research in transportation business & management*, vol. 1(1), p. 11.

Aldwaik, M. and Adeli, H. (2016). Cost optimization of reinforced concrete flat slabs of arbitrary configuration in irregular high rise building structures, *Structural and Multidisciplinary Optimization*, vol. 54(1), pp. 151–164.

Alhamadi, A. (2020). The impacts of the introduction of Value-Added Tax in the UAE Research Project, *Abu Dhabi University Research Project*, pp. 1–44. doi: 10.13140/RG.2.2.19441.71522.

Ali, A. S. and Kamaruzzaman, S. N. (2010). Cost Performance for Building Construction Projects in Klang Valley, *Journal of Building Performance*, vol. 1(1), pp. 110–118.

Aliverdi, R., Moslemi Naeni, L. and Salehipour, A. (2013). Monitoring project duration and cost in a construction project by applying statistical quality control charts, *International Journal of Project Management*, vol. 31(3), pp. 411–423.

Al-Jibouri, S. H. (2003). Monitoring systems and their effectiveness for project cost control in construction, *International Journal of Project Management*, vol. 21(2), pp. 145–154.

Aljohani, A., Ahiaga-dagbui, D. and Moore, D. (2017). Construction Projects Cost Overrun: What Does the Literature Tell Us?, *International Journal of Innovation, Management and Technology*, vol. 8(2), pp. 137–143.

Almquist, Y. B., Ashir, S. and Brännström, L. (2014). *A guide to quantitative methods: study suide*. Sweden: Stockholm University.

Alshamrani, O. S. (2017). Prediction Model for Construction Cost of Conventional and Sustainable College Buildings in North America, *Journal of Taibah University for Science*. Taibah University, vol. 11(2), pp. 1–9.

Álvarez-García, D., Núñez, J. C., Barreiro, A. and García, T. (2017). Validation of the Cybervictimization Questionnaire (CYVIC) for adolescents, *Computers in Human Behavior*, vol. 1(1) pp. 270–281.

Alzahrani, S (2015). *Dynamic Simulation of the Impact of Risk Events and Risk Cost in KSA PPP Projects*. PhD Thesis. Liverpool, UK: University of Liverpool, Faculty of Engineering.

Alzraiee, H., Zayed, T. and Moselhi, O. (2015). Dynamic planning of construction activities using hybrid simulation, *Automation in Construction*, vol. 49(1), pp. 176–192.

An, S. H., Kim, G. H. and Kang, K. I. (2007). A case-based reasoning cost estimating model using experience by analytic hierarchy process, *Building and Environment*, vol. 42(7), pp. 2573–2579.

Anderson, M., Teisl, M., Noblet, C. and Klein, S. (2015). The incompatibility of benefit???cost analysis with sustainability science, *Sustainability Science*, vol. 10(1), pp. 33–41.

Ashrafian, T., Yilmaz, A. Z., Corgnati, S. P. and Moazzen, N. (2016). Methodology to define cost-optimal level of architectural measures for energy efficient retrofits of existing detached residential buildings in Turkey, *Energy and Buildings*, vol. 120(1), pp. 58–77.

Asif, M. (2016). Growth and sustainability trends in the buildings sector in the GCC region with particular reference to the KSA and UAE, *Renewable and Sustainable Energy Reviews*, vol. 55(1), pp. 1267–1273.

Asmussen, C. B. and Møller, C. (2019). Smart literature review: a practical topic modelling approach to exploratory literature review, *Journal of Big Data*, vol. 6(1). Pp. 1–18.

Assad, M., Hosny, O., Elhakeem, A. and El Haggar, S. (2007). Green building design in Egypt from cost and energy perspectives, *Architectural Engineering and Design Management*, vol. 11(1), pp. 21–40.

Assaf, S. A., Ai-Khalil, M. and Ai-Hazmp, M. (2009). Causes of Delay in Large Building Construction Projects, *JOURNAL OF CONSTRUCTION ENGINEERING AND MANAGEMENT*, vol. 134(11), pp. 831–841.

Asteco Property Management (2015). *Historic Review 2008-2014 And 2015 Outlook*. [online]. [Accessed 1 November 2018]. Available at: <https://www.asteco.com/eshot/pdf/2014q4/20150209_astmisc169_ research_annual_report_uae.pdf>

Atkinson, R. (1999). Project management: cost time and quality two best guesses and a phenomenon, it's time to accept other success criteria, *International Journal of Project Management*, vol. 17(6), pp. 337–342.

Attoh-Okine, N. O. (2002). Probabilistic analysis of factors affecting highway construction costs: a belief network approach, *Canadian Journal of Civil Engineering*, vol. 29(3), pp. 369–374.

Australia-Government (2020). *Capital V Revenue Expenditure Toolkit*. 2019-20 Self Assessment and Company Tax Returns. HM Revenue & Customs, pp.1-20.

Australia-Government (2017). *Total Expenditure Frameworks*. Frontier Economics Pty. Ltd., pp.1-130.

Australia-Government (2019). *Energex Regulatory Proposal 2020-2025*. Queensland: Energex, pp.1-146.

Avison, D., Lau, F., Myers, M. and Nielsen, P. A. (1999). Action research To make academic research relevant, researchers should try out their theories with practitioners in real situations and real organizations, *Communications of the ACM*, vol. 42(1), pp. 94–97.

Ayangade, J. A., Wahab, A. B. and Alake, O. (2009). An Investigation of the Performance of Due Process Mechanism in the Execution of Construction Projects in Nigeria, *Civil Engineering Dimension*, vol. 11(1), pp. 1–7.

Aziz, R. F. and Abdel-Hakam, A. A. (2016). Exploring delay causes of road construction projects in Egypt, *Alexandria Engineering Journal*, vol. 55(2), pp. 1515–1539.

Babashamsi, P., Md Yusoff, N. I., Ceylan, H., Md Nor, N. G. and Salarzadeh Jenatabadi, H. (2016). Evaluation of pavement life cycle cost analysis: Review and analysis, *International Journal of Pavement Research and Technology*, vol. 9(4), pp. 241–254.

Babu, A. J. G. and Suresh, N. (1996). Project management with time, cost, and quality considerations, *European Journal of Operational Research*, vol. 88(2), pp. 320–327.

Bacharach, S. B. (1989). Organizational theories: Some criteria for evaluation, *Academy of Management Review*, vol. 14(4), pp. 496–515.

Bachmann, C., Biel, W., Ciattaglia, S., Federici, G., Maviglia, F., Mazzone, G., Ramogida, G., Villone, F. and Taylor, N. (2017). Initial definition of structural load conditions in DEMO, *Fusion Engineering and Design*. Elsevier B, vol. 124(1), pp. 633–637.

Bagnara, M., Oijen, M. Van, Cameron, D., Gianelle, D., Magnani, F. and Sottocornola, M. (2018). Bayesian calibration of simple forest models with multiplicative mathematical structure : A case study with two Light Use Efficiency models in an alpine forest, *Ecological Modelling*, vol. 1(1), pp. 90–100.

Bain, L. and Engelhardt, M. (1991). STATISTICAL ANALYSIS OF RELIABILITY AND LIFE-TESTING MODELS.

Ballarini, I., Corrado, V., Madonna, F., Paduos, S. and Ravasio, F. (2017). Energy refurbishment of the Italian residential building stock: energy and cost analysis through the application of the building typology, *Energy Policy*, vol. 105(July 2016), pp. 148–160.

Baloi, D. and Price, A. D. F. (2003). Modelling global risk factors affecting construction cost performance, *International Journal of Project Management*, vol. 21(4), pp. 261–269.

Banihashemi, S., Hosseini, M. R., Golizadeh, H. and Sankaran, S. (2017). Critical success factors (CSFs) for integration of sustainability into construction project management practices in developing countries, *International Journal of Project Management*, vol. 1(1), pp. 1–17.

Bari, N. A. A., Yusuff, R., Ismail, N., Jaapar, A. and Ahmad, R. (2012). Factors Influencing the Construction Cost of Industrialised Building System (IBS) Projects, *Procedia - Social and Behavioral Sciences*, vol. 35(12), pp. 689–696.

Barnes, D. (2001). Research methods for the empirical investigation of the process of formation of operations strategy, *International Journal of Operations and Production Management*, vol. 21(8), pp. 1076–1095.

Barratt, M., Choi, T. Y. and Li, M. (2011). Qualitative case studies in operations management: Trends, research outcomes, and future research implications, *Journal of Operations Management*, vol. 29(4), pp. 329–342.

Barratt, M. J. (2012). The efficacy of interviewing young drug users through online chat, *Drug and Alcohol Review*, vol. 31(4), pp. 566–572.

Bates, B. Y. A. and Holt, L. T. (2011). Large, Complex Construction Disputes: The Dynamics of Multi-party Mediation, *Dispute Resolution Journal*, vol. 62(2), pp. 36–41.

Battistoni, G., Genco, M., Marsilio, M., Pancotti, C., Rossi, S. and Vignetti, S. (2016). Cost–benefit analysis of applied research infrastructure. Evidence from health care, *Technological Forecasting and Social Change*, vol. 112(1), pp. 79–91.

Bauer, B., Koppelhuber, J., Wall, J. and Heck, D. (2017). Impact Factors on the Cost Calculation for Building Services within the Built Environment, *Procedia Engineering*, vol. 171(1), pp. 294–301.

Becchio, C., Ferrando, D. G., Fregonara, E., Milani, N., Quercia, C. and Serra, V. (2016). The cost-optimal methodology for the energy retrofit of an ex-industrial building located in Northern Italy, *Energy and Buildings*, vol. 127(1), pp. 590–602.

Belay, A. M., Torp, O., Thodesen, C. and Odeck, J. (2016). A framework for Organizing a Resilient Cost Benefit Analysis for Construction Projects, *Procedia Engineering*, vol. 145(1877), pp. 1169–1176.

Benbasat, I., Goldstein, D. K. and Mead, M. (1987). The Case Research Strategy in Studies of Information Systems Case Research, *MIS Quarterly*, vol. 11(3), pp. 369–386.

Benjaoran, V. (2009). A cost control system development: A collaborative approach for small and medium-sized contractors, *International Journal of Project Management*, vol. 27(3), pp. 270–277.

Berg, A. C., Bank, L. C., Oliva, M. G. and Russell, J. S. (2006). Construction and cost analysis of an FRP reinforced concrete bridge deck, *Construction and Building Materials*, vol. 20(8), pp. 515–526.

Bham, G (2016). Dubai Residential Property Market Review: Putting Current Prices & Trends In Perspective. [online]. [Accessed 25 October 2020]. Lookup.ae – Real Estate. Real Information. Available at: <https://lookup.ae/article/15/dubai-residential-property-market-review-putting-current-prices-trends-in-perspective>

Bhardwaj, P. (2019). Types of sampling in research, *Journal of the Practice of Cardiovascular Sciences*, vol. 5(3), pp. 157–163.

Bigsten, A. (2016). The Development of Development Economics, *Working Papers in Economics*, vol. 2473(653), pp. 1–28.

Binders, M. and Edwards, J. S. (2010). Using grounded theory method for theory building in operations management research: A study on inter-firm relationship governance, *International Journal of Operations and Production Management*, vol. 30(3), pp. 232–259.

Blair, J. and Conrad, F. G. (2011). SAMPLE SIZE FOR COGNITIVE INTERVIEW PRETESTING, *Public Opinion Quarterly*, vol. 75(4), pp. 636–658.

Boateng, P 2014, *A Dynamic Systems Approach to Risk Assessment in Megaprojects*. PhD Thesis. Edinburgh, UK: Heriot-Watt University, School of Energy, Geoscience, Infrastructure and Society.

Bogen, K. (1994). *THE EFFECT OF QUESTIONNAIRE LENGTH ON RESPONSE RATES -- A REVIEW OF THE LITERATURE, U.S. Bureau of the Census*.

Bovsunovskaya, M. (2016). Document Support of Cost Management in Underground Construction Projects, *Procedia Engineering*, vol. 165(1), pp. 960–964.

Boncz, I., Ágoston, I., Csákvári, T., Endrei, D., Gulácsi, L., Kívés, Z. H., Lampek, K., Péntek, M., Traiber-Harth, I. and Vajda, R. (2017). *Introduction to research methodology*. Hungary: University of Pécs.

Boyer, K. K., Olson, J. R., Calantone, R. J. and Jackson, E. C. (2002). Print versus electronic surveys: A comparison of two data collection methodologies, *Journal of Operations Management*, vol. 20(4), pp. 357–373.

Boyer, K. K. and Pagell, M. (2000). Measurement issues in empirical research: Improving measures of operations strategy and advanced manufacturing technology, *Journal of Operations Management*, vol. 18(3), pp. 361–374.

Boyer, K. K. and Swink, M. L. (2008). Empirical elephants: why multiple methods are essential to quality research in operations and supply chain management, *Journal of Operations Management*, vol. 26(1), pp. 337–348.

Brunnström, K. and Barkowsky, M. (2018). Statistical quality of experience analysis : on planning the sample size and statistical significance testing, *Journal of Electronic Imaging*, vol. 27(5), pp. 1–11.

Bujang, M. A. and Baharum, N. (2016). Sample Size Guideline for Correlation Analysis, *World Journal of Social Science Research*, vol. 3(1), p. 37–46.

Bukaçi, E., Korini, T., Periku, E., Allkja, S. and Sheperi, P. (2016). Number of iterations needed in Monte Carlo Simulation using reliability analysis for tunnel supports, *Int. Journal of Engineering Research and Applications*, vol. 6(6), pp. 60–64.

Burns, E., Prigerson, H. G., Quinn, S. J., Abernethy, A. P. and Currow, D. C. (2018). Moving on: Factors associated with caregivers' bereavement adjustment using a random population-based face-to-face survey, *Palliative Medicine*, vol. 32(1), pp. 257–267.

Burns, T. J., Page, C., Haven, L., Rita, A. and Pryor, G. M. (1993). Totally Integrated Construction Cost Estimating, Analysis, and Reporting System, *U.S PATENT DOCUMENTS*, vol. 1(1), pp. 1–31.

Bustreo, C., Bolzonella, T. and Zollino, G. (2015). The Monte Carlo approach to the economics of a DEMO-like power plant, *Fusion Engineering and Design*, vol. 98–99, pp. 2108–2111.

Busygin, S. V, Voytishek, A. V, Kablukova, E. G. and Efremov, A. I. (2008). Discrete Stochastic Consistent Estimators of the Monte Carlo Method, *Computational Mathematics and Mathematical Physics*, vol. 48(9), pp. 1543–1555.

Cabitza, F., Ciucci, D. and Locoro, A. (2016). Exploiting Collective Knowledge with three-way decision theory. Cases from the questionnaire-based research, *International Journal of Approximate Reasoning*, vol. 83(November), pp. 356–370.

Caffo, B. S., Jank, W. and Jones, G. L. (2005). Ascent-based Monte Carlo expectation – maximization, *Royal Statistical Society*, vol. 67(2), pp. 235–251.

Cai, J., Liu, W., Huang, C., Wang, X., Shen, L., Zou, Z., Hu, Y., Sun, C., Wei, X., Chang, J., Zhao, Z., Sun, Y. and Sundell, J. (2016) 'Validity of subjective questionnaire in evaluating dwelling characteristics, home dampness, and indoor odors in Shanghai, China: Cross-sectional survey and on-site inspection', *Energy and Buildings*, vol. 127(1), pp. 1019–1027.

Cai, Y. and Hames, D. (2011). Minimum sample size determination for generalized extreme value distribution, *Communications in Statistics - Simulation and Computation*, vol. 40(1), pp. 87–98.

Cambini, C., Congiu, R. and Soroush, G. (2020). Regulation, Innovation, and Systems Integration: Evidence from the EU, *energies*, vol. 13(1670), pp. 1–18.

Campus, F. (2004). Comparing telephone and face-to-face qualitative interviewing: a research note JUDITH, *Qualitative Research*, vol. 4(1), pp. 107–118.

CANE, M. A. (2019). Myeloperoxidase-463G/A polymorphism in patients with diabetic nephropathy in Sikkim, India, *Current Science*, vol. 117(11), pp. 1768–1769.

Canesi, R. and Marella, G. (2017). Residential construction cost: An Italian survey, *Data in Brief*, vol. 11(1), pp. 231–235.

Carlile, P. R. and Christensen, C. M. (2005). The Cycles of Theory Building in Management Research The Cycles of Theory Building in Management Research, *Building*.

Carter, C. R., Sanders, N. R. and Dong, Y. (2008). Paradigms, revolutions, and tipping points: The need for using multiple methodologies within the field of supply chain management, *Journal of Operations Management*, vol. 26(6), pp. 693–696.

Cassell, C. and Symon, G. (2004). Essential Guide to Qualitative Methods in Organizational Research, *Athenaeum Studi Periodici Di Letteratura E Storia Dell Antichita*.

Cassettari, L., Mosca, M., Mosca, R., Rolando, F., Costa, M. and Pisaturo, V. (2016). IVF cycle cost estimation using Activity Based Costing and Monte Carlo simulation, *Health Care Management Science*, vol. 19(1), pp. 20–30.

Cavazzini, G., Santolin, A., Pavesi, G. and Ardizzon, G. (2016). Accurate estimation model for small and micro hydropower plants costs in hybrid energy systems modelling, *Energy*, vol. 103(1), pp. 746–757.

Chang, C. and Ko, J. (2012). New Approach to Estimating the Standard Deviations of Lognormal Cost Variables in the Monte Carlo Analysis of Construction Risks, *Journal of Construction Engineering and Management*, vol. 143(1), pp. 1–22.

Chapman, R. J. (1998). The role of system dynamics in understanding the impact of changes to key project personnel on design production within construction projects, *International Journal of Project Management*, vol. 16(4), pp. 235–247.

Charles Donovan, D. and Corbishley, C. (2016). The cost of capital and how it affects climate change mitigation investment, *Imperial College London Grantham Briefing Papers*, vol. 1(15), pp. 1–16.

Chen, K., Lei, H., Li, G., Huang, W. and Mu, L. (2015). Cash incentives improve participation rate in a face-to-face survey: an intervention study, *Journal of Clinical Epidemiology*, vol. 68(1), pp. 228–233.

Cheng, Y. M. (2014). An exploration into cost-influencing factors on construction projects, *International Journal of Project Management*, vol. 32(5), pp. 850–860.

Cheung, F. K. T., Rihan, J., Tah, J., Duce, D. and Kurul, E. (2012). Early stage multi-level cost estimation for schematic BIM models, *Automation in Construction*, vol. 27(1), pp. 67–77.

Cho, K., Hong, T. and Hyun, C. (2010). Integrated Schedule and Cost Model for Repetitive Construction Process, *Journal of Management in Engineering*, vol. 26(2), pp. 78–88.

Choopojcharoen, T. and Magzari, A. (2012). Mathematics behind System Dynamics. *Worcester Polytechnic Institute*, pp. 1–102.

Chou, J. S. (2011). Cost simulation in an item-based project involving construction engineering and management, *International Journal of Project Management*, vol. 29(6), pp. 706–717.

Chowdhury, A., Sharma, K. and Platz, D. (2016). Public-Private Partnerships and the 2030 Agenda for Sustainable Development: Fit for purpose?, *UNITED NATIONS Department of Economic and Social Affairs*, pp. 1–30.

Clifton, D (2016). *Construction Intelligence Report: United Arab Emirates*. [online]. [Accessed 19 Dec. 2016]. Available at: https://www.fgould.com/middle-east/articles/construction-intelligence-report-uae-04-16/.

Cicmil, S., Williams, T., Thomas, J. and Hodgson, D. (2006). Rethinking Project Management: Researching the actuality of projects, *International Journal of Project Management*, vol. 24(8), pp. 675–686.

Cocks, K. and Torgerson, D. J. (2013). Sample size calculations for pilot randomized trials: a confidence interval approach, *Journal of Clinical Epidemiology*, vol. 66(2), pp. 197–201.

Cohen, M. A. and Kunreuther, H. (2007). Operations risk management: Overview of Paul Kleindorfer's contributions, *Production and Operations Management*, vol. 16(5), pp. 525–541.

Coluci, M. Z. O., Alexandre, N. M. C. and Rosecrance, J. (2009). Reliability and validity of an ergonomics-related Job Factors Questionnaire, *International Journal of Industrial Ergonomics*, vol. 39(6), pp. 995–1001.

Cople, D. G. and Brick, E. S. (2010). A simulation framework for technical systems life cycle cost analysis, *Simulation Modelling Practice and Theory*, vol. 18(1), pp. 9–34.

Cottereau, T. (2014) 'The Future of Live Video Interviews for Recruitment', *Workforce Solutions Review*, vol. 3(1), pp. 33–36.

Cottrell, E., Roddy, E., Rathod, T., Thomas, E., Porcheret, M. and Foster, N. E. (2015). Maximising response from GPs to questionnaire surveys: do length or incentives make a difference?, *BMC Medical Research Methodology*, vol. 15(3), pp. 1–7.

Coughlan, P. and Coghlan, D. (2002). Action research for operations management, *International Journal of operations & Production Management*, vol. 22(2), pp. 220–240.

Creba, A. (2019). Demolition and deconstruction legacies: Toronto's Honest Ed's and Mirvish Village, *Journal of Cultural Heritage Management and Sustainable Development*, vol. 10(1), pp. 52–64.

Cristóbal, J. R. S. (2017). The S-curve envelope as a tool for monitoring and control of projects', *Procedia Computer Science*, vol. 121(1), pp. 756–761.

Crouch, M. and McKenzie, H. (2006). The logic of small samples in interview-based qualitative research, *Social Science Information*, vol. 45(4), pp. 483–499.

Currall, S. C., Hammer, T. H., Baggett, L. S. and Doniger, G. M. (1999). Combining Qualitative and Quantitative Methodologies to Study Group Processes: An Illustrative Study of a Corporate Board of Directors, *Organizational Research Methods*, vol. 2(1), pp. 5–36.

Cui, Q (2005). *DYNAMIC MODEL FOR PROFITABILITY ANALYSIS OF CONSTRUCTION FIRMS: TOWARDS COMPLEXITY, LEARNING, AND UNCERTAINTY*. PhD Thesis. United States: ProQuest Information and Learning Company, Graduate School.

Darby, J. L. (2010). Sample Sizes for Confidence Limits for Reliability, *SANDIA REPORT*, pp. 1–28.

De Resende, C. C., Pereira, A. C. M., Cardoso, R. T. N. and de Magalhães, A. R. B. (2017). Investigating market efficiency through a forecasting model based on differential equations, *Physica A: Statistical Mechanics and its Applications*, vol. 474, pp. 199–212.

Delice, A. (2010). The sampling issues in quantitative research, *Educational Sciences: Theory & Practices*, vol. 10(4), pp. 2001–2019.

Delmastro, C., Mutani, G. and Corgnati, S. P. (2016). A supporting method for selecting cost-optimal energy retrofit policies for residential buildings at the urban scale, *Energy Policy*, vol. 99(1), pp. 42–56.

Deloitte (2018). *Middle East Real Estate Predictions: Dubai 2018*. [online]. [Accessed 1 November 2018]. Available at: <https://www2.deloitte.com/content/dam/Deloitte/xe/Documents/realestate/me_re_real-estate-predictions-2018.pdf>

DeSoto, K. A. and Roediger, H. L. (2014). Positive and Negative Correlations Between Confidence and Accuracy for the Same Events in Recognition of Categorized Lists, *Psychological Science*, vol. 25(3), pp. 781–788.

DiCicco-Bloom, B. and Crabtree, B. F. (2006). The qualitative research interview, *Medical Education*, vol. 40(4), pp. 314–321.

Dikmen, I., Birgonul, M. T. and Han, S. (2007). Using fuzzy risk assessment to rate cost overrun risk in international construction projects, *International Journal of Project Management*, vol. 25(5), pp. 494–505.

Dillman, D. A., Phelps, G., Tortora, R., Swift, K., Kohrell, J., Berck, J. and Messer, B. L. (2009). Response rate and measurement differences in mixed-mode surveys using mail, telephone, interactive voice response (IVR) and the Internet, *Social Science Research*, vol. 38(1), pp. 1–18.

Dillman, D., Sinclair, M. and Clark, J. (1993). Effects of Questionnaire Length Respondent-Friendly Design, and a Difficult Question on Response Rate for Occupant-Addressed Census Mail Surveys, *American Association for Opinion Research*, vol. 57(1), pp. 289–304.

Diskiene, D., Galiniene, B. and Marcinskas, A. (2008). A strategic management model for economic development, *Technological and Economic Development of Economy*, vol. 14(3), pp. 375–387.

Doan, D. T. and Chinda, T. (2016). Modeling Construction and Demolition Waste Recycling Program in Bangkok: Benefit and Cost Analysis, *Journal of Construction Engineering and Management*, vol. 142(12), pp. 1–11.

Doloi, H. (2012). Understanding impacts of time and cost related construction risks on operational performance of PPP projects, *International Journal of Strategic Property Management*, vol. 16(3), pp. 316–337.

Doloi, H. K. (2011). Understanding stakeholders' perspective of cost estimation in project management, *International Journal of Project Management*, vol. 29(5), pp. 622–636.

Dowd, K. and Cotter, J. (2007). Exponential Spectral Risk Measures, *Journal of Economic Literature*, vol. 15(1), pp. 1–16.

Dowlatshahi, S. (2010). A cost-benefit analysis for the design and implementation of reverse logistics systems: case studies approach, *International Journal of Production Research*, vol. 48(5), pp. 1361–1380.

Dyer, W. G. and Wilkins, A. L. (1991). Better Stories, Not Better Constructs, to Generate Better Theory: A Rejoinder to Eisenhardt BETTER STORIES, NOT BETTER CONSTRUCTS, TO GENERATE BETTER THEORY: A REJOINDER TO EISENHARDT, *Academy of Managemenf Revlew*, vol. 16(3), pp. 613–619.

Dubai-Government (2016). Dubai-Industrial-Strategy-2030, [online]. [Accessed 21 Dec. 2016]. Available at: http://www.dubaiplan2021.ae/wp-content/uploads/2016/06/Dubai-Industrial-Strategy-2030.pdf

Dubailand 2013. *DUBAI REAL ESTATE LEGISLATION*. [online]. [Accessed 29 January 2020]. Available at: <https://dubailand.gov.ae/media/zrrd4qw4/en-legislation.pdf>

Dubai-Municipality (2020). *Design Life Extension of Rc Structures Arabic part2*. Dubai Government, pp.1-144.

Easton, G. (2010). Critical realism in case study research, *Industrial Marketing Management*, vol. 39(1), pp. 118–128.

Eckman, D, Cavaluzzi, G, & Rabasca, A (2014). Engineers Joint Contract Documents Committee. 2020. *Construction Documents For Future Of Infrastructure*. [online]. [Accessed 25 October 2020]. Available at: <https://www.ejcdc.org/>

Eden, C., Williams, T. and Ackermann, F. (2005). Analysing project cost overruns: Comparing the "measured mile"; analysis and system dynamics modelling, *International Journal of Project Management*, vol. 23(2), pp. 135–139.

Eid, M. S., Moghrabi, C. and Eldin, H. K. (1997). A simulation approach to evaluating quality/cost decision scenarios, *Computers & Industrial Engineering*, vol. 33(1–2), pp. 105–108.

Eisenhardt, K. M. (1991). Better stories and better constructs: The case for rigor and comparative logic, *Academy of Management Review*, vol. 16(3), pp. 620–627.

Eisenhardt, K. M. (1989). Building theories from case study research, *Academy of Management Review1*, vol. 14(4), pp. 532–550.

Elhag, T. M. S., Boussabaine, A. H. and Ballal, T. M. A. (2005). Critical determinants of construction tendering costs: Quantity surveyors' standpoint, *International Journal of Project Management*, vol. 23(7), pp. 538–545.

El-Sawy, I., Hosny, H. and Abdel-Razek, M. (2011). A Neural Network Model for Construction Projects Site Overhead Cost Estimating in Egypt, *International Journal of Computer Science Issues*, vol. 8(3), pp. 273–283.

Emirates 24|7 (2016). *Dazzle the world, Mohammed tells Expo Dubai panel*. [online]. [Accessed 23 Dec. 2016]. Available at: http://www.emirates247.com/news/government/dazzle-the-world-mohammed-tells-expo-dubai-panel-2015-06-10-1.593369

Fan, W. and Yan, Z. (2010). Factors affecting response rates of the web survey: A systematic review', *Computers in Human Behavior*, vol. 26(2), pp. 132–139.

Fanning, E. (2005). Formatting a Paper-based Survey Questionnaire: Best Practices, *A peer-reviewed electronic journal*, vol. 10(12), pp. 1–14.

Federici, G., Bachmann, C., Barucca, L., Biel, W., Boccaccini, L., Brown, R., Bustreo, C., Ciattaglia, S., Cismondi, F., Coleman, M., Corato, V., Day, C., Diegele, E., Fischer, U., Franke, T., Gliss, C., Ibarra, A., Kembleton, R., Loving, A., Maviglia, F., Meszaros, B., Pintsuk, G., Taylor, N., Tran, M. Q., Vorpahl, C., Wenninger, R. and You, J. H. (2018). DEMO design activity in Europe: Progress and updates, *Fusion Engineering and Design*, vol. 136(April), pp. 729–741.

Fernández, E. A., Igúzquiza, V. D. de R., Lautre, I. G. and Calvo, I. L. (2012). Face to face and telephone surveys in terms of sampling representativeness: a multidimensional analysis, *Qual Quant*, vol. 46(1), pp. 303–313.

Feuillette, S., Levrel, H., Boeuf, B., Blanquart, S., Gorin, O., Monaco, G., Penisson, B. and Robichon, S. (2016). The use of cost-benefit analysis in environmental policies: Some issues raised by the Water Framework Directive implementation in France, *Environmental Science and Policy*, vol. 57(1), pp. 79–85.

Filippini, R. (1997). Operations management research: Some reflections on evolution, models and empirical studies in OM, *International Journal of Operations & Production Management*, vol. 17(7–8), p. 655–670.

Filippini, R. and Voss, C. (1997). Survey research in operations management, *International Journal of Operations & Production Management*, vol. 17(7–8), pp. 652–654.

Fleming, C. M. and Bowden, M. (2009). Web-based surveys as an alternative to traditional mail methods, *Journal of Environmental Management*, vol. 90(1), pp. 284–292.

Flores-Colen, I., de Brito, J. and Freitas, V. (2010). Discussion of Criteria for Prioritization of Predictive Maintenance of Building Façades: Survey of 30 Experts, *Journal of Performance of Constructed Facilities*, vol. 24(4), pp. 337–344.

Florio, M., Forte, S. and Sirtori, E. (2016). Forecasting the Socio-Economic Impact of the Large Hadron Collider: a Cost-Benefit Analysis to 2025 and Beyond, *Technological Forecasting & Social Change*, vol. 112(1), p. 28.

Florio, M. and Sirtori, E. (2016). Social benefits and costs of large scale research infrastructures, *Technological Forecasting and Social Change*, vol. 112, pp. 65–78.

Flynn, B. (1990). Empirical research methods in operations management, *Journal of Operations Management*, vol. 9(2), pp. 250–284.

Flyvbjerg, B. (2016). Five Misunderstandings About Case-Study Research, *Qualitative Inquiry*, vol. 12(2), pp. 219–245.

Flyvbjerg, B. (2005). Policy and Planning for Large Infrastructure Projects: Problems, Causes, Cures, *World Bank Policy Research Working Paper*.

Flyvbjerg, B., Ansar, A., Budzier, A., Buhl, S., Cantarelli, C., Garbuio, M., Glenting, C., Skamris, M., Lovallo, D., Lunn, D., Molin, E., Rønnest, A., Stewart, A. and Wee, B. Van (2018). Five things you should know about cost overrun, *Transportation Research Part A journal*, vol. 118(July), pp. 174–190.

Flyvbjerg, B. B., Holm, M. S. and Buhl, S. (2002). Cost Underestimation in Public Works Projects: Error or Lie?, *Journal of the American Planning Association*, vol. 63(3), pp. 279–295.

Fogsgaard, K. K., Herskin, M. S., Gorden, P. J., Timms, L. L., Shearer, J. K. and Millman, S. T. (2016). Management and design of hospital pens relative to behavior of the compromised dairy cow: A questionnaire survey of Iowa dairy farms, *Applied Animal Behaviour Science*, vol. 175(1), pp. 50–55.

Forza, C. (2002). Survey research in operations management: a process-based perspective, *International Journal of Operations & Production Management*, vol. 22(2), pp. 152–194.

Fransoo, J. W. M. B. J. C., Bertrand, J. W. and Fransoo, J. W. M. B. J. C. (2002). Operations management research methodologies using quantitative modeling, *International Journal of Operations & Production Management*, vol. 22(2), p. 241.

Friedler, E. and Pisanty, E. (2006). Effects of design flow and treatment level on construction and operation costs of municipal wastewater treatment plants and their implications on policy making, *Water Research*, vol. 40(20), pp. 3751–3758.

Frimpong, Y., Oluwoye, J. and Crawford, L. (2003). Causes of delay and cost overruns in construction of groundwater projects in a developing countries; Ghana as a case study, *International Journal of Project Management*, vol. 21(5), pp. 321–326.

Fujairah-Government (2020). *Fujairah 2040 Plan - The Official Portal Of The UAE Government*. [online]. [Accessed 18 October 2019]. Available at: <https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/local-governments-strategies-and-plans/fujairah-2040-plan#:~:text=Fujairah%202040%20Plan%20focuses%20on,cost%20of%20AED%201.5%20billion.>

Galvan, J. L. (2002). *Writing literature reviews*. Oxfordshire: Taylor & Francis Group.

Galesic, M. and Bosnjak, M. (2009). EFFECTS OF QUESTIONNAIRE LENGTH ON PARTICIPATION AND INDICATORS OF RESPONSE QUALITY IN A WEB SURVEY, *Oxford University Press on behalf of the American Association for Public Opinion Research*, vol. 73(2), pp. 349–360.

García, H., Valles, A., Sánchez, J., Noriega, S. and Dominguez, G. (2016). Statistical equation modeling analysis for industrial projects, designing for critical factors and latent variables: quality, cost, time, and success, *The International Journal of Advanced Manufacturing Technology*, vol. 1(4090), pp. 1–13.

Gardiner, P. D. and Stewart, K. (2000). Revisiting the golden triangle of cost, time and quality: the role of NPV in project control, success and failure, *International Journal of Project Management*, vol. 18(4), pp. 251–256.

Geissmann, T. (2017). A probabilistic approach to the computation of the levelized cost of electricity, *Energy*, vol. 124(1), pp. 372–381.

Gilbert, A., Sovacool, B. K., Johnstone, P. and Stirling, A. (2016). Cost overruns and financial risk in the construction of nuclear power reactors: A critical appraisal, *Energy Policy*, vol. 102(1), pp. 644–649.

Gill, P., Stewart, K., Treasure, E. and Chadwick, B. (2008). Methods of data collection in qualitative research: interviews and focus groups, *BRITISH DENTAL JOURNAL*, vol. 204(6), pp. 291–295.

Glasow, P. (2005). *Fundamintals of Survey Research Methodology*. Washington C3 center: MITRE, pp. 1–20.

Gniel, A. (2012). *Operating Expenditure Forecasting Methodology*. [online]. [Accessed 2 November 2019]. Aer.gov.au. Available at: <https://www.aer.gov.au/system/files/Appendix%20R%20-%20Opex%20Modelling%20Methodology.pdf>

Golafshani, N. (2003). Understanding reliability and validity in qualitative research, *The Qualitative Report*, vol. 8(4), pp. 597–607.

Golenko-Ginzburg, D., Laslo, Z., Ben-Yair, A. and Baron, A. (2006). Optimizing budget allocation among project activities, *Journal of Business Economics and Management*, vol. 7(1), pp. 17–20.

Gonçalves, A., Sousa, P. and Zacarias, M. (2013). Using DEMO and Activity Theory to Manage Organization Change, *Procedia Technology*, vol. 9(1), pp. 563–572.

Graham, C. and Talay, D. (2013). *Stochastic Simulation and Monte Carlo Method*, Springer Heidelberg.

Guo, Z. and Sultan, S. A. (2017). Feasibility of perpetual pavement stage construction in China: A life cycle cost analysis, *International Journal of Transportation Science and Technology*, vol. 1(1), pp. 1–9.

Hardcastle, C (1992). *An Information Model of the Construction Cost Estimating Process*. PhD Thesis. Edinburgh: Heriot Watt University, Department of Building.

Harvey, J. (1979). *Competitive Bidding on Canadian Public Construction Contracts: Stochastic Analysis for Optimization*. Thesis (PhD). University of Western Ontario

Hafez, S. M., Aziz, R. F. and Eldars, E. A. (2015). Construction Cost Prediction by Using Building Information Modeling, *Int. Journal of Engineering Research and Applications*, vol. 5(8), pp. 67–77.

Hamaker, J. W. and Componation, P. J. (2005). Improving Space Project Cost Estimating With Engineering Management Variables, *Engineering Management Journal*, vol. 17(2), pp. 28–33.

Hammersley, M. (2003). Recent radical criticism studies of interview any implications for the sociology of education, *British Journal of Sociology of Education*, vol. 24(1), pp. 119–126.

Han, G., Srebric, J. and Enache-Pommer, E. (2014). Variability of optimal solutions for building components based on comprehensive life cycle cost analysis, *Energy and Buildings*, vol. 79(1), pp. 223–231.

Hancock, B. (1998). *Trent Focus for Development in Primary Health Care An Introduction to Qualitative Research An Introduction to Qualitative*, Division of General Practice University of Nottingham.

Handfield, R. and Melnyk, S. A. (1998). The scientific theory-building process: a primer using the case of TQM, *Journal of Operations Management*, vol. 16(4), pp. 321–339.

Harmeyer, D. (2010). Reviving the reference interview: From desk to chat to phone, *Reference Librarian*, vol. 51(2), pp. 163–166.

Harms, C., Jackel, L. and Montag, C. (2017). Reliability and completion speed in online questionnaires under consideration of personality, *Personality and Individual Differences*, vol. 111(1), pp. 281–290.

Steward, B. (2014). Writing a literature review, *British Journal of Occupational Therapy*, vol. 67(11), pp. 137–155.

Hasançebi, O. (2017). Cost efficiency analyses of steel frameworks for economical design of multi-storey buildings, *Journal of Constructional Steel Research*, vol. 128(1), pp. 380–396.

Heijungs, R. (2020). On the number of Monte Carlo runs in comparative probabilistic LCA, *The International Journal of Life Cycle Assessment*, vol. 25(1), pp. 394–402.

Henry, S. G. and Fetters, M. D. (2012). Research Method for Investigating Physician-Patient Interactions, *Annals of Family Medicine*, vol. 10(2), pp. 118–126.

Heralova, R. S. (2014). Life Cycle Cost optimization within decision making on alternative designs of public buildings, *Procedia Engineering*, vol. 85(1), pp. 454–463.

Hernandez-Sancho, F., Molinos-Senante, M. and Sala-Garrido, R. (2010). Cost modelling for wastewater treatment processes, *Desalination*, vol. 268(1), pp. 1–5.

Hernández-Sancho, F. and Sala-Garrido, R. (2009). Technical efficiency and cost analysis in wastewater treatment processes: A DEA approach, *Desalination*, vol. 249(1), pp. 230–234.

Herzog, R. and Bachman, J. (1981). Effects of Questionnaire Length on Response Quality, *Public Opinion Quarterly*, vol. 45(1), pp. 549–559.

Hess, J., Moore, J., Pascale, J. and Rothgeb, J. (2001). THE EFFECTS OF PERSON-LEVEL VERSUS HOUSEHOLD-LEVEL QUESTIONNAIRE DESIGN ON SURVEY ESTIMATES AND DATA QUALITY, *U.S. Census Bureau I. Introduction and Background II. Research Methods and Procedures*, vol. 1(1), pp. 574–584.

Hoddinott, S. N. and Bass, M. J. (1986). The Diliman Total Design Survey Method: A Sure-Fire way to Get High Survey Return Rates, *CAN. FAM. PHYSICIAN*, vol. 32(11), pp. 2366–2368.

Hoffman, I. M., Goldman, C. A., Rybka, G., Leventis, G., Schwartz, L., Sanstad, A. H. and Schiller, S. (2017). Estimating the cost of saving electricity through U.S. utility customer-funded energy efficiency programs, *Energy Policy*, vol. 104(September 2016), pp. 1–12.

Hong, T., Hyun, C. and Moon, H. (2011). CBR-based cost prediction model-II of the design phase for multi-family housing projects, *Expert Systems with Applications*, vol. 38(3), pp. 2797–2808.

Horta, I. M., Camanho, A. S. and Moreira Da Costa, J. (2012). Performance assessment of construction companies: A study of factors promoting financial soundness and innovation in the industry, *International Journal of Production Economics*, vol. 137(1), pp. 84–93.

Howell, G. and Koskela, L. (2000). Reforming project management: the role of lean construction, *Proceedings of the 8th Annual Conference of the International Group for Lean Construction*. Brighton, UK, 17-19 Jul 2000.

Hu, W. and He, X. (2014). An innovative time-Cost-Quality tradeoff modeling of building construction project based on resource allocation, *The Scientific World Journal*. Hindawi Publishing Corporation, vol. 1(1), pp. 1–10.

Huang, H. M. (2006). Do print and Web surveys provide the same results?, *Computers in Human Behavior*, vol. 22(3), pp. 334–350.

Huang, X., Tian, G. L., Liu, Y. and Yu, J. W. (2015). Type IIcombination questionnaire model: A new survey design for a totally sensitive binary variable correlated with another nonsensitive binary variable, *Journal of the Korean Statistical Society*, vol. 44(3), pp. 432–447.

Hunter, H., Fitzgerald, R. and Barlow, D. (2014). Improved cost monitoring and control through the Earned (B)crOSsMark Value Management System, *Acta Astronautica*, vol. 93(1), pp. 497–500.

Hurt, M. A. and Schrock, S. D. (2016). Bridge Life Cycle Costing, in Highway Bridge Maintenance Planning and Scheduling. *Elsevier Inc.*, 255–287

Hwang, S. and Asce, M. (2011). Time Series Models for Forecasting Construction Costs Using Time Series Indexes, *JOURNAL OF CONSTRUCTION ENGINEERING AND MANAGEMENT*, vol. 137(September), pp. 656–662.

Hyari, K. H., Al-daraiseh, A. and El-mashaleh, M. (2016). Conceptual Cost Estimation Model for Engineering Services in Public Construction Projects, *Journal of Management in Engineering*, vol. 32(1), pp. 1–9.

Ibanez-Lopez, A. S., Martinez-Val, J. M. and Moratilla-Soria, B. Y. (2017). A dynamic simulation model for assessing the overall impact of incentive policies on power system reliability, costs and environment, *Energy Policy*, vol. 102(March 2016), pp. 170–188.

Ibn-Homaid, N. . and Tijani, I. A. (2015). Financial Analysis of a Construction Company in Saudi Arabia, *International Journal of Construction Engineering and Management*, vol. 4(3), pp. 80–86.

Ioannou, A., Angus, A. and Brennan, F. (2017). Stochastic Prediction of Offshore Wind Farm LCOE through an Integrated Cost Model, *Energy Procedia*, vol. 107(September 2016), pp. 383–389.

Ireland, M. J., Clough, B. A. and Day, J. J. (2017). The cognitive emotion regulation questionnaire: Factorial, convergent, and criterion validity analyses of the full and short versions, *Personality and Individual Differences*, vol. 110, pp. 90–95.

Islam, H., Jollands, M. and Setunge, S. (2015). Life cycle assessment and life cycle cost implication of residential buildings - A review, *Renewable and Sustainable Energy Reviews*, vol. 42(1), pp. 129–140.

Iyer, K. C. and Jha, K. N. (2005). Factors affecting cost performance: Evidence from Indian construction projects, *International Journal of Project Management*, vol. 23(4), pp. 283–295.

Isaksson, T (2002). *MODEL FOR ESTIMATION OF TIME AND COST BASED ON RISK EVALUATION APPLIED ON TUNNEL PROJECTS*. PhD Thesis. Stockholm, Sweden: Royal Institute of Technology,

Jack, E. P. and Raturi, A. S. (2006). Lessons learned from methodological triangulation in management research, *Management Research News*, vol. 29(6), pp. 345–357.

Jackel, P. (2002) *Monte-Carlo methods in finance*, *Interscience.wiley.com*. [online]. [Accessed 10 October 2020]. Available at: http://www3.interscience.wiley.com/journal/114179393/abstract.

Jafary, B., Mele, A. and Fiondella, L. (2020). Component-based system reliability subject to positive and negative correlation, *Reliability Engineering and System Safety*, vol. 202(June), pp. 1–10.

Jafarzadeh, R., Ingham, J., Walsh, K., Hassani, N. and Ghodrati Amiri, G. (2015). Using statistical regression analysis to establish construction cost models for seismic retrofit of confined masonry buildings, *Journal of Construction Engineering and Management*, vol. 141(5), pp. 1–11.

James, P. (2014). Project Financial Management and Modern Financial Slavery: The Case of a KSA Metro Project Start-up, *Asian Journal of Finance & Accounting*, vol. 6(2), p. 278–300.

Jarkas, A. (2016). Predicting contract duration for building construction : Is Bromilow ' s time-cost model a panacea ?, *Journal of Management in Engineering*, vol. 32(1), pp. 1–8.

Jang, S.G (2011). *A Concessionaire Selection Decision Model Development and Application for the PPP Project Procurement*. PhD Thesis. UNIVERSITY OF SOUTHAMPTON, FACULTY OF LAW, ART & SOCIAL SCIENCES, School of Management.

Jick, T. (1979). Mixing Qualitative and Quantitative Methods : Triangulation in Action Mixing Qualitative and Quantitative Methods : Triangulation in Action, *Qualitative Methodology*, vol. 24(4), pp. 602–611.

Jin, R., Cho, K., Hyun, C. and Son, M. (2012). MRA-based revised CBR model for cost prediction in the early stage of construction projects, *Expert Systems with Applications*, vol. 39(5), pp. 5214–5222.

John, I (2016). *5% value added tax in UAE from 2018 - Khaleej Times*. [online]. [Accessed 21 Nov. 2016]. Khaleejtimes.com. Available at: http://www.khaleejtimes.com/business/5-value-added-tax-in-uae-from-2018

Johnsen, T., Howard, M. and Miemczyk, J. (2009). UK defence change and the impact on supply relationships, *Supply Chain Management: An International Journal*, vol. 14(4), pp. 270–279. doi: 10.1108/13598540910970108

Jrade, A. and Lessard, J. (2015). An Integrated BIM System to Track the Time and Cost of Construction Projects : A Case Study, *Journal of Construction Engineering*, vol. 1(1), pp. 1–11.

Ju, H., Li, H., Yang, X., Zhou, X. and Huang, B. (2017). Cost-sensitive rough set: a multi-granulation approach, *Knowledge-Based Systems*, vol. 1(1), pp. 1–17.

Kadiyala, K. R. (1970). TESTING FOR THE INDEPENDENCE OF REGRESSION DISTURBANCES, *Econometrica*, vol. 38(1), pp. 1–21.

Kaiser, M. J. and Snyder, B. (2012). Modeling the decommissioning cost of offshore wind development on the U.S. Outer Continental Shelf, *Marine Policy*. Elsevier, vol. 36(1), pp. 153–164.

Kambanou, M. L. and Lindahl, M. (2016). A Literature Review of Life Cycle Costing in the Product-Service System Context, *Procedia CIRP*, vol. 47(1), pp. 186–191.

Kang, S., Kim, Sangyong, Kim, Seungho and Lee, D. (2020). System dynamics model for the improvement planning of school building conditions, *Sustainability*, vol. 12(10), pp. 1–16.

Kaplan, B. and Duchon, D. (2011). Combining Qualitative and Quantitative Methods in Information Systems A Case Study1, *MIS Quarterly*, vol. 12(4), pp. 571–586.

Karim, A. and Adeli, H. (1999). A new generation software for construction scheduling and management, *Engineering Construction & Architectural Management*, vol. 6(4), pp. 380–390.

Karwan, K. R. and Markland, R. E. (2006). Integrating service design principles and information technology to improve delivery and productivity in public sector

operations: The case of the South Carolina DMV, *Journal of Operations Management*, vol. 24(September), pp. 347–362.

Kazaz, A., Birgonul, M. T. and Ulubeyli, S. (2005). Cost-based analysis of quality in developing countries: A case study of building projects, *Building and Environment*, vol. 40(10), pp. 1356–1365.

Ketokivi, M. and Choi, T. (2014). Renaissance of case research as a scientific method, *Journal of Operations Management*, vol. 32(5), pp. 232–240.

Khalilzadeh, J., Tasci, A. D. A. and Mcafee, A. (2017). Large sample size, significance level, and the effect size: Solutions to perils of using big data for academic research, *Tourism Management*, vol. 62(1), pp. 89–96.

Khang, D. B. and Myint, Y. M. (1999). Time, cost and quality trade-off in project management: a case study, *International Journal of Project Management*, vol. 17(4), pp. 249–256.

Kilic, S. (2013). Linear regression analysis, *Journal of Mood Disorders*, vol. 3(2), pp. 33–36.

Kim, B. C. and Reinschmidt, K. F. (2011). Combination of Project Cost Forecasts in Earned Value Management, *Journal of Construction Engineering and Management*, vol. 137(11), pp. 958–966.

Kim, G. H., An, S. H. and Kang, K. I. (2004). Comparison of construction cost estimating models based on regression analysis, neural networks, and case-based reasoning, *Building and Environment*, vol. 39(10), pp. 1235–1242.

Kim, G. H., Yoon, J. E., An, S. H., Cho, H. H. and Kang, K. I. (2004). Neural network model incorporating a genetic algorithm in estimating construction costs, *Building and Environment*, vol. 39(11), pp. 1333–1340.

Kim, H. J., Seo, Y. C. and Hyun, C. T. (2012). A hybrid conceptual cost estimating model for large building projects', *Automation in Construction*, vol. 25(1), pp. 72–81.

Kim, M., Lee, S., Woo, S. and Shin, D. H. (2012). Approximate cost estimating model for river facility construction based on case-based reasoning with genetic algorithms, *KSCE Journal of Civil Engineering*, vol. 16(3), pp. 283–292.

King, P. L. and King, J. S. (2006) *VALUE STREAM MAPPING FOR THE PROCESS INDUSTRIES*. San Francesco: Taylor & Francis Group.

Kirkwood, L., Giuntini, L., Shehab, E. and Baguley, P. (2016). Development of a Whole Life Cycle Cost Model for Electrification options on the UK Rail System, *Procedia CIRP*, vol. 47(1), pp. 1–5.

Klassen, R. D. and Jacobs, J. (2001). Experimental comparison of Web, electronic and mail survey technologies in operations management, *Journal of Operations Management*, vol. 19(6), pp. 713–728.

Klein, H. K. and Myers, M. D. (1999). For Conducting and a Set of Principles Field Studies in Interpretive Evaluating, *MIS Quarterly*, vol. 23(1), pp. 67–93.

Kleyner, A. and Sandborn, P. (2008). Minimizing life cycle cost by managing product reliability via validation plan and warranty return cost, *International Journal of Production Economics*, vol. 112(2), pp. 796–807.

Konior, J. and Szóstak, M. (2020). Methodology of planning the course of the cumulative cost curve in construction projects, *Sustainability*, vol. 12(6), 1–22.

Koo, C., Hong, T. and Hyun, C. (2011). The development of a construction cost prediction model with improved prediction capacity using the advanced CBR approach', *Expert Systems with Applications*, vol. 38(7), pp. 8597–8606.

Koo, C., Hong, T., Hyun, C. and Koo, K. (2010). A CBR-based hybrid model for predicting a construction duration and cost based on project characteristics in multi-family housing projects, *Canadian Journal of Civil Engineering*, vol. 37(5), pp. 739–752.

Koomey, J., Hultman, N. E. and Grubler, A. (2016). A reply to "Historical construction costs of global nuclear power reactors", *Energy Policy*, vol. 102(1), pp. 640–643.

Koul, S., Falebita, O. A., Akinbami, J. F. K. and Akarakiri, J. B. (2016). System dynamics, uncertainty and hydrocarbon resources modelling: A systematic review, *Renewable and Sustainable Energy Reviews*, vol. 59(1), pp. 199–205.

Kraemer, H. C., Mintz, J., Noda, A., Tinklenberg, J. and Yesavage, J. A. (2006). Caution regarding the use of pilot studies to guide power calculations for study proposals, *Archives of General Psychiatry*, vol. 63(5), pp. 484–489.

Krstić, H. and Mareniak, S. (2012)3 Analysis of buildings operation and maintenance costs, *Gradjevinar*, vol. 64(4), pp. 293–303.

Krzywinski, M. and Altman, N. (2013). Power and sample size, *Nature Methods*, vol. 10(12), pp. 1139–1142.

KSA-Government (2016). *Saudi Vision 2030*. [online]. [Accessed 21 Dec. 2016].Available at: http://vision2030.gov.sa/en

Kubba, S. (2017). *Chapter Twelve – Project Cost Analysis*, Handbook of Green Building Design and Construction.

Kucan, L. (2011). Approximating the Practice of Writing the Dissertation Literature Review, *Literacy Research and Instruction*, vol. 50(3), pp. 229–240.

Kucharavy, D. and De Guio, R. (2015). Application of logistic growth curve, *Procedia Engineering*, vol. 131(1), pp. 280–290.

Kujawski, E., Postgraduate, N. and Acquisition, A. (2007). Dynamic Cost-contingency Management: A Method for Reducing Project Costs While Increasing the Probability of Success, *4th Annual Acquisition Research Symposium of the Naval Postgraduate School*, vol. 1(1), pp. 1–29.

Kuricheva, E. K. and Popov, A. A. (2016). Housing construction dynamics in the 2010s as a factor of transformation of the Moscow agglomeration, *Regional Research of Russia*, vol. 6(1), pp. 9–20.

Kushner, R. F., Choi, S. W. and Burns, J. L. (2016). Development of a six-factor questionnaire for use in weight management counseling, *Patient Education and Counseling*, vol. 99(12), pp. 2018–2025.

Kvale, S. (1983). The Qualitative Research Interview: A Phenomenological and a Hermeneutical Mode of Understanding Kvale, *Journal of phenomenological psychology*, vol. 14(2), pp. 171–196.

Kvale, S. (2005). THE QUALITATIVE RESEARCH INTERVIEW: A PHENOMENOLOGICAL AND HERMENEUTICAL MODE OF UNDERSTANIDING, *Journal of phenomenological Psychology*, vol. 14(2), pp. 171–175.

Kvale, S. (1992). Ten Standard Responses to Qualitative Research Interviews, *Journal of Phenomenological Psychology*, vol. pp. 1–31.

Lai, G. and Lin, X. (2011). Condition for relaxed Monte Carlo method of solving systems of linear equations, *Supercomput*, vol. 57(1), pp. 256–264.

Lambert, D. M., Emmelhainz, M. A. and Gardner, J. T. (1996). Developing and Implementing Supply Chain Partnerships, *Emerald insight*, vol. 7(2), pp. 1–17.

Lee, A. S. (1989). A Scientific Methodology for MIS Case Studies, *MIS Quarterly*, vol. 13(1), pp. 33–50.

Lee, J. Y., Lee, S., Woo, S. and Shin, D. H. (2011). Framework of the approximate cost estimating model for river dredging construction, *KSCE Journal of Civil Engineering*, vol. 15(1), pp. 33–42.

Lee, S. H., Peña-Mora, F. and Park, M. (2006). Dynamic planning and control methodology for strategic and operational construction project management, *Automation in Construction*, vol. 15(1), pp. 84–97.

Lee, S. K., Kim, K. R. and Yu, J. H. (2014). BIM and ontology-based approach for building cost estimation, *Automation in Construction*, vol. 41(1), pp. 96–105.

Lee, S., Jin, Y., Woo, S. and Shin, D. H. (2013). Approximate cost estimating model of eco-type trade for river facility construction using case-based reasoning and genetic algorithms, *KSCE Journal of Civil Engineering*, vol. 17(2), pp. 292–300.

Leeuw, E. D., Mellenbergh, G. J. and Hox, J. J. (1996). The Influence of Data Collection Method on Structural Models: A Comparison of a Mail, a Telephone, and a Face-to-Face Survey, *Sociological Methods & Research*, vol. 24(4), pp. 443–472.

Lehtonen, J. L. L. and Kiiras, J. M. K. (2010). Cost modelling in underpinning projects, *Construction Management and Economics*, vol. 28(9), pp. 985–995.

Leiringer, R. (2006). Technological innovation in PPPs: incentives, opportunities and actions, *Construction Management and Economics*, vol. 24(3), pp. 301–308.

Leonard-Barton, D. (1990). A Dual Methodology for Case Studies - Synergistics Use of a Longitudinal Single Site with Replicated Multiple Sites, *Organization Science*, vol. 1(3), pp. 248–266.

Levitt, R. E. and Eriksson, K. (2016). *Funding Streams of Design-Build-Finance-Operate-Mitigating PPP Governance Challenges: Lessons from Eastern Australia to Focus Future PPP Mitigating PPP Governance Challenges, Engineering Project Organization Conference*. Stanford University, USA. 28-30 June.

Lewis, M. W. (1998). Iterative triangulation: a theory development process using existing case studies, *Journal of Operations Management*, vol. 16(4), pp. 455–469.

Lindemann, C. F. W. and Jahnke, U. (2017). *Modelling of laser additive manufactured product lifecycle costs, Laser Additive Manufacturing*. Paderborn University: Paderborn: Germany. Ch.11. pp. 281–316.

Linderman, K. and Chandrasekaran, A. (2010). The scholarly exchange of knowledge in Operations Management, *Journal of Operations Management*, vol. 28(4), pp. 357–366.

Liu, H. and Lin, B. (2017). Cost-based modelling of optimal emission quota allocation, *Journal of Cleaner Production*, vol. 149(1), pp. 472–484.

Liu, Z., Xu, J., Li, Y., Wang, X. and Wu, J. (2012). Using system dynamics to study the logistics outsourcing cost of risk, *Kybernetes*, vol. 41(9), pp. 1200–1208.

Love, P. E. D., Holt, G. D., Shen, L. Y., Li, H. and Irani, Z. (2002). Using systems dynamics to better understand change and rework in construction project management systems, *International Journal of Project Management*, vol. 20(6), pp. 425–436.

Love, P. E. D. and Irani, Z. (2003). A project management quality cost information system for the construction industry, *Information & Management*, vol. 40(7), pp. 649–661.

Lovering, J. R., Nordhaus, T. and Yip, A. (2016). Apples and oranges: Comparing nuclear construction costs across nations, time periods, and technologies, *Energy Policy*, vol. 102(September), pp. 650–654.

Lowe, B. (2015). "Should Consumers Request Cost Transparency?" Cost Transparency in Consumer Markets, *European Journal of Marketing*, vol. 49(11/12), pp. 1992–1998.

Lu, Q. and Qiao, X. (2018). *Significance Analysis of High-Dimensional, Low-Sample Size Partially Labeled Data*, Department of Mathematical Sciences Binghamton University.

Lundesgaard, S. A., Solberg, A., Oldevik, J., France, R., Aagedal, J. Ø. and Eliassen, F. (2007). *Construction and execution of adaptable applications using an aspect-oriented and model driven approach*, Distributed Applications and Interoperable Systems, pp. 76–89.

Ma, Z., Wei, Z. and Zhang, X. (2013). Semi-automatic and specification-compliant cost estimation for tendering of building projects based on IFC data of design model, *Automation in Construction*, vol. 30(1), pp. 126–135.

Macek, D. and Dobias, J. (2014). Buildings renovation and maintenance in the public sector, *Procedia Engineering*, vol. 85(1), pp. 368–376.

Mahesh C. Gupta (1995). Survey research in operations management: a process- based perspective, *International Journal of Operations & Production Management*, vol. 15(8), pp. 34–51.

Maier, H. R. (2013). What constitutes a good literature review and why does its quality matter?, *Environmental Modelling and Software*, vol. 43(1), pp. 3–4.

Maiwenn J.Al (2013). Cost-effectiveness acceptability curves revisited, *PharmacoEconomics*, vol. 31(2), pp. 93–100.

Makienko, I. and Bernard, E. K. (2012). Teaching applied value of marketing research: A questionnaire design project, *International Journal of Management Education*, vol. 10(2), pp. 139–145.

Malhotra, M. K., Singhal, C., Shang, G. and Ployhart, R. E. (2014). A critical evaluation of alternative methods and paradigms for conducting mediation analysis in operations management research, *Journal of Operations Management*, vol. 32(4), pp. 127–137.

Malhotra, M. K. and Grover, V. (1998). An assessment of survey research in POM: from constructs to theory, *Journal of Operations Management*, vol. 16(4), pp. 407–425.

Mallasi, Z. and Dawood, N. (2000). Assessing Space Criticality in Sequencing and Identifying Execution Patterns for Construction Activities Using VR Visualisations, *Centre for Construction Innovation Research: School of Science and Technology, University of Teesside*, vol. 1(3), pp. 22–27.

Marrero, M. and Ramirez-De-Arellano, A. (2010). The building cost system in andalusia: Application to construction and demolition waste management, *Construction Management and Economics*, vol. 28(5), pp. 495–507.

Marshall, E. and Balentyne, P. (2014). *Chapter 4 of The Basic Practice of Statistics (6th ed.): Scatterplots and correlation in SPSS*. Available at: www.statstutor.ac.uk.

Marzouk, M. and Azab, S. (2014). Environmental and economic impact assessment of construction and demolition waste disposal using system dynamics, *Resources, Conservation and Recycling*, vol. 82(1), pp. 41–49.

Mason, M. (2010). FORUM: QUALITATIVE SOCIAL RESEARCH SOZIALFORSCHUNG Sample Size and Saturation in PhD Studies Using Qualitative Interviews, *FORUM: QUALITATIVE SOCIAL RESEARCH SOZIALFORSCHUNG*, vol. 11(3), pp. 1–19.

Mättö, T. and Sippola, K. (2016). Cost Management in the Public Sector: Legitimation Behaviour and Relevant Decision Making, *Financial Accountability & Management*, vol. 32(2), pp. 179–201.

Mawdesley, M. J. and Al-Jibouri, S. (2009). Modelling construction project productivity using systems dynamics approach, *International Journal of Productivity and Performance Management*, vol. 59(1), pp. 18–36.

Maylor, H., Brady, T., Cooke-Davies, T. and Hodgson, D. (2006). From projectification to programmification, *International Journal of Project Management*, vol. 24(8), pp. 663–674.

McCombes, S. (2019). *An Introduction To Sampling Methods*. [online]. [Accessed 1 October 2020].Scribbr. Available at: <https://www.scribbr.com/methodology/sampling-methods/>

McCutcheon, D. M. and Meredith, J. R. (1993). Conducting case study research in operations management, *Journal of Operations Management*, vol. 11(3), pp. 239–256.

McLean, T. and McGovern, T. (2017). Costing for strategy development and analysis in an emerging industry: The Newcastle Upon Tyne Electric Supply Company, 1889–1914, *The British Accounting Review*, vol. 1(1), pp. 1–22.

Mehran, D. (2016). Exploring the Adoption of BIM in the UAE Construction Industry for AEC Firms, *Procedia Engineering*, vol. 145(1), pp. 1110–1118.

Memon, A. H. and Abdul-Rahman, I. (2014). SEM-PLS analysis of inhibiting factors of cost performance for large construction projects in malaysia: Perspective of clients and consultants, *The Scientific World Journal*, vol. 1(1), pp. 1–9.

Memon, A. H., Rahman, I. A., Abdullah, M. R. and Asmi, A. (2010). Factors Affecting Construction Cost in Mara Large Construction Project : Perspective of Project Management Consultant, *International Journal of Sustainable Construction Engineering & Technology*, vol. 1(2), pp. 41–54.

Meredith, J. (1998). Building operations management theory through case and field research, *Journal of Operations Management*, vol. 16(4), pp. 441–454.

Meszaros, B., Bachmann, C., Kemp, R. and Federici, G. (2015). Definition of the basic DEMO tokamak geometry based on systems code studies, *Fusion Engineering and Design*, vol. 98–99(1), pp. 1556–1560.

Meszek, W. and Polewski, M. (2006). Certain aspects of working capital in a construction company, *Technological and Economic Development of Economy*, vol. 12(3), pp. 222–226.

Metzler, D. P. and Davis, P. C. (1998). EMPLOYING A MIXED-MODE QUALITATIVE RESEARCH METHOD PRIOR TO CONDUCTING QUANTITATIVE RESEARCH. University of Arkansas at Little Rock Institute. pp. 1–6.

Meyer, A.-M., Wheeler, S. B., Weinberger, M., Chen, R. C. and Carpenter, W. R. (2013). An Overview of Methods for Comparative Effectiveness Research, *Seminars in Radiation Oncology*, vol. 24(1), pp. 5–13.

Michigan-State-Government (2003). MICHIGAN RESIDENTIAL ASSESSOR'S MANUAL. [online]. [Accessed 25 October 2020]. Available at: <https://www.michigan.gov/documents/Vol1-02GeneralInstructions-PricingExamples_120864_7.pdf>

Mieg, H. A. (2009). Two factors of expertise? Excellence and professionalism of environmental experts, *High Ability Studies*, vol. 20(1), pp. 91–115.

Mills, A. (2001). A systematic approach to risk management for construction, *Structural Survey*, vol. 19(5), pp. 245–252.

Ministry of Culture and Youth (2017). *Ministry Of Culture Launches The Event "All Together In The Emirates Of Zayed Al-Khair" - Ministry of Culture and Youth*. [online]. [Accessed 29 July 2017].Available at: <https://www.mckd.gov.ae/en/news/ministry-of-culture-launches-the-event-all-together-in-the-emirates-of-zayed-al-khair/>

Mishra, S., Schwab, C. and Šukys, J. (2013). Multi-level Monte Carlo Finite Volume Methods for Uncertainty Quantification in Nonlinear Systems of Balance Laws, *Lecture Notes in Computational Science and Engineering*, vol. 92(1), pp. 225–294.

Mizell, C. and Malone, L. (2007). A Project Management Approach to Using Simulation for Cost Estimation on Large, Complex Software Development Projects, *Engineering Management Journal*, vol. 19(4), pp. 28–34.

Modell, S. (2005). Triangulation between case study and survey methods in management accounting research: An assessment of validity implications, *Management Accounting Research*, vol. 16(2), pp. 231–254.

Mohd Yasin Ă, R., Amin Nur Yunus, F., Che Rus, R., Ahmad, A. and Bekri Rahim, M. (2015). Validity and Reliability Learning Transfer Item Using Rasch Measurement Model, *Procedia - Social and Behavioral Sciences*, vol. 204(November), pp. 212–217.

Molinos-Senante, M., Hernández-Sancho, F. and Sala-Garrido, R. (2010). Economic feasibility study for wastewater treatment: A cost-benefit analysis, *Science of the Total Environment*, vol. 408(20), pp. 4396–4402.

Moore, N. Y. and Loredo, E. N. (2013). *identifying and managing Air force Sustainment Supply chain risks*, United States Air Force Strategic Planning Division.

Mostavi, E., Asadi, S. and Boussaa, D. (2017). Development of a new methodology to optimize building life cycle cost, environmental impacts, and occupant satisfaction, *Energy*, vol. 121(1), pp. 606–615.

Murat Günaydın, H. and Zeynep Doğan, S. (2004). A neural network approach for early cost estimation of structural systems of buildings, *International Journal of Project Management*, 22(7), pp. 595–602.

Murillo-Hoyos, J., Volovski, M. and Labi, S. (2016). Rolling stock purchase cost for rail and road public transportation: random-parameter modelling and marginal effect analysis, *Transportmetrica A: Transport Science*, vol. 12(5), pp. 436–457.

Naderpajouh, N. and Hastak, M. (2014). Quantitative analysis of policies for governance of emergent dynamics in complex construction projects, *Construction Management and Economics*, vol. 32(12), pp. 1222–1237.

Nasirzadeh, F., Khanzadi, M. and Rezaie, M. (2014). Dynamic modeling of the quantitative risk allocation in construction projects, *International Journal of Project Management*, vol. 32(3), pp. 442–451.

Nastasi, B. K. and Schensul, S. L. (2005). Contributions of qualitative research to the validity of intervention research, *Journal of School Psychology*, vol. 43(3), pp. 177–195.

National-Research-Council (2006). *Reference Materials for the Facility Manager Leaders Program*. Indiana University: USA.

Nazif, A., Mohammed, N. I., Malakahmad, A. and Abualqumboz, M. S. (2016). Application of Step Wise Regression Analysis in Predicting Future Particulate Matter Concentration Episode, *Water, Air, and Soil Pollution*, vol. 227(4), pp. 1–12.

Nelson, A. M. (2008). Addressing the threat of evidence-based practice to qualitative inquiry through increasing attention to quality: A discussion paper, *International Journal of Nursing Studies*, vol. 45(2), pp. 316–322.

Nematchoua, M. K. and Orosa, J. A. (2016). Building construction materials effect in tropical wet and cold climates: A case study of office buildings in Cameroon, *Case Studies in Thermal Engineering*, vol. 7(1), pp. 55–65.

Newman, D. (1989). Alternative Research Paradigms in Operations, *Journal of Operations Management*, vol. 8(4), pp. 297–326.

Nguyen, L. D., Ogunlana, S. O. and Lan, D. T. X. (2004). A study on project success factors in large construction projects in Vietnam, *Journal of Operations Management*, vol. 11(6), pp. 404–413.

Nguyen, N. T., McFadden, A., Tangen, D. and Beutel, D. (2013). *Video-Stimulated Recall Interviews in Qualitative Research*: Joint AARE Annual Conference. Queensland University of Technology. Brisbane:Australia.

Nielsen, H. B. (2005). Dynamic Regression Models for Stationary Variables, *Journal of Construction Engineering and Management*, vol. 135(2), pp. 360–367.

Niknam, M. and Karshenas, S. (2015). Integrating distributed sources of information for construction cost estimating using Semantic Web and Semantic Web Service technologies, *Automation in Construction*, vol. 57(1), pp. 222–238.

NikoliC, M (2003), *Money Supply-Inflation Relationship in Postcommunist Russia*. PhD Thesis. London: University College London, School of Slavonic and East European Studies.

Nowak, M., Miao, J., Dumonteil, E., Forget, B., Onillon, A., Smith, K. S. and Zoia, A. (2016). Annals of Nuclear Energy Monte Carlo power iteration: Entropy and spatial correlations, *Annals of Nuclear Energy*, vol. 94(1), pp. 856–868.

Odeyinka, H. a., Lowe, J. and Kaka, A. P. (2013). Artificial neural network cost flow risk assessment model, *Construction Management and Economics*, vol. 31(5), pp. 423–439.

Ökmen, Ö. and Öztaş, A. (2010). Construction cost analysis under uncertainty with correlated cost risk analysis model, *Construction Management and Economics*, vol. 28(2), pp. 203–212.

Oliver, D. G., Serovich, J. M. and Mason, T. L. (2005). Constraints and Opportunities with Interview Transcription: Towards Reflection in Qualitative Research, *Social forces; a scientific medium of social study and interpretation*, vol. 84(2), pp. 1273–1289.

Omair, A. (2014). Sample size estimation and sampling techniques for selecting a representative sample, *142 Journal of Health Specialties*, vol. 2(4), pp. 142–147.

Ong, A. S. L. and Ong, H. L. (2016). Modelling of Conveyance Construction Cost by Decomposition Technique, *Journal of Operations Research*, vol. 37(10), pp. 979–985.

Onwuegbuzie, A. J. (2007). A Typology of Mixed Methods Sampling Designs in Social Science Research A Typology of Mixed Methods Sampling Designs in Social Science, *The Qualitative Report*, vol. 12(2), pp. 281–316.

Osigweh, C. A. B. (1989). Concept Fallibility in Organizational Science, *Academy of Management Review*, vol. 14(4), pp. 579–594.

Östlund, U., Kidd, L., Wengström, Y. and Rowa-Dewar, N. (2011). Combining qualitative and quantitative research within mixed method research designs: A methodological review, *International Journal of Nursing Studies*, vol. 48(3), pp. 369–383. doi

Oswald, D., Ahiaga-Dagbui, D. D., Sherratt, F. and Smith, S. D. (2020). An industry structured for unsafety? An exploration of the cost-safety conundrum in construction project delivery, *Safety Science*, vol. 122(May), pp. 1-10.

Ozcan-Deniz, G. and Zhu, Y. (2016). A system dynamics model for construction method selection with sustainability considerations, *Journal of Cleaner Production*, vol. 121(1), pp. 33–44.

Pajares, J. and López-Paredes, A. (2011). An extension of the EVM analysis for project monitoring: The Cost Control Index and the Schedule Control Index, *International Journal of Project Management*, vol. 29(5), pp. 615–621.

Pantouvakis, J. and Vandoros, N. (2006). A Critical Review of Published Research on PFI / PPPs in Construction, *Department of Construction Engineering & Management, Faculty of Civil Engineering, National Technical University of Athens*, vol. 1(1), pp. 410–419.

Park, M., Ahn, C., Lee, H. and Yoon, Y. (2012). System dynamics-based strategies to diffuse construction VE in the public sector, *KSCE Journal of Civil Engineering*, vol. 16(4), pp. 486–498.

Pasandideh, S. H. R., Niaki, S. T. A., Nobil, A. H. and Cárdenas-Barrón, L. E. (2015).A multiproduct single machine economic production quantity model for an imperfect production system under warehouse construction cost, *International Journal of Production Economics*, vol. 169, pp. 203–214.

Pautasso, M. (2013). Ten Simple Rules for Writing a Literature Review, *PLoS Computational Biology*, vol. 9(7), pp. 1–5.

Peña-Mora, F., Han, S., Lee, S. and Park, M. (2008). Strategic-Operational Construction Management: Hybrid System Dynamics and Discrete Event Approach, *Journal of construction engineering and management*, vol. 134(9), pp. 701–710.

Peng, D. X. and Lai, F. (2012). Using partial least squares in operations management research: A practical guideline and summary of past research, *Journal of Operations Management*, vol. 30(6), pp. 467–480.

Perera, A. A. D. A. J. and Imriyas, K. (2004). An integrated construction project cost information system using MS AccessTM and MS ProjectTM, *Construction Management and Economics*, vol. 22(2), pp. 203–211.

Pérez, M. and Pericchi, L. R. (2014). Changing statistical significance with the amount of information: The adaptive α significance level, *Statistics and Probability Letters*, vol. 85(1), pp. 20–24.

Petroutsatou, K. and Lambropoulos, S. (2010). Road tunnels construction cost estimation: A structural equation model development and comparison, *Operational Research*, vol. 10(2), pp. 163–173.

Poh, Y. P. and Tah, J. H. M. (2006). Integrated duration–cost influence network for modelling risk impacts on construction tasks, *Construction Management and Economics*, vol. 24(8), pp. 861–868.

Poole, M. S. and Van de Ven, A. H. (1989). Using Paradox to Build Management and Organization Theories, *Academy of Management Review*, vol. 14(4), pp. 562–578.

Price, a. D. F. (2003). The strategy process within large construction orgnisations, *Engineering, Construction and Architectural Management*, vol. 10(1), pp. 283–296.

Phillips, P. P. and Stawarski, C. A. (2013). *Data Collection: Planning for and Collecting All Types of Data*. San Francisco: John Wiley & Sons, Inc.

Qu, S. Q. and Dumay, J. (2011). The qualitative research interview, *Qualitative research in Accounting and Management*, vol. 8(3), pp. 238–264.

Radhi, H. (2009). Evaluating the potential impact of global warming on the UAE residential buildings - A contribution to reduce the CO2 emissions, *Building and Environment*, vol. 44(12), pp. 2451–2462.

Radhi, H. (2010). Energy analysis of fa??ade-integrated photovoltaic systems applied to UAE commercial buildings, *Solar Energy*, vol. 84(12), pp. 2009–2021.

Radhi, H., Sharples, S. and Fikiry, F. (2013). Will multi-facade systems reduce cooling energy in fully glazed buildings? A scoping study of UAE buildings, *Energy and Buildings*, vol. 56(1), pp. 179–188.

Rahayah Ariffin, S., Omar, B., Isa, A. and Sharif, S. (2010). Validity and reliability Multiple Intelligent item using Rasch measurement model, *Procedia - Social and Behavioral Sciences*, vol. 9(1), pp. 729–733.

Rahman, S., Odeyinka, H., Perera, S. and Bi, Y. (2012). Product-cost modelling approach for the development of a decision support system for optimal roofing material selection, *Expert Systems with Applications*, vol. 39(8), pp. 6857–6871.

Ramasesh, R. V. and Browning, T. R. (2014). A conceptual framework for tackling knowable unknown unknowns in project management, *Journal of Operations Management*, vol. 32(4), pp. 190–204.

Ratner, B. (2009). The correlation coefficient: Its values range between 1/1, or do they?, *Journal of Targeting, Measurement and Analysis for Marketing*, vol. 17(2), pp. 139–142.

Rawn, M. L. (1953). An approximate table for determining sample size by means of the sign test, *John Wiley & Sons, Inc*, vol. 1(1), pp. 90–91.

Ray, G., Muhanna, W. A. and Barney, J. B. (2005). Information Technology and the Performance of the Customer Service Process: A Resource-Based Analysis, *MIS Quarterly*, vol. 29(4), pp. 625–652.

RdnReuters, T (2016). *His Excellency Sheikh Nahyan bin Mubarak Al Nahyan officially launches Abu Dhabi Entrepreneurship Forum 2013 | Zawya*. [online]. [Accessed 23 Dec. 2016]. Zawya.com. Available at: https://www.zawya.com/story/His_Excellency_Sheikh_Nahyan_bin_Mubarak_Al_Nahyan_officially_launches_Abu_Dhabi_Entrepreneurship_Forum_2013-ZAWYA20131008150108/

Reichelt, K. and Lyneis, J. (1999). The dynamics of project performance: Benchmarking the drivers of cost and schedule overrun, *European Management Journal*, vol. 17(2), pp. 135–150.

Reina, A., Kocsis, Á., Merlo, A., Németh, I. and Aggogeri, F. (2016). Maintenance decision support for manufacturing systems based on the minimization of the life cycle cost, *Procedia CIRP*, vol. 1(1), pp. 674–679.

Reja, U., Manfreda, K. L. and Hlebec, V. (2003). Open-ended vs . Close-ended Questions in Web Questionnaires, *Developments in Applied Statistics*, vol. 19(1), pp. 159–177.

Rewhorn, S. (2018). Writing your successful literature review, *Journal of Geography in Higher Education*, vol. 42(1), pp. 143–147.

RICS (2011). *COST ANALYSIS AND BENCHMARKING*. 1st Edition. London: Park Communications Limited, pp.1-38.[Online]. [Accessed 6 December 2020].Available at: <https://www.rics.org/globalassets/rics-website/media/upholding-professional-standards/sector-standards/construction/black-book/cost-analysis-and-benchmarking-uk-1st-edition-rics.pdf>

Riley, D. R., Varadan, P., James, J. S. and Thomas, H. R. (2005). Benefit-Cost Metrics for Design Coordination of Mechanical , Electrical , and Plumbing Systems in Multistory Buildings, *JOURNAL OF CONSTRUCTION ENGINEERING AND MANAGEMENT*, vol. 1(August), pp. 877–889.

Rodrigues, A. and Bowers, J. (1996). The role of system dynamics in project management, *International Journal of Project Management*, vol. 14(4), pp. 213–220.

Rodrigues, C. and Freire, F. (2017). Building retrofit addressing occupancy: an integrated cost and environmental life-cycle analysis, *Energy and Buildings*, vol. 140(1), pp. 388–398.

Rowe, V. C. (2009). Using video-stimulated recall as a basis for interviews: Some experiences from the field, *Music Education Research*, vol. 11(4), pp. 425–437.

Ruan, D. (2001). Implementation of adaptive fuzzy control for a real-time control demo-model, *Real-Time Systems*, vol. 21(3), pp. 219–239.

Ruiz, M. A., Gonza-ez-Porras, J. R., Aranguren, J. L., Franco, E., Villasante, F., Tunon, J., Gonza-lez-Lopez, T. J., Salas-Cansado, M. de and Soto, J. (2017). Development and validation of a new questionnaire measuring treatment satisfaction in patients with non-valvular atrial fibrillation : SAFUCA, *Quality Life Research*, vol. 4(1474), pp. 767–778.

Rungtusanatham, M. J., Choi, T. Y., Hollingworth, D. G., Wu, Z. and Forza, C. (2003). Survey research in operations management: Historical analyses, *Journal of Operations Management*, vol. 21(4), pp. 475–488.

Ruppert, Fan, J., Renault, E. and Zivot, E. (2016). *Statistics and Econometrics for Finance: Quantitative Analysis and IBM® SPSS® Statistics*.

Saez, P. V., Del Río Merino, M., San-Antonio González, A. and Porras-Amores, C. (2013). Best practice measures assessment for construction and demolition waste management in building constructions, *Resources, Conservation and Recycling*, vol. 75(1), pp. 52–62.

Salling, K. B. and Leleur, S. (2015). Accounting for the inaccuracies in demand forecasts and construction cost estimations in transport project evaluation, *Transport Policy*, vol. 38(1), pp. 8–18.

San, O. T. and Heng, B. (2011). Capital Structure and Corporate Performance of Malaysian Construction Sector, *International Journal of Humanities and Social Science*, vol. 1(2), pp. 28–36.

Santos, J. and Ferreira, A. (2013). Life-cycle cost analysis system for pavement management at project level, *International Journal of Pavement Engineering*, vol. 14(1), pp. 71–84.

Santos, K. dos, Vilela, R. A. de G., Cardoso, M. R. A., Andrade, D. F. de and Maeda, S. T. (2017). Work constraints leads to accident: Questionnaire validity and a qualitative interpretation of the cutoff point, *Safety Science*, vol. 93(32), pp. 199–213.

Sathian, B., Sreedharan, J., Baboo, N. S., Sharan, K., Abhilash, E. S. and Rajesh, E. (2010). Relevance of Sample Size Determination in Medical Research, *Nepal Journal of Epidemiology*, vol. 1(June), pp. 4–10.

Sauro, J. and Lewis, J. R. (2012). *Chapter 8 - Standardized Usability Questionnaires*. Second Edi, *Quantifying the User Experience*. Second Ed. Elsevier Inc.

Sayed, S. S. M. and Sawant, P. H. (2015). Life-cycle cost and financial analysis of energy components in mass housing projects – A case project in sub-urban India, *International Journal of Sustainable Built Environment*, vol. 4(2), pp. 202–221.

Sawyer, T. Y. (2015). *Financial Modeling for Business Owners and Entrepreneurs*. New York: Heinz Weinheimer Springer.

Scandura, T. A. and Williams, E. (2000). Research Methodology in Management : Current Practices , Trends , and Implications for Future Research, *Academy of Management*, vol. 43(6), pp. 1248–1264.

Schell, K. R., Claro, J. and Guikema, S. D. (2017). Probabilistic cost prediction for submarine power cable projects, *International Journal of Electrical Power & Energy Systems*, vol. 90(1), pp. 1–9.

Scheufele, F. B., Borba, C. E., Hinterholz, C. L. and Quiñones, F. R. E.- (2019). Complex mathematical analysis of photobioreactor system, *Engineering in life sciences*, vol. 8(1), pp. 844–859.

Schieg, M. (2010). Risk management in construction project management, *Journal of Business Economics and Management*, vol. 2(2), pp. 77–83.

Schober, P. and Schwarte, L. A. (2018). Correlation coefficients: Appropriate use and interpretation, *Anesthesia and Analgesia*, vol. 126(5), pp. 1763–1768.

Scudder, G. D. and Hill, C. a. (1998). A review and classification of empirical research in operations management, *Journal of Operations Management*, vol. 16(1), pp. 91–101.

Seijts, G. and Latham, G. P. (2005). Learning versus performance goals: When should each be used ?, *Academy of Management*, vol. 19(1), pp. 124–131.

Self, J. and Mackey, M. C. (2016). Random Numbers from a Delay Equation, *Journal of Nonlinear Science*, vol. 26(5), pp. 1311–1327.

Seo, J. and Park, H. (2017). Probabilistic seismic restoration cost estimation for transportation infrastructure portfolios with an emphasis on curved steel I-girder bridges, *Structural Safety*, vol. 65(1), pp. 27–34.

Seshadri, S. and Subrahmanyam, M. (2005). Introduction to the special issue on optimizing risk management in services, *Production and Operations Management*, vol. 14(1), pp. 1–4.

Shah, R. and Goldstein, S. M. (2006). Use of structural equation modeling in operations management research: Looking back and forward, *Journal of Operations Management*, vol. 24(2), pp. 148–169.

Shahandashti, S. M., Asce, S. M., Ashuri, B. and Asce, M. (2013). Forecasting Engineering News-Record Construction Cost Index Using Multivariate Time Series Models, *Journal of Construction Engineering and Management*, vol. 139(September), pp. 1237–1243.

Sharma, J. Ph. D., M.ASCE, Najafi, M. Ph. D., P.E., F.ASCE, Qasim, S. R., Ph. D., P.E., M. A. and Asce, M. (2013). Preliminary Cost Estimation Models for Construction , Operation , and Maintenance of Water Treatment Plants, *Journal of Infrastructure Systems*, vol. 19(December), pp. 451–464.

Shash, A. A. (1993). Factors considered in tendering in UK, *Construction Management and Economics*, vol. 11(1), pp. 111–118.

Shehu, Z., Endut, I. R., Akintoye, A. and Holt, G. D. (2014). Cost overrun in the Malaysian construction industry projects: A deeper insight, *International Journal of Project Management*, vol. 32(8), pp. 1471–1480.

Shen, L. L., Li Hao, J., Tam, V. W. W., Yao, H. and Hao, J. L. (2007). A checklist for assessing sustainability performance of construction projects, *Journal of Civil Engineering and Management*, vol. 13(4), pp. 273–281.

Shen, S.-W., Nguyen, T.-D. and Ojiako, U. (2013). Modelling the predictive performance of credit scoring, *Acta Commercii*, vol. 13(1), pp. 12–pages.

Sher, D. J. and Punglia, R. S. (2014). Decision analysis and cost-effectiveness analysis for comparative effectiveness research-a primer, *Seminars in Radiation Oncology*, vol. 24(1), pp. 14–24.

Shi, Q. (2011). Rethinking the implementation of project management: A Value Adding Path Map approach', *International Journal of Project Management*, vol. 29(3), pp. 295–302.

Signor, R., Love, P. E. D., Olatunji, O., Marchiori, F. F. and Gripp, W. G. (2016). A Probabilistic Method for Forensic Cost Estimating of Infrastructure Projects, *Applied Mathematical Modelling*, vol. 21–22(1), pp. 1–15.

Singh, A. and Masuku, M. (2014). SAMPLING TECHNIQUES & DETERMINATION OF SAMPLE SIZE IN APPLIED STATISTICS RESEARCH : AN OVERVIEW, *International Journal of Economics, Commerce and Management*, vol. 2(11), pp. 1–22.

Skamris, M. K. and Flyvbjerg, B. (1996). Accuracy of Traffic Forecasts and Cost Estimates on Large Transportation Projects, *Transportation Research Record Journal*, vol. 1518(January), pp. 65–69.

Smith, D. P. (2014). BIM & the 5D Project Cost Manager, *Procedia - Social and Behavioral Sciences*, vol. 119(1), pp. 475–484.

Smith, P. (2014). Project Cost Management – Global Issues and Challenges, *Procedia - Social and Behavioral Sciences*, vol. 119, pp. 485–494.

Soltanian, A. R., Borzouei, S. and Afkhami-Ardekan, M. (2016). Design, developing and validation a questionnaire to assess general population awareness about type II diabetes disease and its complications, *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, vol. 1(1), pp. 1–5.

Sondik, E. J., Anderson, J. R., Madans, J. H., Curtin, L. R., Williams, D., Hunter, E. L., Zinn, D. L., Rothwell, C. J., Ezzati-Rice, T., Givens, J. D. and Harris, K. W. (2004). Vital and Health Statistics Design and Estimation for the National Health Interview, *National Center for Health Statistics*, vol. 2(130), pp. 1–30.

Spickova, M. and Myskova, R. (2015). Costs Efficiency Evaluation using Life Cycle Costing as Strategic Method, *Procedia Economics and Finance*, vol. 34(15), pp. 337–343.

Stasiak-Betlejewska, R. and Potkány, M. (2015). Construction Costs Analysis and its Importance to the Economy, *Procedia Economics and Finance*, vol. 34(15), pp. 35–42.

Sterman, J. D. (2003). *SYSTEM DYNAMICS: SYSTEMS THINKING AND MODELING FOR A COMPLEX WORLD, Massachusetts Institute of Technology Engineering Systems Division*. pp. 1–32.

Stockton, D. J., Khalil, R. A. and Mukhongo, M. L. (2013). Cost model development using virtual manufacturing and data mining: Part i - Methodology development, *International Journal of Advanced Manufacturing Technology*, vol. 66(5–8), pp. 741–749.

Stuart, I., McCutcheon, D., Handfield, R., McLachlin, R. and Samson, D. (2002). Effective case research in operations management: a process perspective, *Journal of Operations Management*, vol. 20(5), pp. 419–433.

Support.microsoft.com. (2020). *RAND Function*. [online]. [Accessed 19 January 2020]. Available at: <https://support.microsoft.com/en-us/office/rand-function-4cbfa695-8869-4788-8d90-021ea9f5be73?ui=en-us&rs=en-us&ad=us>

Sydor, P., Shehab, E., Mackley, T., John, P. and Harrison, A. (2014). Improvement of System Design Process: Towards Whole Life Cost Reduction, *3rd International Conference on Through-life Engineering Services*, vol. 22(1), pp. 293–297.

Szolnoki, G. and Hoffmann, D. (2013). Online, face-to-face and telephone surveys — Comparing different sampling methods in wine consumer research, *Wine Economics and Policy*, vol. 2(2), pp. 57–66.

Szyk, B., Mah, J. and Pal, T. (2020). *Confidence Interval Calculator*. [online]. [Accessed 1 November 2020]. Omnicalculator .com. Available at: <https://www.omnicalculator.com/statistics/confidence-interval>

Takim, R. and Akintoye, A. (2002). Performance Indicators for Successful Construction Project Performance, *Association of Researchers in Construction Management*, vol. 2(September), pp. 2–4.

Tam, V. W. Y., Senaratne, S., Le, K. N., Shen, L.-Y., Perica, J. and Illankoon, I. M. C. S. (2017). Life-cycle cost analysis of green-building implementation using timber applications, *Journal of Cleaner Production*, vol. 147(1), pp. 458–469.

Tang, S. L., Aoieong, R. T. and Ahmed, S. M. (2004). The use of Process Cost Model (PCM) for measuring quality costs of construction projects: model testing, *Construction Management and Economics*, vol. 22(3), pp. 263–275.

Tareghian, H. R. and Taheri, S. H. (2007). A solution procedure for the discrete time, cost and quality tradeoff problem using electromagnetic scatter search, *Applied Mathematics and Computation*, vol. 190(2), pp. 1136–1145.

Tareghian, H. R. and Taheri, S. H. (2006). On the discrete time, cost and quality trade-off problem, *Applied Mathematics and Computation*, vol. 181(2), pp. 1305–1312.

Techet, A. H. (2005). Overview of basic probability, *Design Principles for Ocean Vehicles*, vol. 3(1), pp. 1–13.

Teerajetgul, W., Chareonngam, C. and Wethyavivorn, P. (2009). Key knowledge factors in Thai construction practice, *International Journal of Project Management*, vol. 27(8), pp. 833–839.

Tehrani Nejad Moghaddam, A. and Michelot, C. (2009). A contribution to the linear programming approach to joint cost allocation: Methodology and application, *European Journal of Operational Research*, vol. 197(3), pp. 999–1011.

Terracon-Consultant (2019) *Report of Findings for Facility Condition Assessment.* University Hospitals Authority & Trust: Oklahoma-USA.

Testa, M. A. and Simonson, D. C. (2009). *The Use of Questionnaires and Surveys*, *Clinical and Translational Science*. Boston. Ch.12.

Thijssen, J. J. J. (2015). A model for irreversible investment with construction and revenue uncertainty, *Journal of Economic Dynamics and Control*, vol. 57, pp. 250–266.

Thompson, K. and Mcleod, A. (2009). Accelerated ensemble Monte Carlo simulation, *CUTTING EDGE CREDIT RISK*, vol. 4(April), pp. 86–92.

Thompson, J (2020). Engineering Fees A Percentage Of Construction Costs. [online]. [Accessed 25 October 2020]. Small Business - Chron.com. Available at: <https://smallbusiness.chron.com/engineering-fees-percentage-construction-costs-51642.html>

Todorov, T. S. (2014). Evaluating Project and Program Management as Factor for Socio-economic Development within EU, *Procedia - Social and Behavioral Sciences*, vol. 119(1), pp. 819–828.

Toh, T.-C., Ting, C., Ali, K.-N., Aliagha, G.-U. and Munir, O. (2012). Critical Cost Factors of Building Construction Projects in Malaysia, *Procedia - Social and Behavioral Sciences*, vol. 57(1), pp. 360–367.

Tokede, O., Ahiaga-Dagbui, D. D., Smith, S. D. and Wamuziri, S. (2014). Mapping Relational Efficiency in Neuro-Fuzzy Hybrid Cost Models, in *Construction Research Congress 2014 May 19-21*, pp. 1–10.

Tongco, M. D. C. (2007). Purposive Sampling as a Tool for Informant Selection, *Ethnobotany Research & Applications*, vol. 1(1), pp. 147–158.

Toor, S.-R. and Ogunlana, S. O. (2009). Construction professionals' perception of critical success factors for large-scale construction projects, *Construction Innovation: Information, Process, Management*, vol. 9(2), pp. 149–167.

Torp, O., Belay, A. M., Thodesen, C. and Klakegg, O. J. (2016). Cost Development Over-time at Construction Planning Phase: Empirical Evidence from Norwegian Construction Projects, *Procedia Engineering*, vol. 145(1877), pp. 1177–1184.

Torriti, J. (2012). Multiple-project discount rates for cost-benefit analysis in construction projects: A formal risk model for microgeneration renewable energy technologies, *Construction Management and Economics*, vol. 6193(30), pp. 739–747.

Trafimow, D., Amrhein, V., Areshenkoff, C. N., Barrera-causil, C. J., Beh, E. J., Bilgiç, Y. K., Bono, R., Bradley, M. T., Briggs, W. M., Cepeda-freyre, H. A., Chaigneau, S. E., Ciocca, D. R., Correa, J. C., Cousineau, D., Boer, M. R. De, Dhar, S. S., Dolgov, I., Gómez-benito, J., Grendar, M., Grice, J. W., Guerrero-gimenez, M. E., Gutiérrez, A., Huedo-medina, T. B., Kosugi, K., Lachmair, M., Ledesma, R. D., Limongi, R., Badenes-ribera, L., Faulkenberry, T. J., Trafimow, D., Amrhein, V. and Marmolejo-ramos, F. (2018). Manipulating the Alpha Level Cannot Cure Significance Testing, *Frontiers in Psychology*, vol. 9(May), pp. 1–7.

Trangkanont, S. and Charoenngam, C. (2014). Private partner's risk response in PPP low-cost housing projects, *Property Management*, vol. 32(1), pp. 67–94.

Trier-Bieniek, a. (2012). Framing the telephone interview as a participant-centred tool for qualitative research: a methodological discussion, *Qualitative Research*, vol. 12(6), pp. 630–644.

Tsang, E. W. K. (2014). Generalizing from research findings: The merits of case studies, *International Journal of Management Reviews*, vol. 16(4), pp. 369–383.

Tummala, R. and Schoenherr, T. (2011). Assessing and managing risks using the Supply Chain Risk Management Process (SCRMP), *Supply Chain Management: An International Journal*, vol. 16(6), pp. 474–483.

Turner, D. W. (2010). Qualitative interview design: A practical guide for novice investigators, *The Qualitative Report*, vol. 15(3), pp. 754–760.

Turskis, Z. (2008). Multi-attribute contractors ranking method by applying ordering of feasible alternatives of solutions in terms of preferability technique, *Technological and Economic Development of Economy*, vol. 14(2), pp. 224–239.

UK-Government (2019). *The Cost Of London's Infrastructure Requirements To 2041 And The Funding Gap*. London: Greater London Authority, pp.1-53.

UK-Government (2017). *Transmission & Distribution 6Th Price Control (RP6) Final*

Determination. Northern Ireland: Utility Regulator, pp.1-279.

Van Den Broeke, M., Boute, R., Cardoen, B. and Samii, B. (2017). An efficient solution method to design the cost-minimizing platform portfolio, *European Journal of Operational Research*, vol. 259(1), pp. 236–250.

Van Den Ende, L. and Van Marrewijk, A. (2014). The ritualization of transitions in the project life cycle: A study of transition rituals in construction projects, *International Journal of Project Management*, vol. 32(7), pp. 1134–1145.

Van Poucke, E., Matthyssens, P. and Weeren, A. (2016). Enhancing cost savings through early involvement of purchasing professionals in sourcing projects: Bayesian estimation of a structural equation model, *Journal of Purchasing and Supply Management*, vol. 22(4), pp. 299–310.

Vanbrabant, L., Schoot, R. Van De and Rosseel, Y. (2015). Constrained statistical inference: sample-size tables for ANOVA and regression, *Frontiers in Psychology*, vol. 5(January), pp. 1–8.

Vanderwal, T., Eilbott, J., Kelly, C., Frew, S. R., Woodward, T. S., Milham, M. P. and Castellanos, F. X. (2021). Stability and similarity of the pediatric connectome as developmental measures, *NeuroImage*, vol. 226(November), pp. 1–12.

Vanhoucke, M. (2012). Measuring the efficiency of project control using fictitious and empirical project data, *International Journal of Project Management*, vol. 30(2), pp. 252–263.

Venkatesh, V., Brown, S. A. and Bala, H. (2013). Bridging the qualitative-quantitative divide: Guidelines for conducting mixed methods research in information systems, *Management Information Systems Quarterly*, vol. 37(1), pp. 21–54.

Vensim.com. (2019). *Reference Manual, The Vensim Modeling Language, Mathematical Foundation, Integral And Differential Equations*. [online]. [Accessed 12 April 2019]. Available at: <https://www.vensim.com/documentation/21990.htm>

Vidogah, W. and Ndekugri, I. (1998). Improving the management of claims on construction contracts: Consultant's perspective, *Construction Management and Economics*, vol. 16(3), pp. 363–372.

Viechtbauer, W., Smits, L., Kotz, D., Bud, L. and Spigt, M. (2015). A simple formula for the calculation of sample size in pilot studies, *Journal of Clinical Epidemiology*, vol. 68(1), pp. 1375–1379.

Volk, R., Luu, T. H., Mueller-Roemer, J. S., Sevilmis, N. and Schultmann, F. (2018). Deconstruction project planning of existing buildings based on automated acquisition and reconstruction of building information, *Automation in Construction*, vol. 91(February), pp. 226–245.

Voss, C., Tsikriktsis, N., Frohlich, M., Voss, C., Tsikriktsis, N. and Frohlich, M. (2002). Case research in operations management, *International Journal of Operations & Production Management*, vol. 22(2), pp. 195–219.

Wacker, J. G. (1998). A definition of theory research guidelines for different-theory building research methods in operations management, *Journal of Operations Management*, vol. 16(4), pp. 361–385.

Walker, H., Chicksand, D., Randnor, Z. and Watson, G. (2015). Theoretical perspectives in operations management: an analysis of the literature, *International Journal of Operations & Production Management*, vol. 35(8). pp. 1182 – 1206.

Walsham, G. (1995). Interpretive case studies in IS research: nature and method, *European Journal of Information Systems*, vol. 4(2), pp. 74–81.

Wang, B., Xia, X. and Zhang, J. (2014). A multi-objective optimization model for the life-cycle cost analysis and retrofitting planning of buildings, *Energy and Buildings*, vol. 77(1), pp. 227–235.

Wang, C.-H. and Mei, Y.-H. (1998). Model for forecasting construction cost indices in Taiwan, *Construction Management and Economics*, vol. 16(2), pp. 147–157.

Wang, F., Ding, L., Love, P. E. D. and Edwards, D. J. (2016). Modeling tunnel construction risk dynamics: Addressing the production versus protection problem, *Safety Science*, vol. 87(1), pp. 101–115.

Wang, K., Wang, W., Wang, H., Hsu, P., Wu, W. and Kung, C. (2016). Automation in Construction Applying building information modeling to integrate schedule and cost for establishing construction progress curves, *Automation in Construction*, vol. 72(1), pp. 397–410.

Wang, L. L. (2010). Quantitative Research Methodology: Common Pitfalls and Recommended Solutions, *Newborn and Infant Nursing Reviews*, vol. 10(1), pp. 2–4.

Watson, R. T., Leyland, F. P. and Kavan, C. B. (1998). Measuring Information Systems Service Quality: Lessons from Two Longitudinal Case Studies, *Misq*, vol. 22(1), pp. 61–79.

Webster, J. and Watson, R. T. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review, *MIS Quarterly*, vol. 26(2), pp. xiii–xxiii.

Weick, K. E. (1989). Theory Construction as Disciplined Imagination, *Academy of Management Review*, vol. 14(4), pp. 516–531.

West, B. T., Kreuter, F. and Jaenichen, U. (2013). " Interviewer " Effects in Face-to-Face Surveys : A Function of Sampling , Measurement Error , or Nonresponse ?, *Journal of Official Statistics*, vol. 29(2), pp. 277–297.

Westbrook, R. (1995). Action research: a new paradigm for research in, *International Journal of Operations & Production Management*, vol. 15(12), pp. 6–20.

Whetten, D. A. (1989). What Constitutes a Theoretical Contribution?, *Academy of Management Review*, vol. 14(4), pp. 490–495.

Wibowo, A. (2015). Returns to scale in buildings construction costs: Indonesian cases', *Procedia Engineering*, vol. 125(1), pp. 18–24.

Wild, C. (2014). *An Introduction to Data Analysis: Association and Correlation'*, Data to Insight: The University of Auckland, pp. 1–3.

Wilke, T. J. (2005). The Project Cost Variance Analysis Model: A Project Management Tool, *The Journal of Cost Analysis & Management*, vol. 1656(2), pp. 13–23.

Williams, M. and Crass, D. (2020). *What Makes a Property Historic?*.

Williams, T. (2003). Assessing Extension of Time delays on major projects, *International Journal of Project Management*, vol. 21(1), pp. 19–26.

Willis, T. H. and Willis, W. D. (1995). A quality performance management system for industrial construction engineering projects, *International Journal of Quality & Reliability Management*, vol. 13(9), pp. 38–48.

Winch, G. (1989). The construction firm and the construction project: a transaction cost approach, *Construction Management and Economics*, vol. 7(1), pp. 331–345.

Winter, M., Smith, C., Morris, P. and Cicmil, S. (2006). Directions for future research in project management: The main findings of a UK government-funded research network, *International Journal of Project Management*, vol. 24(8), pp. 638–649.

Winter, S. G. (2016). *Pursuing the Evolutionary Agenda in Economics and Management Research*. The Wharton School: University of Pennsylvania.

Won, J. and Cheng, J. C. P. (2017). Identifying potential opportunities of building information modeling for construction and demolition waste management and minimization', *Automation in Construction*, vol. 79(1), pp. 3–18.

Woodward, A., Chan, Y. H., Gong, R., Nguyen, M., Gee, T., Delmas, P., Gimel'farb, G. and Marquez Flores, J. A. (2017). A low cost framework for real-time marker based 3-D human expression modeling, *Journal of Applied Research and Technology*, vol. 15(1), pp. 61–77.

Wu, D. D., Olson, D. L. and Birge, J. R. (2011). *Modeling Risk Management in Sustainable Construction*. Springer.

Wu, S. and Clements-Croome, D. (2007). Ratio of Operating and Maintenance Costs to Initial Costs, *Cost Engineering*, vol. 49(12), pp. 30–33.

Wudhikarn, R. (2012). Improving overall equipment cost loss adding cost of quality, *International Journal of Production Research*, vol. 50(12), pp. 3434–3449.

Wytykowska, A., Fajkowska, M., Domaradzka, E. and Jankowski, K. S. (2017). Construct validity of the Polish version of the reinforcement sensitivity theory-personality questionnaire, *Personality and Individual Differences*, vol. 109(1), pp. 172–180.

Xiong, B., Skitmore, M. and Xia, B. (2015). Exploring and validating the internal dimensions of occupational stress: evidence from construction cost estimators in China, *Construction Management and Economics*, vol. 33(5–6), pp. 495–507.

Xu, J. W. and Moon, S. (2013). Stochastic Forecast of Construction Cost Index Using a Cointegrated Vector Autoregression Model, *Journal of Management in Engineering*, vol. 29(1), pp. 10–18.

Yana, A. A. G. A., Rusdhi, H. A. and Wibowo, M. A. (2015). Analysis of factors affecting design changes in construction project with Partial Least Square (PLS), *Procedia Engineering*, vol. 125(1), pp. 40–45.

Yang, P. Y., Hui, C. J., Tien, D. J., Snowden, A. W., Derfus, G. E. and Opel, C. F. (2019). Accurate definition of control strategies using cross validated stepwise regression and Monte Carlo simulation, *Journal of Biotechnology*, vol. 2(November), pp. 1–10.

Yasin, M. M., Czuchry, A. J., Dorsch, J. J. and Small, M. (1999). In search of an optimal cost of quality: An integrated framework of operational efficiency and strategic effectiveness, *Journal of Engineering and Technology Management*, vol. 16(2), pp. 171–189.

Yoon, K. B., Kim, H. S. and Sohn, S. Y. (2008). An Air Force Logistics Management Index for effective aircraft operation, *Transportation Research Part E: Logistics and Transportation Review*, vol. 44(6), pp. 1188–1204.

Yu, W.-D. and Lo, S.-S. (2005). Time-dependent construction social costs model, *Construction Management and Economics*, vol. 23(3), pp. 327–337.

Yuan, H. P., Shen, L. Y., Hao, J. J. L. and Lu, W. S. (2011). A model for cost-benefit analysis of construction and demolition waste management throughout the waste chain, *Resources, Conservation and Recycling*, vol. 55(6), pp. 604–612.

Yusof, N., Zainul Abidin, N., Zailani, S. H. M., Govindan, K. and Iranmanesh, M. (2016). Linking the environmental practice of construction firms and the environmental behaviour of practitioners in construction projects, *Journal of Cleaner Production*, vol. 121(1), pp. 64–71.

Zahir, S. (2015). *Approaches and Associated Costs of Building Demolition and Deconstruction*, Michigan State University Dissertation. pp. 1–151.

Zakis, K., Zakis, V. and Arfridsson, J. (2017). Eleven Nearly Zero New Building Life Cycle Cost and Dynamic Performance Optimization by Computer Modeling in Cold Climate, *Procedia Computer Science*, vol. 104(December), pp. 302–312.

Zeng, J., An, M. and Smith, N. J. (2007). Application of a fuzzy based decision making methodology to construction project risk assessment, *International Journal of Project Management*, vol. 25(6), pp. 589–600.

Zhang, B. and Chen, B. (2016). Emergy-based Cost-benefit Analysis for Urban Biogas Project, *Energy Procedia*, vol. 88(1), pp. 119–125.

Zhang, Z., Gong, L., Jin, Y., Xie, J. and Hao, J. (2017). A quantitative approach to design alternative evaluation based on data-driven performance prediction, *Advanced Engineering Informatics*, vol. 32(1), pp. 52–65.

Zhao, Z.-Y., Chen, Y.-L. and Thomson, J. D. (2017). Levelized cost of energy modeling for concentrated solar power projects: A China study, *Energy*, vol. 120(1), pp. 117–127.

Zhiliang, M., Zhenhua, W., Wu, S. and Zhe, L. (2011). Application and extension of the IFC standard in construction cost estimating for tendering in China, *Automation in Construction*, vol. 20(2), pp. 196–204.

Zhu, X., Ruiz, R., Li, S. and Li, X. (2017). An effective heuristic for project scheduling with resource availability cost, *European Journal of Operational Research*, vol. 257(3), pp. 746–762.

Zidane, Y. J.-T., Johansen, A. and Ekambaram, A. (2013). Megaprojects-Challenges and Lessons Learned, *Procedia - Social and Behavioral Sciences*, vol. 74(March), pp. 349–357.

Zimmermann, J. and Eber, W. (2017). Criteria on the Value of Expert's Opinions for Analyzing Complex Structures in Construction and Real Estate Management, *Procedia Engineering*, vol. 196(June), pp. 335–342.

APPENDIX: A

"Previous researchers have tested the questionnaire's validity and reliability."

(Ariffin et al. 2010, p. 733)

The demand of accurate Cost Estimation of Construction Projects in the United Arab Emirates after the economic crises in 2008 due to the drop of real estate prices while the increase of construction prices which required to be decreased made a strong recession in the construction industry. Then, the fast dropping in the construction cost in 2011 onwards made a very low quality deliverables that leaded to disputes and fatalities in some cases; therefore, it is important to know accurately as a client whether the bidder is giving a logical price, very high price, or a very low price which increase the risk of project failure or significant undesired deviation from the required and targeted deliverables. Hence, this research study shall contribute in solving this issue through adding to the body of knowledge and

This interview survey is done for collecting the required data for the academic research degree "**Doctor of Philosophy in Project Management**" with specialization in Project Cost Estimation. However, it is designed to satisfy the requirements and demand of closed question survey interview with a focus on using the consequences likelihood risk matrix (Australian Government, 2019; PMBOK, 2017). This is to extract the accurate risk percentage from interviewees which is based on their experience with each of the cost changing factors listed in the survey. The process of this data collection is to give a detailed explanation of each factor and what it reflect in this study while instructing the interviewee to give a percentage from the given matrix based on what they think about each factor "changing probability" and its "occurrence impact" on the cost of a construction project in the United Arab Emirates.

This is to let you know how valuable your contribution will be when you provide this research study with your related experience in order to contribute in the field of Project Management through a PhD degree research outputs and improve the cost estimation approaches in the United Arab Emirates.

A- GENERAL INFORMATION

- **Name (Optional):** _____
- **Email (Optional):** _____
- **Phone Number (Optional):** _____

- **Respondent's position:**

☐ Public Sector ☐ Private Sector

- **Job title:**

☐ Estimator ☐ Cost Engineer
☐ Project Manager ☐ Security Engineer
☐ General Manager ☐ Security Consultant
☐ Project Engineer ☐ Technician
☐ Control Room Operator ☐ Others
☐ QA/QC Manager

- **Experience in the organization:**

☐ Less than 3 years ☐ 5 years – 10 years
☐ 3 - 5 years ☐ More than 10 years

- **Sizes of the projects involve:**

☐ Less than 500,000 AED ☐ 500,000 – 1,000,000 AED
☐ 1,000,000 - 5,000,000 AED ☐ More 5,000,000 AED

B- The influence/ impact of construction factors on changing the construction cost:

1. Please rate the influence/impact of the following CAPEX (i.e. Capital Expenditures) factors on changing the construction cost.

	CAPEX Activities' Factors	Degree of Factors' impact on cost (1 %-72%)	Risk Matrix
1	Selection Method		
2	Type of Client: Solo Individual		
3	Type of Client: Bank- Individual Partnership		
4	Type of Client: Developer		
5	Type of Client: Group of People		
6	Location: City Area		
7	Location: Regional Area		
8	Location: Beach Area		
9	Location: Desert Area		
10	Building Services Complexity: Operational Services		
11	Building Services Complexity: Fitness Services		
12	Number of Basement Levels		
13	Procurement Method		
14	Site Topography		
15	Site Conditions		
16	Working Space		
17	Site Access		
18	Frame Structure		
19	Foundation Type		
20	Ground Conditions		
21	Type of Soil		
22	Mark-up Size		

Probability					
VH (90%)	5%	9%	18%	36%	72%
H (70%)	4%	7%	14%	28%	56%
M (50%)	3%	5%	10%	20%	40%
L (30%)	2%	3%	6%	12%	24%
VL (10%)	1%	1%	2%	4%	8%
	VL (5%)	L (10%)	M (20 %)	H (40%)	VH (80%)
	IMPACT				

23	Need for Work	
24	Deadline Requirements	
25	Number of Stories	
26	Project Duration	
27	Gross Floor Area	
28	Equipment Required	
29	Construction Technology	

Probability					
VH (90%)	5%	9%	18%	36%	72%
H (70%)	4%	7%	14%	28%	56%
M (50%)	3%	5%	10%	20%	40%
L (30%)	2%	3%	6%	12%	24%
VL (10%)	1%	1%	2%	4%	8%
	VL (5%)	L (10%)	M (20 %)	H (40%)	VH (80%)
	IMPACT				

CAPEX Political Risks' Factors		Degree of Factors' impact on cost (1 %-72%)	Risk Matrix
30	Change in Law		
31	Delay in Project Approvals and Permits		
32	Poor Public Decision Making Process		
33	Government Intervention		
34	Unstable Government		
35	Government Reliability		
36	Inconsistencies in Government Policies		
37	Strong Political Opposition / Hostility		
38	Expropriation/ Nationalization of Assets		
39	Inability of Concessionaire		

Probability					
VH (90%)	5%	9%	18%	36%	72%
H (70%)	4%	7%	14%	28%	56%
M (50%)	3%	5%	10%	20%	40%
L (30%)	2%	3%	6%	12%	24%
VL (10%)	1%	1%	2%	4%	8%
	VL (5%)	L (10%)	M (20 %)	H (40%)	VH (80%)
	IMPACT				

CAPEX Legal Factors		Degree of Factors' impact on cost (1 %-72%)	Risk Matrix
40	Change in Tax Regulation		
41	Corruption and Lack of Respect for Law		
42	Legislation Change		
43	Import / Export Restrictions		
44	Rate of Return Restrictions		
45	Industrial Regulatory Change		

Probability					
VH (90%)	5%	9%	18%	36%	72%
H (70%)	4%	7%	14%	28%	56%
M (50%)	3%	5%	10%	20%	40%
L (30%)	2%	3%	6%	12%	24%
VL (10%)	1%	1%	2%	4%	8%
	VL (5%)	L (10%)	M (20 %)	H (40%)	VH (80%)
	IMPACT				

CAPEX Economic Change Cost Factors		Degree of Factors' impact on cost (1%-72%)	Risk Matrix
46	Interest Rate Volatility		
47	Inflation Rate Volatility		
48	Foreign Exchange and Convertibility		
49	Poor Financial Market		

Probability					
VH (90%)	5%	9%	18%	36%	72%
H (70%)	4%	7%	14%	28%	56%
M (50%)	3%	5%	10%	20%	40%
L (30%)	2%	3%	6%	12%	24%
VL (10%)	1%	1%	2%	4%	8%
	VL (5%)	L (10%)	M (20 %)	H (40%)	VH (80%)
	IMPACT				

CAPEX Natural Cost Factors		Degree of Factors' impact on cost (1%-72%)	Risk Matrix
50	Force Majeure		
51	Environment		
52	Weather		
53	Geotechnical Condition		

Probability					
VH (90%)	5%	9%	18%	36%	72%
H (70%)	4%	7%	14%	28%	56%
M (50%)	3%	5%	10%	20%	40%
L (30%)	2%	3%	6%	12%	24%
VL (10%)	1%	1%	2%	4%	8%
	VL (5%)	L (10%)	M (20 %)	H (40%)	VH (80%)
	IMPACT				

CAPEX Market Cost Factors		Degree of Factors' impact on cost (1%-72%)	Risk Matrix
54	Market Supply		
55	Market Demand		
56	Fluctuation of Material Cost by Public/Private		
57	Value of Production Effort		

Probability					
VH (90%)	5%	9%	18%	36%	72%
H (70%)	4%	7%	14%	28%	56%
M (50%)	3%	5%	10%	20%	40%
L (30%)	2%	3%	6%	12%	24%
VL (10%)	1%	1%	2%	4%	8%
	VL (5%)	L (10%)	M (20 %)	H (40%)	VH (80%)
	IMPACT				

	CAPEX Project Selection Cost Factors	Degree of Factors' impact on cost (1%-72%)	Risk Matrix
58	Public Opposition to Projects		
59	Uncompetitive Tender		
60	Level of Demand for the Project		
61	Land Acquisition		
62	Competition Risk		

Probability					
VH (90%)	5%	9%	18%	36%	72%
H (70%)	4%	7%	14%	28%	56%
M (50%)	3%	5%	10%	20%	40%
L (30%)	2%	3%	6%	12%	24%
VL (10%)	1%	1%	2%	4%	8%
	VL (5%)	L (10%)	M (20%)	H (40%)	VH (80%)
	IMPACT				

	CAPEX Project Finance Cost Factors	Degree of Factors' impact on cost (1%-72%)	Risk Matrix
63	Inaccurate Estimates		
64	High Finance Cost		
65	High Bidding Costs		
66	Delay in Payment of Annuity		
67	Financial Attraction of Project to Investors		
68	Lack of Creditworthiness		
69	Delay in Financial Closure		
70	Inability to Service Debt		
71	Lack of Government Guarantees		
72	Financer Unwilling to Take High Risk		

Probability					
VH (90%)	5%	9%	18%	36%	72%
H (70%)	4%	7%	14%	28%	56%
M (50%)	3%	5%	10%	20%	40%
L (30%)	2%	3%	6%	12%	24%
VL (10%)	1%	1%	2%	4%	8%
	VL (5%)	L (10%)	M (20%)	H (40%)	VH (80%)
	IMPACT				

CAPEX Building Functionality and Serviceability Cost Factors		Degree of Factors' impact on cost (1 %-72%)	Risk Matrix
73	Construction Time Delay		
74	Material Availability		
75	Labor Availability		
76	Poor Quality of Workmanship		
77	Default of Sub-Contractors or Suppliers		
78	Design & Construction Complexity		
79	Design Deficiency		
80	Late Design Change		
81	Construction Technology Risk		
82	Contractual Risk		
83	Contractor Failure		
84	Quality Risk		

Probability					
VH (90%)	5%	9%	18%	36%	72%
H (70%)	4%	7%	14%	28%	56%
M (50%)	3%	5%	10%	20%	40%
L (30%)	2%	3%	6%	12%	24%
VL (10%)	1%	1%	2%	4%	8%
	VL (5%)	L (10%)	M (20 %)	H (40%)	VH (80%)
	IMPACT				

CAPEX Stakeholders Relationship Cost Factors		Degree of Factors' impact on cost (1 %-72%)	Risk Matrix
85	Different Working Method Between Partners		
86	Inadequate Experience in Residential Projects		
87	Lack of Commitment From Public/Private Sector		
88	Organization and Coordination Risk		
89	Inadequate Distribution of Responsibility & Risk		
90	Inadequate Negotiation Period Prior to Initiation		
91	Conflict Between Project's Participants		
92	Workers Strike		
93	Cultural Differences Between Main Stakeholders		

Probability					
VH (90%)	5%	9%	18%	36%	72%
H (70%)	4%	7%	14%	28%	56%
M (50%)	3%	5%	10%	20%	40%
L (30%)	2%	3%	6%	12%	24%
VL (10%)	1%	1%	2%	4%	8%
	VL (5%)	L (10%)	M (20 %)	H (40%)	VH (80%)
	IMPACT				

	CAPEX Knowledge Cost Factors	Degree of Factors' impact on cost (1 %-72%)	Risk Matrix
94	Expertise		
95	Familiarities		
96	Number of Bidders		
97	Market Conditions		
98	Size of the Project		
99	Type of Building		
100	Extent of Database		
101	Homogeneity of Samples		
102	Details of Information		

Probability					
VH (90%)	5%	9%	18%	36%	72%
H (70%)	4%	7%	14%	28%	56%
M (50%)	3%	5%	10%	20%	40%
L (30%)	2%	3%	6%	12%	24%
VL (10%)	1%	1%	2%	4%	8%
	VL (5%)	L (10%)	M (20 %)	H (40%)	VH (80%)
	IMPACT				

2. Please rate the influence/impact of the following OPEX (i.e. Operation Expenditures) factors on changing the project cost.

	OPEX Activities' Factors	Degree of Factors' impact on cost (1 %-72%)	Risk Matrix
103	Energy Costs		
104	Service Life of Building Components		
105	Building Components' Eco-Costs		
106	Asset Operation Eco-Costs		
107	Disposal Eco-Costs		
108	Components' Deterioration Rate		
109	Fabric Maintenance		
110	Services		
111	Equipment's Maintenance		
112	Overheads		
113	Utilities		
114	Cleaning		
115	Percentage of Current Replacement Value		
116	Ratio of Maintenance to Capital Cost		
117	Ratio of Operation to Capital Cost		

Probability					
VH (90%)	5%	9%	18%	36%	72%
H (70%)	4%	7%	14%	28%	56%
M (50%)	3%	5%	10%	20%	40%
L (30%)	2%	3%	6%	12%	24%
VL (10%)	1%	1%	2%	4%	8%
	VL (5%)	L (10%)	M (20 %)	H (40%)	VH (80%)
	IMPACT				

References:

1- Ajay, S. and Micah, B. (2014) 'SAMPLING TECHNIQUES & DETERMINATION OF SAMPLE SIZE IN APPLIED STATISTICS RESEARCH : AN OVERVIEW', II(11), pp. 1–22.
2- Barkowsky, M. (2018) 'Statistical quality of experience analysis : on planning the sample size and statistical significance testing', *Journal of Electronic Imaging*, 27(5), pp. 1–11. doi: 10.1117/1.JEI.27.5.053013.
3- Blair, J. and Conrad, F. G. (2011) 'SAMPLE SIZE FOR COGNITIVE INTERVIEW PRETESTING', 75(4), pp. 636–658. doi: 10.1093/poq/nfr035.
4- Bosnjak, M. (2009) 'EFFECTS OF QUESTIONNAIRE LENGTH ON PARTICIPATION AND INDICATORS OF RESPONSE QUALITY IN A WEB SURVEY', 73(2), pp. 349–360. doi: 10.1093/poq/nfp031.
5- Cai, Y. and Hames, D. (2011) 'Minimum sample size determination for generalized extreme value distribution', *HAL*, 40(1), pp. 87–98.
6- Burns, E. *et al.* (2018) 'Moving on : Factors associated with caregivers ' bereavement adjustment using a random population-based face-to-face survey', *Palliative Medicine*, 32(1), pp. 257–267. doi: 10.1177/0269216317717370.
7- Chen, K. *et al.* (2015) 'Cash incentives improve participation rate in a face-to-face survey : an intervention study', 68, pp. 228–233. doi: 10.1016/j.jclinepi.2014.08.002.
8- Cottrell, E. *et al.* (2015) 'Maximising response from GPs to questionnaire surveys : do length or incentives make a difference ?', pp. 1–7.
9- Cleland, D. I. (2004) *Field Guide to Field Guide to Project Management*. doi: 10.1117/3.2186106.
10- DE LEEUW, EDITH D, G. J. M. and J. J. H. (1996) 'The Influence of Data Collection Method on Structural Models : A Comparison of a Mail, a Telephone, and a Face-to-Face Survey', *Sociological Methods & Research*, 24(4), pp. 443–472. doi: 10.1177/0049124196024004002.
11- Effect, N. (2013) 'Power and sample size', *nature methods*, 10(12), pp. 1139–1142. doi: 10.1038/nmeth.2738.
12- Fanning, E. (2005) 'Formatting a Paper-based Survey Questionnaire : Best Practices', *A peer-reviewed electronic journal*, 10(12), pp. 1–14.
13- Glasow, P. (2005) 'Fundamintals of Survey Research Methodology'. Washington C3 /center: MITRE, pp. 1–20.
14- Hess, J. *et al.* (2001) 'THE EFFECTS OF PERSON-LEVEL VERSUS HOUSEHOLD-LEVEL QUESTIONNAIRE DESIGN ON SURVEY ESTIMATES AND DATA QUALITY U . S . Census Bureau I . Introduction and Background II . Research Methods and Procedures', pp. 574–584.
15- Hoddinott, S. N. and Bass, M. J. (1986) 'Research The Diliman Total Design Survey Method : A Sure-Fire way to Get High Survey Return Rates', *CAN. FAM. PHYSICIAN*, 32(November), pp. 2366–2368.
16- Jalali, A., Maggi, F. M. and Reijers, H. A. (2018) 'RESEARCH ARTICLE A hybrid approach for aspect-oriented business process modeling', *John Wiley & Sons, Ltd*, 1(November 2017), pp. 1–21. doi: 10.1002/smr.1931.
17- Khalilzadeh, J., Tasci, A. D. A. and Mcafee, A. (2017) 'Large sample size , signi fi cance level , and the effect size : Solutions to perils of using big data for academic research', *Tourism Management*. Elsevier Ltd, 62(1), pp. 89–96. doi: 10.1016/j.tourman.2017.03.026.
18- Lu, Q. and Qiao, X. (2018) 'Significance Analysis of High-Dimensional , Low-Sample Size Partially Labeled Data', *Department of Mathematical Sciences Binghamton University*, (246649), pp. 1–37.
19- Mason, M. (2010) 'FORUM : QUALITATIVE SOCIAL RESEARCH SOZIALFORSCHUNG Sample Size and Saturation in PhD Studies Using Qualitative Interviews', *FORUM: QUALITATIVE SOCIAL RESEARCH SOZIALFORSCHUNG*, 11(3), pp. 1–19.

20- Mclachlan, G J and Peel, D. (1981) 'On a Resampling Approach to Choosing the Number of Components in Normal Mixture Models', *Department of Mathematics The University of Queensland*, 1(1), pp. 1–6.
21- Omair, A. (2014) 'Sample size estimation and sampling techniques for selecting a representative sample', *142 Journal of Health Specialties*, 2(4), pp. 142–147. doi: 10.4103/1658-600X.142783.
22- Onwuegbuzie, A. J. (2007) 'A Typology of Mixed Methods Sampling Designs in Social Science Research A Typology of Mixed Methods Sampling Designs in Social Science', *The Qualitative Report*, 12(2), pp. 281–316.
23- Pérez, M. and Pericchi, L. R. (2014) 'Changing statistical significance with the amount of information : The adaptive α significance level', *Statistics and Probability Letters*. Elsevier B.V., 85(1), pp. 20–24. doi: 10.1016/j.spl.2013.10.018.
24- Reja, U., Manfreda, K. L. and Hlebec, V. (2003) 'Open-ended vs . Close-ended Questions in Web Questionnaires', *Developments in Applied Statistics*, 19(1), pp. 159–177.
25- Rawn, M. L. (1953) 'An approximate table for determining sample size by means of the sign test', *John Wiley & Sons, Inc*, 1(1), pp. 90–91.
26- Takim, R. and Akintoye, A. (2002) 'Performance Indicators for Successful Construction Project Performance', *Association of Researchers in Construction Management*, 2(September), pp. 2–4.
27- Tongco, M. D. C. (2007) 'Purposive Sampling as a Tool for Informant Selection', *Ethnobotany Research & Applications*, 1(1), pp. 147–158.
28- Trafimow, D. *et al.* (2018) 'Manipulating the Alpha Level Cannot Cure Significance Testing', *Frontiers in Psychology*, 9(May), pp. 1–7. doi: 10.3389/fpsyg.2018.00699.
29- Vanbrabant, L., Schoot, R. Van De and Rosseel, Y. (2015) 'Constrained statistical inference : sample-size tables for ANOVA and regression', *Frontiers in Psychology*, 5(January), pp. 1–8. doi: 10.3389/fpsyg.2014.01565.
30- Viechtbauer, W. *et al.* (2015) 'A simple formula for the calculation of sample size in pilot studies', *Journal of Clinical Epidemiology*, 68(1), pp. 1375–1379. doi: 10.1016/j.jclinepi.2015.04.014.
31- West, B. T., Kreuter, F. and Jaenichen, U. (2013) '" Interviewer " Effects in Face-to-Face Surveys : A Function of Sampling , Measurement Error , or Nonresponse ?', *Journal of Official Statistics*, 29(2), pp. 277–297.
32- Szolnoki, G. and Hoffmann, D. (2013) 'Online , face-to-face and telephone surveys — Comparing different sampling methods in wine consumer research', *Wine Economics and Policy*. Elsevier, 2(2), pp. 57–66. doi: 10.1016/j.wep.2013.10.001.
33- Services, H. (2004) *Vital and Health Statistics Design and Estimation for the National Health Interview*.Darby, J. L. (2010) 'Sample Sizes for Confidence Limits for Reliability', *SANDIA REPORT*, 1(1), pp. 1–28.
34- Aranguren, L. and Soto, M. D. S. J. (2017) 'Development and validation of a new questionnaire measuring treatment satisfaction in patients with non-valvular atrial fibrillation : SAFUCA Ò', pp. 767–778. doi: 10.1007/s11136-016-1474-4.
35- Abascal, E. *et al.* (2012) 'Face to face and telephone surveys in terms of sampling representativeness : a multidimensional analysis', pp. 303–313. doi: 10.1007/s11135-010-9353-5.

APPENDIX: B

"Because quantitative researchers reduce information to statistics such as averages, percentages, and so on, their research articles are easy to spot. If an article has a results section devoted mainly to the presentation of statistical data, it is a safe bet that it is quantitative."

(Galvan 2002, p. 45)

- **CAPEX**:

A- Construction Activities' Factors:

1- **Project Selection Method:**

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.760, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.760 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.919, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.919 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA1.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA1.1} = -27.785 + 0.461 X_{prob} + 0.649 X_{imp} \quad \text{(Eq.5-CA1)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA1 is equal to **31.9%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA1.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.6% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	31.93	22.386	55
Probability	60.87	18.943	55
Impact	48.69	24.724	55

Table 5-CA1.1: Project Selection Method Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.760**	.919**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.760**	1	.516**
	Sig. (2-tailed)	.000		.000
	N	55	55	55
Impact	Pearson Correlation	.919**	.516**	1
	Sig. (2-tailed)	.000	.000	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA1.2: Project Selection Method Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25865.194	2	12932.597	562.045	.000[b]
	Residual	1196.515	52	23.010		
	Total	27061.709	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA1.3: Project Selection Method linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-27.785	2.208		-12.584	.000
	Probability	.461	.040	.390	11.474	.000
	Impact	.649	.031	.717	21.076	.000

a. Dependent Variable: Risk

Table 5- CA1.4: Project Selection Method regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.978[a]	.956	.954	4.797	2.071

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA1.5: Project Selection Method regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

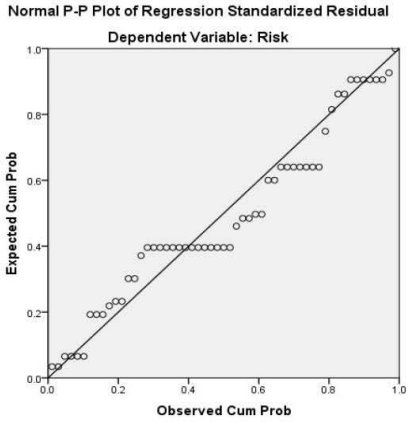


Figure 5- CA1.1: Project Selection Method normal Predicted Probability of the residual.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-16.68	65.70	31.93	21.886	55
Residual	-8.735	17.676	.000	4.707	55
Std. Predicted Value	-2.221	1.543	.000	1.000	55
Std. Residual	-1.821	3.685	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA1.6: Project Selection Method regression Residuals Statistics showing the Mean value of population Error.

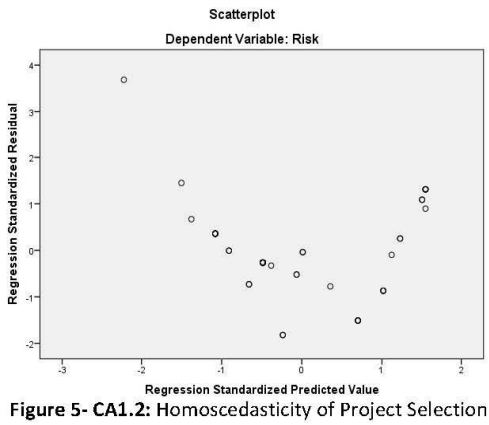


Figure 5- CA1.2: Homoscedasticity of Project Selection Method normal Error (i.e. Constant Variance).

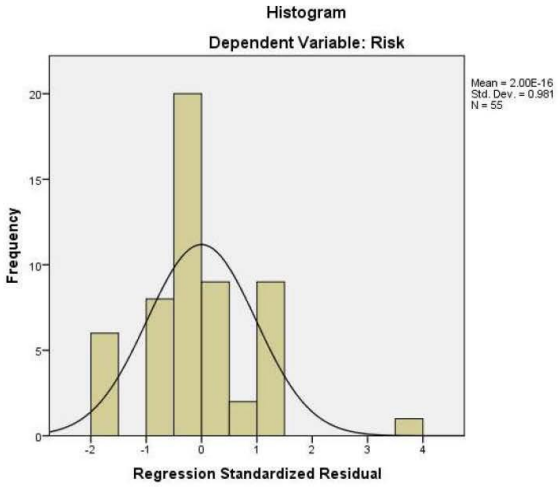


Figure 5- CA1.3: Normality of Project Selection Method Error distribution (i.e. Bell Shaped).

2- **Type of Client: Solo Individual:**

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.806, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.806 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.927, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.927 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA2.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA2.1} = -20.684 + 0.362 X_{prob} + 0.663 X_{imp} \quad \text{(Eq.5-CA2)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA1 is equal to **24.5%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA2.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.5% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	24.55	23.277	55
Probability	52.75	24.039	55
Impact	39.40	24.375	55

Table 5- CA2.1: Type of Client- Solo Individual Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.806**	.927**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.806**	1	.623**
	Sig. (2-tailed)	.000		.000
	N	55	55	55
Impact	Pearson Correlation	.927**	.623**	1
	Sig. (2-tailed)	.000	.000	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA2.2: Type of Client- Solo Individual Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	27657.539	2	13828.769	449.408	.000[b]
	Residual	1600.097	52	30.771		
	Total	29257.636	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA2.3: Type of Client- Solo Individual linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-20.684	1.833		-11.282	.000
	Probability	.362	.040	.374	9.030	.000
	Impact	.663	.040	.694	16.747	.000

a. Dependent Variable: Risk

Table 5- CA2.4: Type of Client- Solo Individual regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Std. Error of the Estimate	Durbin-Watson
1	.972[a]	.945	5.547	1.605

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA2.5: Type of Client- Solo Individual regression Model Summary showing how much in percentage (%) the population is represented by the

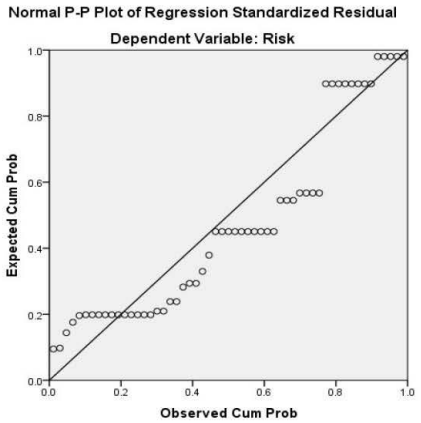


Figure 5- CA2.1: Type of Client- Solo Individual normal Predicted Probability of the residual.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-10.43	64.96	24.55	22.631	55
Residual	-7.273	11.432	.000	5.443	55
Std. Predicted Value	-1.546	1.786	.000	1.000	55
Std. Residual	-1.311	2.061	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA2.6: Type of Client- Solo Individual regression Residuals Statistics showing the Mean value of population

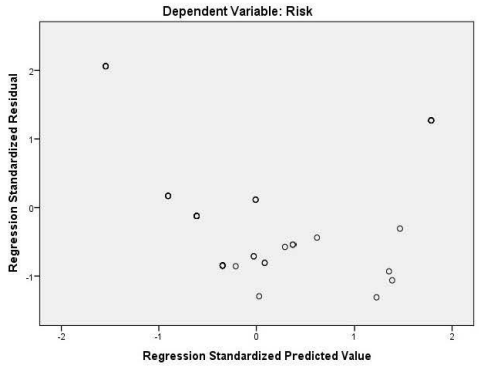


Figure 5- CA2.2: Homoscedasticity of Type of Client- Solo Individual normal Error (i.e. Constant Variance).

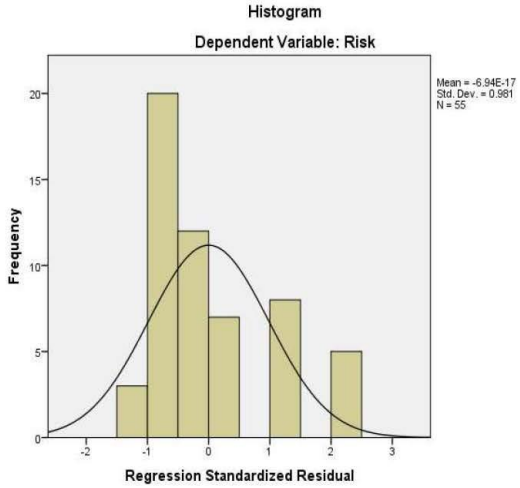


Figure 5- CA2.3: Normality of Type of Client- Solo Individual Error distribution (i.e. Bell Shaped).

3- Type of Client: Bank- Individual Partnership:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_l: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.493, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.493 (0.5> r >0.3), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.780, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.780 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA3.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA3.1} = -19.336 + 0.399\, X_{prob} + 0.481\, X_{imp} \quad \text{(Eq.5-CA3)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA3 is equal to **22.6%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA3.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 84% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	22.58	17.649	55
Probability	51.82	21.306	55
Impact	44.22	28.356	55

Table 5- CA3.1: Type of Client- Individual Partnership Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.493**	.780**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.493**	1	.016
	Sig. (2-tailed)	.000		.909
	N	55	55	55
Impact	Pearson Correlation	.780**	.016	1
	Sig. (2-tailed)	.000	.909	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA3.2: Type of Client- Individual Partnership Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14127.401	2	7063.701	136.447	.000[b]
	Residual	2691.981	52	51.769		
	Total	16819.382	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA3.3: Type of Client- Individual Partnership linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-19.336	2.972		-6.507	.000
	Probability	.399	.046	.481	8.675	.000
	Impact	.481	.035	.772	13.920	.000

Table 5- CA3.4: Type of Client- Individual regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Std. Error of the Estimate	Durbin-Watson
1	.916[a]	.840	7.195	2.178

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA3.5: Type of Client- Individual regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

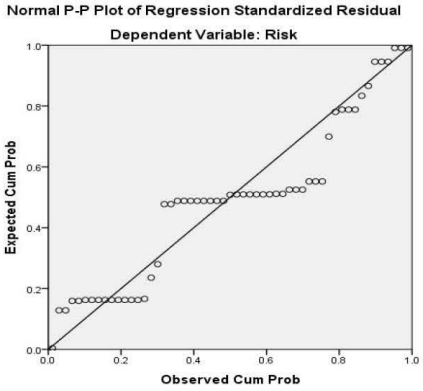


Figure 5- CA3.1: Type of Client- Individual normal Predicted Probability of the residual.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-10.54	55.01	22.58	16.175	55
Residual	-19.604	16.993	.000	7.061	55
Std. Predicted Value	-2.048	2.005	.000	1.000	55
Std. Residual	-2.725	2.362	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA3.6: Type of Client- Individual regression Residuals Statistics showing the Mean value of population Error.

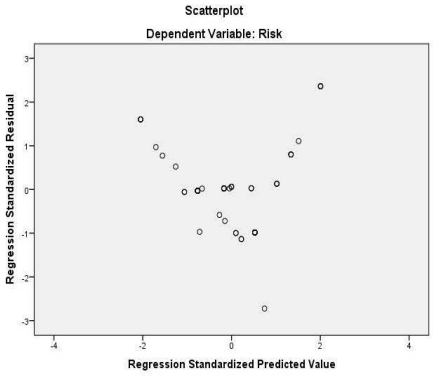


Figure 5- CA3.2: Homoscedasticity of Type of Client- Individual normal Error (i.e. Constant Variance).

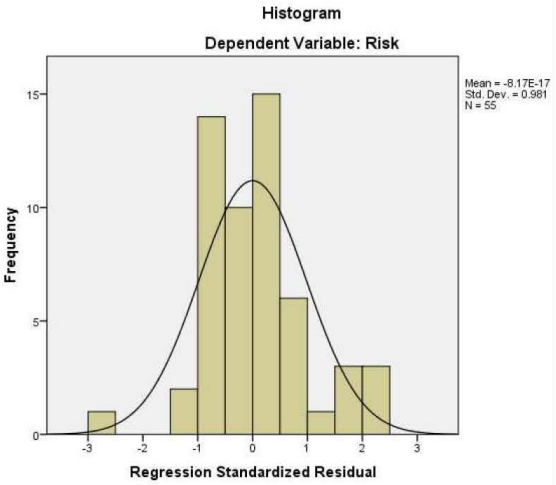


Figure 5- CA3.3: Normality of Type of Client- Individual Error distribution (i.e. Bell Shaped).

4- **Type of Client: Developer:**

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.451, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.451 (0.5> r >0.3), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.841, P-value= 0.001 (P-value < α), So H_o is ***Rejected***.
- r= 0.841 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA4.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA4.1} = -24.268 + 0.418\, X_{prob} + 0.577\, X_{imp} \quad \text{(Eq.5-CA4)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA1 is equal to **21.2%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA4.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.3% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	21.22	15.645	55
Probability	55.00	18.216	55
Impact	39.04	23.354	55

Table 5-CA4.1: Type of Client- Developer Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.451**	.841**
	Sig. (2-tailed)		.001	.000
	N	55	55	55
Probability	Pearson Correlation	.451**	1	-.041
	Sig. (2-tailed)	.001		.764
	N	55	55	55
Impact	Pearson Correlation	.841**	-.041	1
	Sig. (2-tailed)	.000	.764	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA4.2: Type of Client- Developer Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12466.476	2	6233.238	431.650	.000[b]
	Residual	750.906	52	14.440		
	Total	13217.382	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA4.3: Type of Client- Developer linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-24.268	1.888		-12.853	.000
	Probability	.418	.028	.486	14.698	.000
	Impact	.577	.022	.861	26.027	.000

a. Dependent Variable: Risk

Table 5- CA4.4: Type of Client- Developer regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.971[a]	.943	.941	3.800	2.107

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA4.5: Type of Client- Developer regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

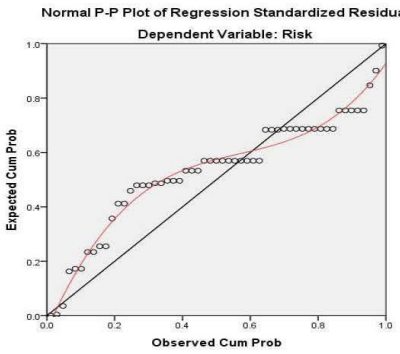


Figure 5- CA4.1: Type of Client- Developer normal Predicted Probability of the residual.

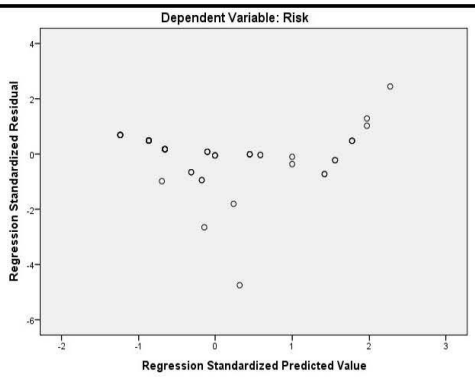


Figure 5- CA4.2: Homoscedasticity of Type of Client- Developer normal Error (i.e. Constant Variance).

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.38	55.70	21.22	15.194	55
Residual	-18.054	9.295	.000	3.729	55
Std. Predicted Value	-1.240	2.270	.000	1.000	55
Std. Residual	-4.751	2.446	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA4.6: Type of Client- Developer regression Residuals Statistics showing the Mean value of population Error.

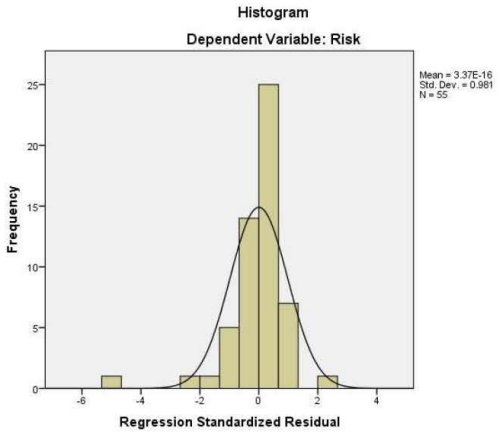


Figure 5- CA4.3: Normality of Type of Client- Developer Error distribution (i.e. Bell Shaped).

5- Type of Client: Group of People:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.400, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.400 (0.5> r >0.3), indicate that a positive weak linear relationship exist between Risk and Probability variables..
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.789, P-value= 0.004 (P-value < α), So H_o is ***Rejected***.
- r= 0.789 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA5.1c} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA5.1c} = -29.351 + 0.519\, X_{prob} + 0.558\, X_{imp} \quad \text{(Eq.5-CA5c)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA5c is equal to **26.1%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA5.5c, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.5% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	26.08	15.807	50
Probability	55.92	17.977	50
Impact	47.36	25.833	50

Table 5- CA5.1c: Type of Client- Group of People Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.400**	.789**
	Sig. (2-tailed)		.004	.000
	N	50	50	50
Probability	Pearson Correlation	.400**	1	-.209
	Sig. (2-tailed)	.004		.146
	N	50	50	50
Impact	Pearson Correlation	.789**	-.209	1
	Sig. (2-tailed)	.000	.146	
	N	50	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA5.2c: Type of Client- Group of People Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11691.325	2	5845.663	497.409	.000[b]
	Residual	552.355	47	11.752		
	Total	12243.680	49			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA5.3c: Type of Client- Group of People linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-29.351	2.025		-14.494	.000
	Probability	.519	.028	.590	18.623	.000
	Impact	.558	.019	.912	28.782	.000

a. Dependent Variable: Risk

Table 5- CA5.4c: Type of Client- Group of People regression coefficients of Probability and Impact

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.977[a]	.955	.953	3.428	1.536

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA5.5c: Type of Client- Group of People regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

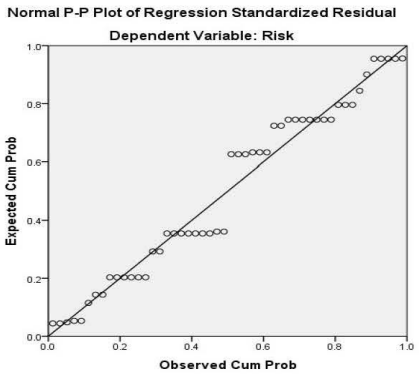


Figure 5- CA5.1c: Type of Client- Group of People normal Predicted Probability of the residual.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-1.85	54.19	26.08	15.447	50
Residual	-5.845	5.847	.000	3.357	50
Std. Predicted Value	-1.808	1.820	.000	1.000	50
Std. Residual	-1.705	1.706	.000	.979	50

a. Dependent Variable: Risk

Table 5- CA5.6c: Type of Client- Group of People regression Residuals Statistics showing the Mean value of population Error.

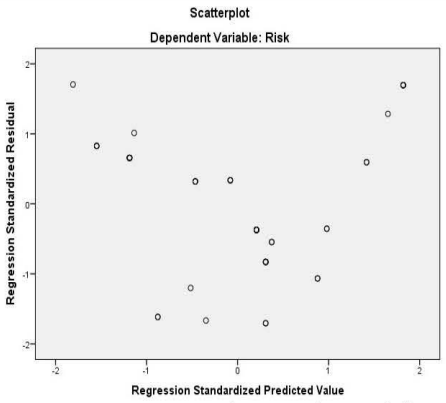


Figure 5- CA5.2c: Homoscedasticity of Type of Client- Group of People normal Error (i.e. Constant Variance).

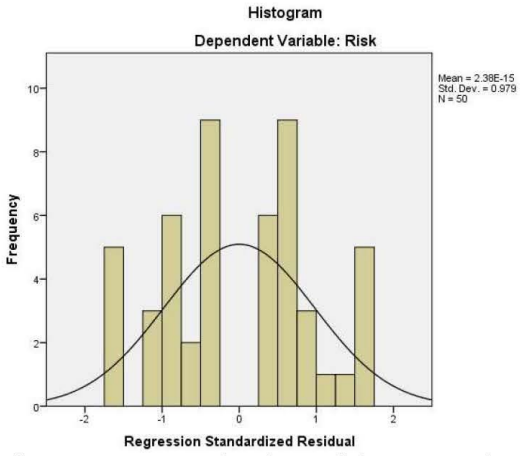


Figure 5- CA5.3c: Normality of Type of Client- Group of People Error distribution (i.e. Bell Shaped).

6- Location: City Area:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.648, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.648 (0.7> r >0.5), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.943, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.943 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA6.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA6.1} = -24.410 + 0.405 X_{prob} + 0.650 X_{imp} \quad \text{(Eq.5-CA6)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA1 is equal to **22.7%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA6.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 97.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	22.67	19.730	55
Probability	58.40	15.420	55
Impact	36.05	24.689	55

Table 5- CA6.1: Location- City Area Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.648**	.943**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.648**	1	.408**
	Sig. (2-tailed)	.000		.002
	N	55	55	55
Impact	Pearson Correlation	.943**	.408**	1
	Sig. (2-tailed)	.000	.002	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA6.2: Location- City Area Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20429.875	2	10214.938	899.943	.000[b]
	Residual	590.234	52	11.351		
	Total	21020.109	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA6.3: Location- City Area linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-24.410	1.795		-13.596	.000
	Probability	.405	.033	.316	12.432	.000
	Impact	.650	.020	.813	31.962	.000

a. Dependent Variable: Risk

Table 5- CA1.4: Location- City Area regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.986[a]	.972	.971	3.369	2.007

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA6.5: Location- City Area of People regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

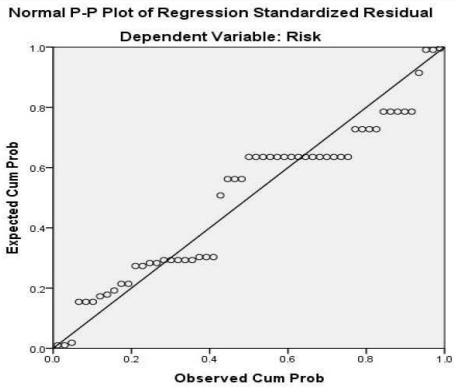


Figure 5- CA6.1: Location- City Area normal Predicted Probability of the residual.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-5.76	64.03	22.67	19.451	55
Residual	-7.840	8.763	.000	3.306	55
Std. Predicted Value	-1.462	2.126	.000	1.000	55
Std. Residual	-2.327	2.601	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA6.6: Location- City Area of People regression Residuals Statistics showing the Mean value of population Error.

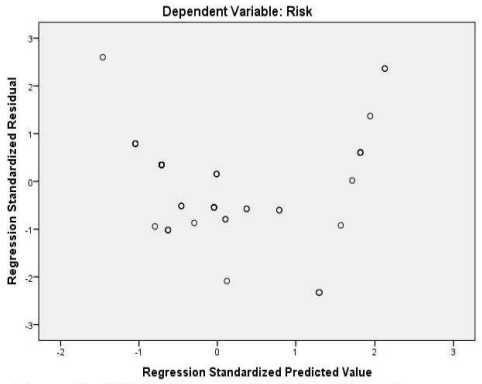


Figure 5- CA6.2: Homoscedasticity of Location- City Area normal Error (i.e. Constant Variance).

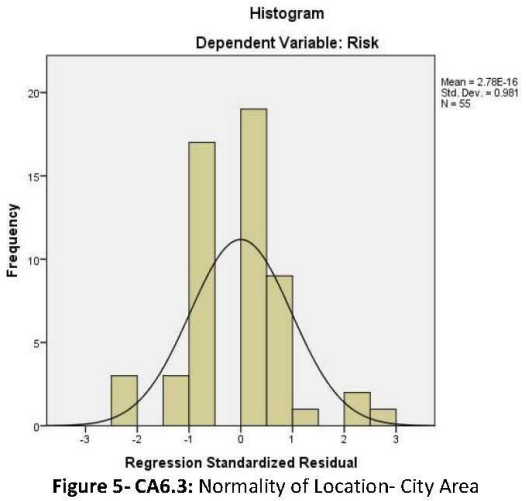


Figure 5- CA6.3: Normality of Location- City Area Error distribution (i.e. Bell Shaped).

7- Location: Regional Area:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.312 P-value= 0.020 (P-value < α), So H_O is ***Rejected***.
- r= 0.312 (0.5> r >0.3), indicate that a positive weak linear relationship exist between Risk and Probability variables..
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.914, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.914 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA7.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA7.1} = -21.507 + 0.341\, X_{prob} + 0.628\, X_{imp} \quad \text{(Eq.5-CA7)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA7 is equal to **22.8%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA7.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.3% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	22.84	18.129	55
Probability	62.07	17.459	55
Impact	36.93	26.565	55

Table 5- CA7.1: Location- Regional Area Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.312*	.914**
	Sig. (2-tailed)		.020	.000
	N	55	55	55
Probability	Pearson Correlation	.312*	1	-.018
	Sig. (2-tailed)	.020		.897
	N	55	55	55
Impact	Pearson Correlation	.914**	-.018	1
	Sig. (2-tailed)	.000	.897	
	N	55	55	55

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA7.2: Location- Regional Area Correlation significance analysis of Risk, Probability and Impact

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16741.622	2	8370.811	432.727	.000[b]
	Residual	1005.906	52	19.344		
	Total	17747.527	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA7.3: Location- Regional Area linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-21.507	2.374		-9.058	.000
	Probability	.341	.034	.328	9.942	.000
	Impact	.628	.023	.920	27.861	.000

a. Dependent Variable: Risk

Table 5- CA7.4: Location- Regional Area regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.971[a]	.943	.941	4.398	1.898

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA7.5: Location- Regional Area of People regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

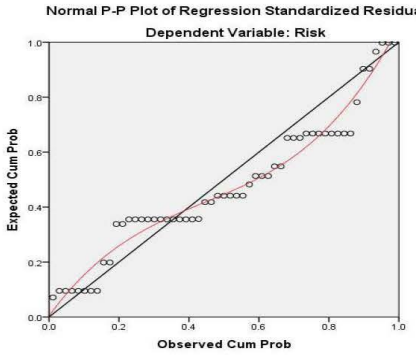


Figure 5- CA7.1: Location- Regional Area normal Predicted Probability of the residual.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-11.82	59.40	22.84	17.608	55
Residual	-6.451	12.820	.000	4.316	55
Std. Predicted Value	-1.968	2.076	.000	1.000	55
Std. Residual	-1.467	2.915	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA7.6: Location- Regional Area regression Residuals Statistics showing the Mean value of population Error.

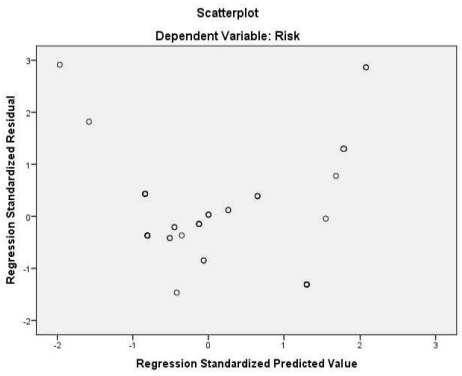


Figure 5- CA7.2: Homoscedasticity of Location- Regional Area normal Error (i.e. Constant Variance).

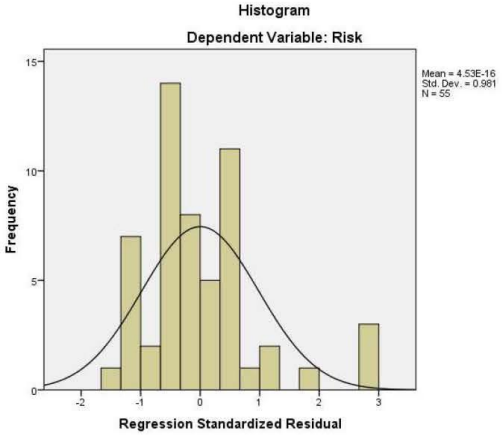


Figure 5- CA7.3: Normality of Location- Regional Area Error distribution (i.e. Bell Shaped).

8- Location: Beach Area:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.737, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.737 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.841, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.841 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA8.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA8.1} = -19.832 + 0.431 X_{prob} + 0.487 X_{imp} \quad \text{(Eq.5-CA8)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA8 is equal to **23.6%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA8.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 93% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	23.55	16.722	55
Probability	48.89	19.581	55
Impact	45.80	22.779	55

Table 5- CA8.1: Location- Beach Area Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.737**	.841**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.737**	1	.351**
	Sig. (2-tailed)	.000		.009
	N	55	55	55
Impact	Pearson Correlation	.841**	.351**	1
	Sig. (2-tailed)	.000	.009	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA8.2: Location- Beach Area Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14043.128	2	7021.564	345.592	.000[b]
	Residual	1056.509	52	20.317		
	Total	15099.636	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA8.3: Location- Beach Area linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-19.832	1.808		-10.972	.000
	Probability	.431	.033	.504	12.874	.000
	Impact	.487	.029	.664	16.949	.000

a. Dependent Variable: Risk

Table 5- CA8.4: Location- Beach Area regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.964[a]	.930	.927	4.507	2.153

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA8.5: Location- Beach Area of People regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

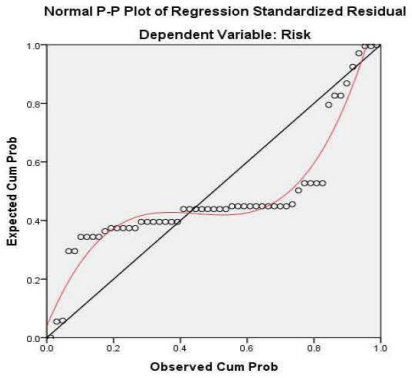


Figure 5- CA8.1: Location- Beach Area normal Predicted Probability of the residual.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-10.65	57.92	23.55	16.126	55
Residual	-15.457	14.082	.000	4.423	55
Std. Predicted Value	-2.121	2.131	.000	1.000	55
Std. Residual	-3.429	3.124	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA8.6: Location- Beach Area regression Residuals Statistics showing the Mean value of population Error.

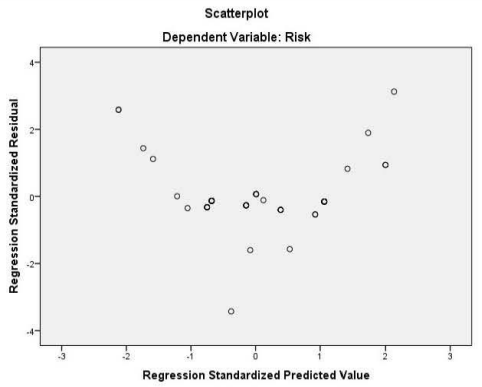


Figure 5- CA8.2: Homoscedasticity of Location- Beach Area normal Error (i.e. Constant Variance).

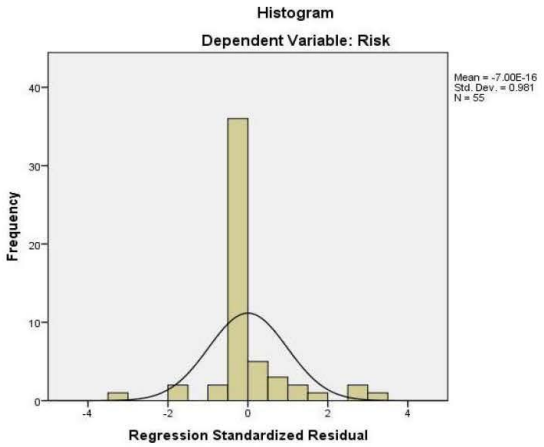


Figure 5- CA8.3: Normality of Location- Beach Area Error distribution (i.e. Bell Shaped).

9- Location: Desert Area:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.801, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.801 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.919, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.919 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA9.1d} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA9.1d} = -41.191 + 0.723 X_{prob} + 0.5549 X_{imp} \quad \text{(Eq.5-CA9d)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA9d is equal to **31.65%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA9.5d, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 96.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	31.65	23.420	52
Probability	55.12	28.047	52
Impact	59.54	24.270	52

Table 5- CA9.1d: Location- Desert Area Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.801**	.476**
	Sig. (2-tailed)		.000	.000
	N	52	52	52
Probability	Pearson Correlation	.801**	1	-.113
	Sig. (2-tailed)	.000		.424
	N	52	52	52
Impact	Pearson Correlation	.476**	-.113	1
	Sig. (2-tailed)	.000	.424	
	N	52	52	52

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA9.2d: Location- Desert Area Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	27042.258	2	13521.129	711.248	.000[b]
	Residual	931.512	49	19.010		
	Total	27973.769	51			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA9.3d: Location- Desert Area linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-41.191	2.123		-19.399	.000
	Probability	.723	.022	.866	32.993	.000
	Impact	.554	.025	.574	21.894	.000

a. Dependent Variable: Risk

Table 5- CA9.4d: Location- Desert Area regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.50	68.21	31.65	23.027	52
Residual	-11.039	9.332	.000	4.274	52
Std. Predicted Value	-1.353	1.588	.000	1.000	52
Std. Residual	-2.532	2.140	.000	.980	52

a. Dependent Variable: Risk

Table 5- CA9.6d: Location- Desert Area regression Residuals Statistics showing the Mean value of population Error.

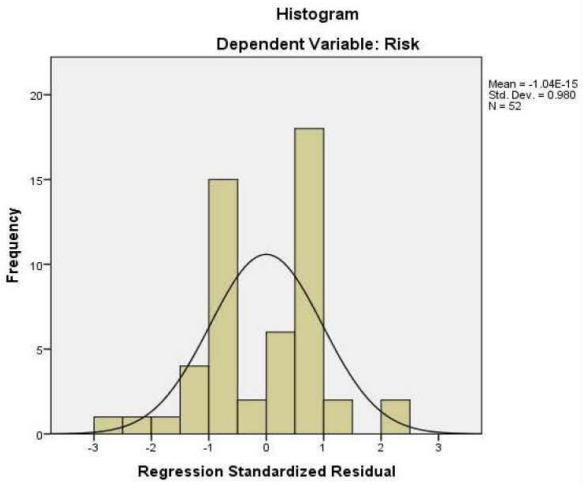


Figure 5- CA9.3d: Normality of Location- Desert Area Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.983[a]	.967	.965	4.360	1.603

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA9.5d: Location- Desert Area of People regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

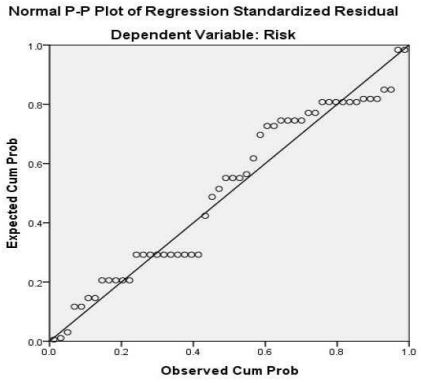


Figure 5- CA9.1d: Location- Desert Area normal Predicted Probability of the residual.

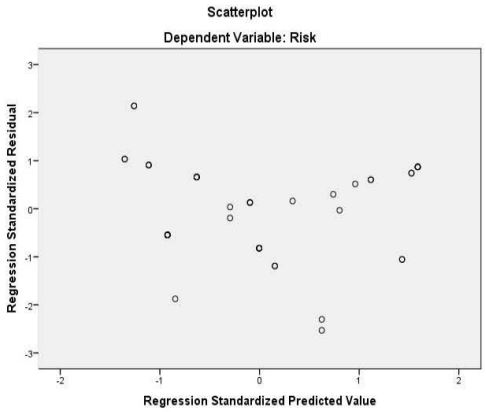


Figure 5- CA9.2d: Homoscedasticity of Location- Desert Area normal Error (i.e. Constant Variance).

10- **Building Services Complexity: Operational Services**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_l: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.467, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.467 (0.3 to 0.5), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.723, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.723 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA10.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA10.1} = -28.441 + 0.514 X_{prob} + 0.529 X_{imp} \quad \text{(Eq.5-CA10)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA10 is equal to **26.8%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA10.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 89.8% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	26.82	17.132	55
Probability	57.05	20.769	55
Impact	48.96	27.172	55

Table 5- CA10.1: Building Services Complexity- Operational Services Data Descriptive Statistics of Risk, Probability and

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.467**	.723**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.467**	1	-.187
	Sig. (2-tailed)	.000		.172
	N	55	55	55
Impact	Pearson Correlation	.723**	-.187	1
	Sig. (2-tailed)	.000	.172	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA10.2: Building Services Complexity- Operational Services Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14226.731	2	7113.366	227.845	.000[b]
	Residual	1623.451	52	31.220		
	Total	15850.182	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA10.3: Building Services Complexity- Operational Services linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-28.441	2.853		-9.968	.000
	Probability	.514	.037	.624	13.806	.000
	Impact	.529	.028	.839	18.574	.000

Table 5- CA10.4: Location- Desert Area regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.947[a]	.898	.894	5.588	2.212

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA10.5: Location- Desert Area of People regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-10.36	60.19	26.82	16.231	55
Residual	-10.444	12.361	.000	5.483	55
Std. Predicted Value	-2.291	2.056	.000	1.000	55
Std. Residual	-1.869	2.212	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA10.6: Location- Desert Area regression Residuals Statistics showing the Mean value of population Error.

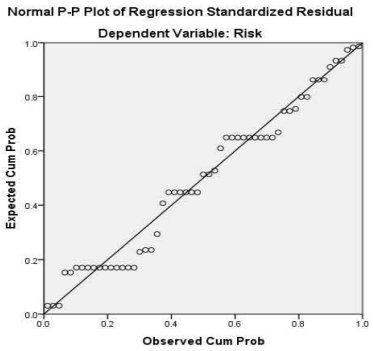


Figure 5- CA10.1: Location- Desert Area normal Predicted Probability of the residual.

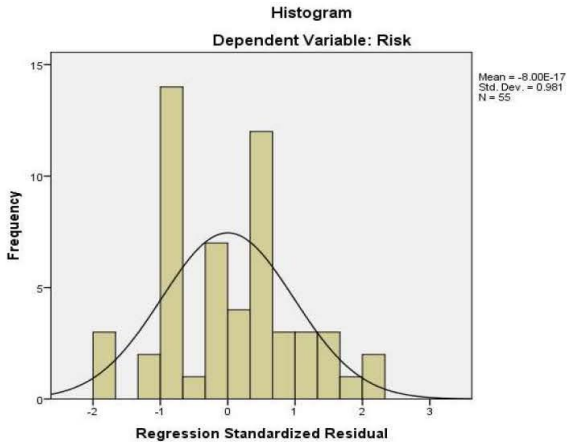


Figure 5- CA10.3: Normality of Building Services Complexity- Operational Services Error distribution (i.e. Bell Shaped).

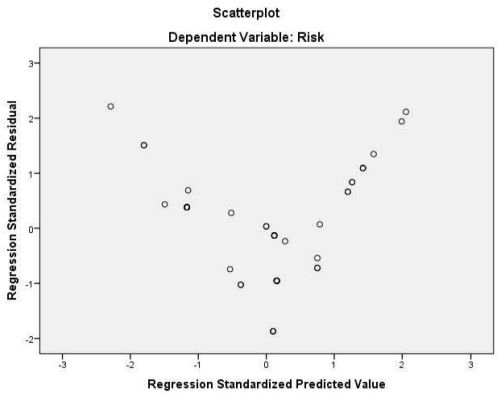


Figure 5- CA10.2: Homoscedasticity of Building Services Complexity- Operational Services normal Error (i.e. Constant Variance).

11- **Building Services Complexity: Fitness Services:**

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.343, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.343 (> 0.7), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.936, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.936 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA11.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA11.1} = -10.250 + 0.234 X_{prob} + 0.490 X_{imp} \quad \text{(Eq.5-CA11)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA11 is equal to **24.2%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA11.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.8% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	24.15	15.401	55
Probability	53.13	18.880	55
Impact	44.91	28.891	55

Table 5- CA11.1: Building Services Complexity- Fitness Services Data Descriptive Statistics of Risk, Probability

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.343*	.936**
	Sig. (2-tailed)		.010	.000
	N	55	55	55
Probability	Pearson Correlation	.343*	1	.062
	Sig. (2-tailed)	.010		.655
	N	55	55	55
Impact	Pearson Correlation	.936**	.062	1
	Sig. (2-tailed)	.000	.655	
	N	55	55	55

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA11.2: Building Services Complexity- Fitness Services Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12268.387	2	6134.194	590.209	.000[b]
	Residual	540.449	52	10.393		
	Total	12808.836	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA11.3: Building Services Complexity- Fitness Services linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-10.250	1.443		-7.105	.000
	Probability	.234	.023	.286	10.033	.000
	Impact	.490	.015	.918	32.179	.000

Table 5- CA11.4: Building Services Complexity- Fitness Services regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-3.02	45.27	24.15	15.073	55
Residual	-11.922	10.734	.000	3.164	55
Std. Predicted Value	-1.802	1.401	.000	1.000	55
Std. Residual	-3.698	3.330	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA11.6: Building Services Complexity- Fitness Services regression Residuals Statistics showing the Mean value of

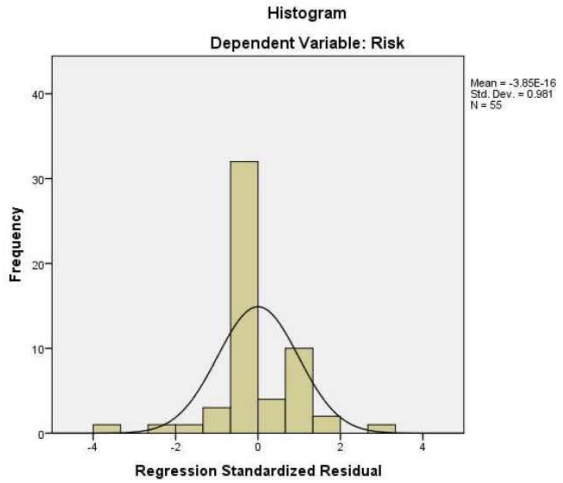


Figure 5- CA11.2: Homoscedasticity of Building Services Complexity- Fitness Services normal Error (i.e. Constant Variance).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.979[a]	.958	.956	3.224	1.903

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA11.5: Building Services Complexity- Fitness Services regression Model Summary showing how much in percentage (%) the population is represented by the

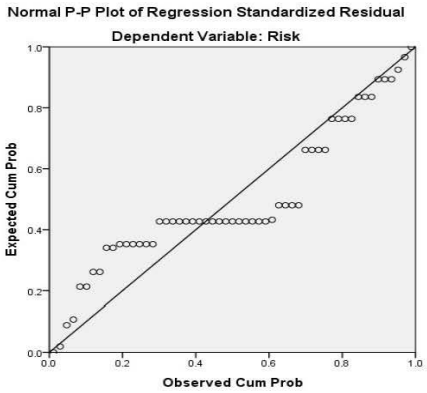


Figure 5- CA11.1: Building Services Complexity- Fitness Services normal Predicted Probability of the residual.

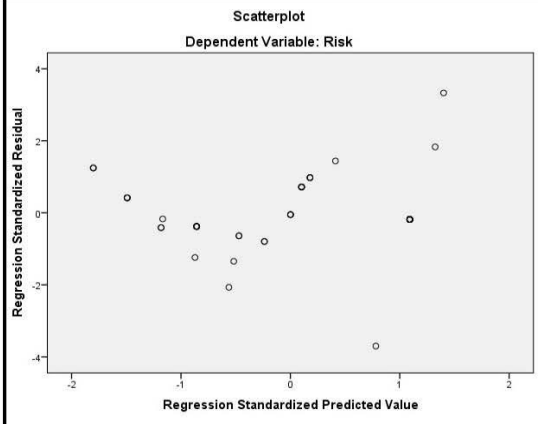


Figure 5- CA11.3: Normality of Building Services Complexity- Fitness Services Error distribution (i.e. Bell Shaped).

12- Number of Basement Levels:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.709, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.709 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.828, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.828 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA12.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA12.1} = -22.454 + 0.497\ X_{prob} + 0.481\ X_{imp} \quad \text{(Eq.5-CA12)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA12 is equal to **22.6%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA12.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	22.56	18.953	55
Probability	50.78	19.394	55
Impact	41.13	26.643	55

Table 5- CA12.1: Number of Basement Levels Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.709**	.828**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.709**	1	.297*
	Sig. (2-tailed)	.000		.028
	N	55	55	55
Impact	Pearson Correlation	.828**	.297*	1
	Sig. (2-tailed)	.000	.028	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CA12.2: Number of Basement Levels Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17854.888	2	8927.444	300.930	.000[b]
	Residual	1542.640	52	29.666		
	Total	19397.527	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA12.3: Number of Basement Levels linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-22.454	2.158		-10.403	.000
1 Probability	.497	.040	.508	12.410	.000
Impact	.481	.029	.677	16.517	.000

a. Dependent Variable: Risk

Table 5- CA12.4: Number of Basement Levels regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.959[a]	.920	.917	5.447	1.636

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA12.5: Number of Basement Levels regression Model Summary showing how much in percentage (%) the population is represented by the

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-12.67	60.75	22.56	18.184	55
Residual	-13.013	13.674	.000	5.345	55
Std. Predicted Value	-1.938	2.100	.000	1.000	55
Std. Residual	-2.389	2.511	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA12.6: Number of Basement Levels regression Residuals Statistics showing the Mean value of population

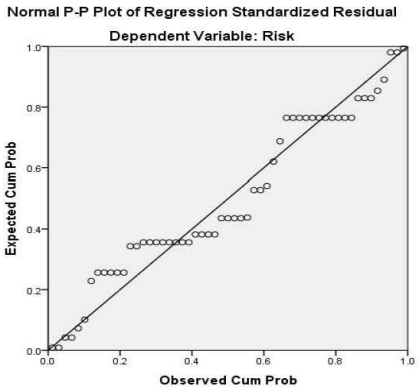


Figure 5- CA12.1: Number of Basement Levels normal Predicted Probability of the residual.

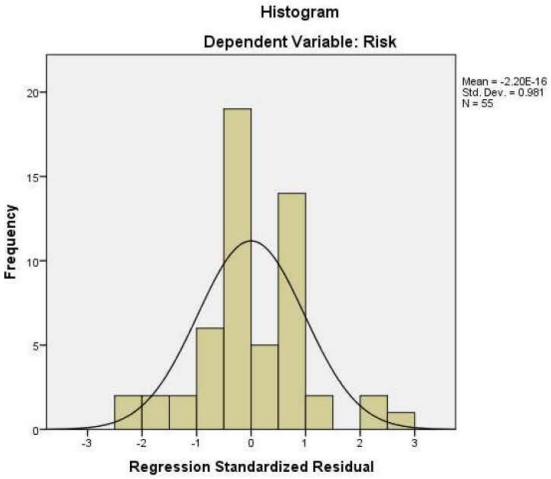


Figure 5- CA12.3: Normality of Number of Basement Levels Error distribution (i.e. Bell Shaped).

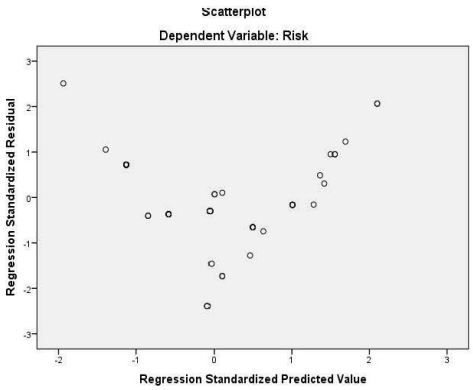


Figure 5- CA12.2: Homoscedasticity of Number of Basement Levels normal Error (i.e. Constant Variance).

13- **Procurement Method**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.426, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.426 (0.3 to 0.5), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.846, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.846 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA13.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA13.1} = -32.193 + 0.502\, X_{prob} + 0.636\, X_{imp} \quad \text{(Eq.5-CA13)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA13 is equal to **29.2%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA13.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	29.20	17.190	55
Probability	61.82	16.545	55
Impact	47.75	23.699	55

Table 5- CA13.1: Procurement Method Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.426**	.846**
	Sig. (2-tailed)		.001	.000
	N	55	55	55
Probability	Pearson Correlation	.426**	1	-.065
	Sig. (2-tailed)	.001		.636
	N	55	55	55
Impact	Pearson Correlation	.846**	-.065	1
	Sig. (2-tailed)	.000	.636	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA13.2: Procurement Method Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15117.370	2	7558.685	468.237	.000[b]
	Residual	839.430	52	16.143		
	Total	15956.800	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA13.3: Procurement Method linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-32.193	2.449		-13.145	.000
	Probability	.502	.033	.483	15.148	.000
	Impact	.636	.023	.877	27.522	.000

a. Dependent Variable: Risk

Table 5- CA13.4: Procurement Method regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.973[a]	.947	.945	4.018	2.005

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA13.5: Procurement Method regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.75	63.86	29.20	16.732	55
Residual	-8.762	8.138	.000	3.943	55
Std. Predicted Value	-1.790	2.072	.000	1.000	55
Std. Residual	-2.181	2.026	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA13.6: Procurement Method regression Residuals Statistics showing the Mean value of population Error.

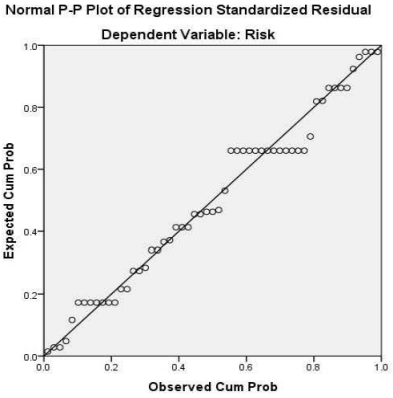


Figure 5- CA13.1: Procurement Method normal Predicted Probability of the residual.

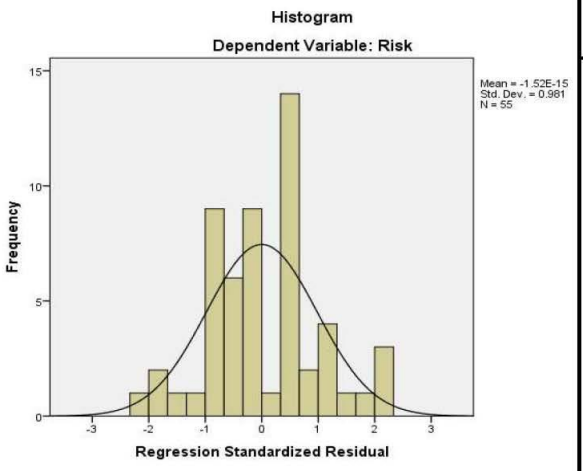


Figure 5- CA13.3: Normality of Procurement Method Error distribution (i.e. Bell Shaped).

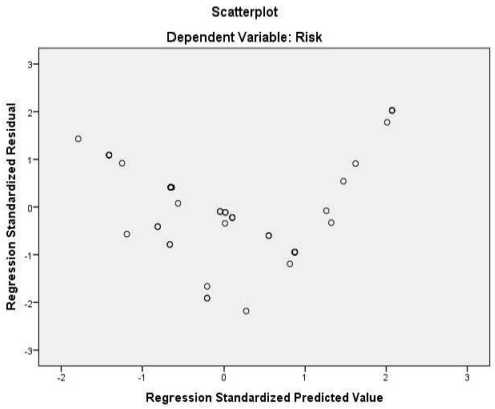


Figure 5- CA13.2: Homoscedasticity of Procurement Method normal Error (i.e. Constant Variance).

14- Site Topography:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.522, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.522 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.856, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.856 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA14.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA14.1} = -24.830 + 0.397 X_{prob} + 0.622 X_{imp} \quad \text{(Eq.5-CA14)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA14 is equal to **26.9%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA14.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92.4% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	26.93	17.920	55
Probability	59.89	19.885	55
Impact	45.00	23.373	55

Table 5- CA14.1: Site Topography Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.522**	.856**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.522**	1	.101
	Sig. (2-tailed)	.000		.462
	N	55	55	55
Impact	Pearson Correlation	.856**	.101	1
	Sig. (2-tailed)	.000	.462	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA14.2: Site Topography Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16032.116	2	8016.058	318.294	.000[b]
	Residual	1309.593	52	25.184		
	Total	17341.709	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA14.3: Site Topography linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-24.830	2.434		-10.200	.000
	Probability	.397	.035	.440	11.493	.000
	Impact	.622	.029	.811	21.182	.000

a. Dependent Variable: Risk

Table 5- CA14.4: Site Topography regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.962[a]	.924	.922	5.018	2.433

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA14.5: Site Topography regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-6.71	60.65	26.93	17.231	55
Residual	-21.033	11.353	.000	4.925	55
Std. Predicted Value	-1.952	1.957	.000	1.000	55
Std. Residual	-4.191	2.262	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA14.6: Site Topography regression Residuals Statistics showing the Mean value of population Error.

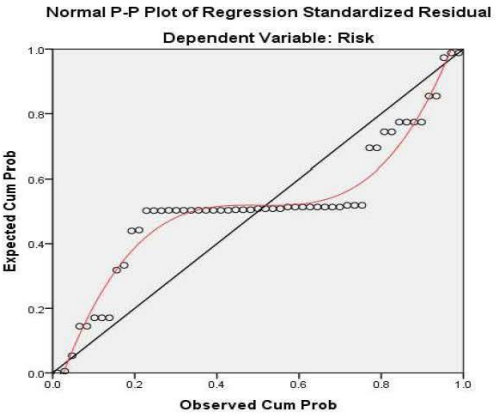


Figure 5- CA14.1: Site Topography normal Predicted Probability of the residual.

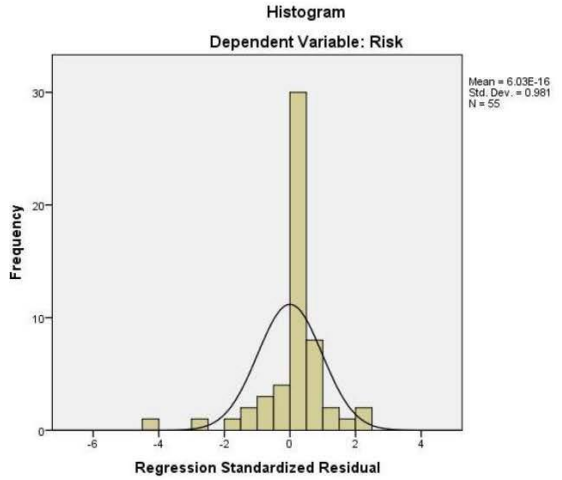


Figure 5- CA14.3: Normality of Site Topography Error distribution (i.e. Bell Shaped).

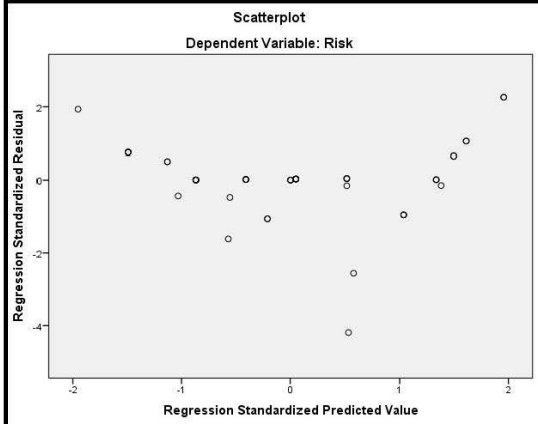


Figure 5- CA14.2: Homoscedasticity of Site Topography normal Error (i.e. Constant Variance).

15- Site Conditions:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.620, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.620 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.908, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.908 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA15.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA15.1} = -26.255 + 0.400\, X_{prob} + 0.668\, X_{imp} \quad \text{(Eq.5-CA15)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA15 is equal to **29.3%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA15.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.6% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	29.33	20.110	55
Probability	60.75	18.461	55
Impact	46.80	23.787	55

Table 5- CA15.1: Site Conditions Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.620**	.908**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.620**	1	.320*
	Sig. (2-tailed)	.000		.017
	N	55	55	55
Impact	Pearson Correlation	.908**	.320*	1
	Sig. (2-tailed)	.000	.017	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CA15.2: Site Conditions Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20652.899	2	10326.449	453.063	.000[b]
	Residual	1185.210	52	22.793		
	Total	21838.109	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA15.3: Site Conditions linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-26.255	2.319		-11.322	.000
	Probability	.400	.037	.367	10.770	.000
	Impact	.668	.029	.791	23.187	.000

a. Dependent Variable: Risk

Table 5- CA15.4: Site Conditions regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.972[a]	.946	.944	4.774	2.032

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA15.5: Site Conditions regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-7.57	63.22	29.33	19.557	55
Residual	-22.169	10.570	.000	4.685	55
Std. Predicted Value	-1.887	1.733	.000	1.000	55
Std. Residual	-4.643	2.214	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA15.6: Site Conditions regression Residuals Statistics showing the Mean value of population Error.

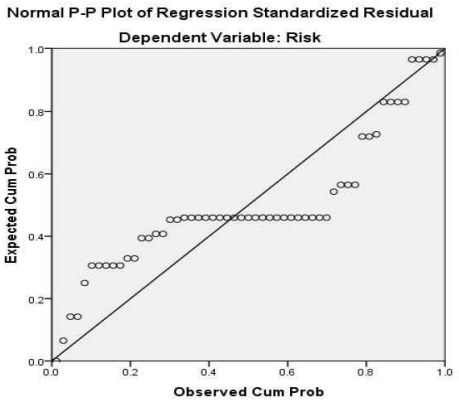


Figure 5- CA15.1: Site Conditions normal Predicted Probability of the residual.

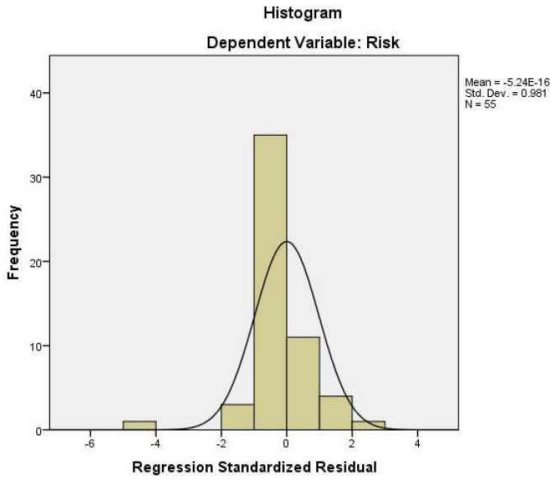


Figure 5- CA15.3: Normality of Site Conditions Error distribution (i.e. Bell Shaped).

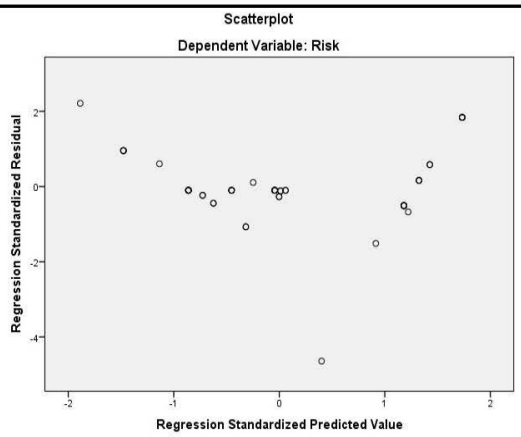


Figure 5- CA15.2: Homoscedasticity of Site Conditions normal Error (i.e. Constant Variance).

16- Working Space:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: $\rho = 0$, (i.e. No Correlation between variables),
H_i: $\rho \neq 0$, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.550, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.550 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.880, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.880 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA16.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA16.1} = -17.034 + 0.339\, X_{prob} + 0.531\, X_{imp} \quad \text{(Eq.5-CA16)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA16 is equal to **19.1%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA16.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92.1% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	19.13	16.546	55
Probability	52.02	19.093	55
Impact	34.91	24.991	55

Table 5- CA16.1: Working Space Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.550**	.880**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.550**	1	.199
	Sig. (2-tailed)	.000		.145
	N	55	55	55
Impact	Pearson Correlation	.880**	.199	1
	Sig. (2-tailed)	.000	.145	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA16.2: Working Space Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13622.921	2	6811.461	305.029	.000[b]
	Residual	1161.188	52	22.331		
	Total	14784.109	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA16.3: Working Space linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-17.034	1.947		-8.749	.000
	Probability	.339	.034	.391	9.851	.000
	Impact	.531	.026	.803	20.238	.000

a. Dependent Variable: Risk

Table 5- CA16.4: Working Space regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-8.33	55.27	19.13	15.883	55
Residual	-11.633	14.730	.000	4.637	55
Std. Predicted Value	-1.729	2.276	.000	1.000	55
Std. Residual	-2.462	3.117	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA16.6: Working Space regression Residuals Statistics showing the Mean value of population Error.

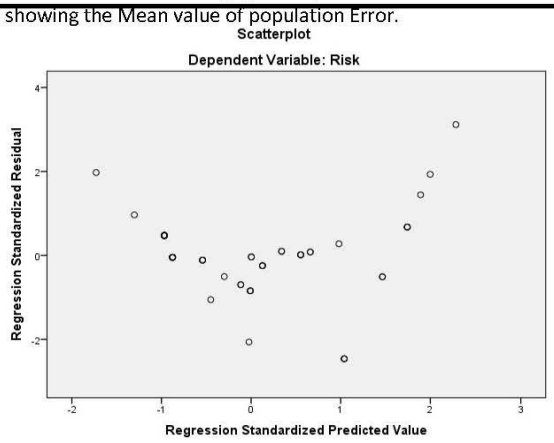


Figure 5- CA16.2: Homoscedasticity of Working Space normal Error (i.e. Constant Variance).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.960[a]	.921	.918	4.726	1.841

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA16.5: Working Space regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

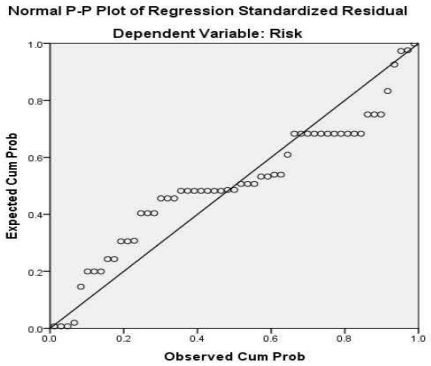


Figure 5- CA16.1: Working Space normal Predicted Probability of the residual.

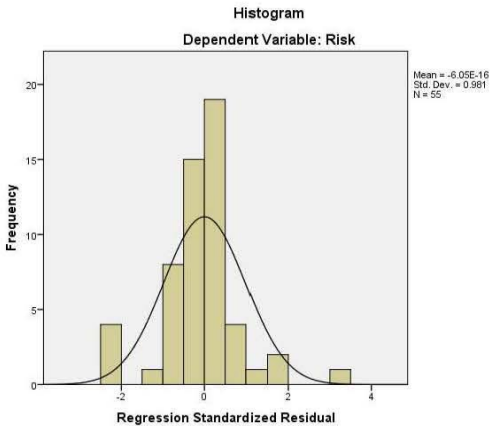


Figure 5- CA16.3: Normality of Project Selection Method Error distribution (i.e. Bell Shaped).

17- **Site Access:**

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.660, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.660 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.925, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.925 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA17.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA17.1} = -17.168 + 0.285 X_{prob} + 0.656 X_{imp} \quad \text{(Eq.5-CA17)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA17 is equal to **19.9%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA17.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.5% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	19.91	18.686	55
Probability	53.80	21.538	55
Impact	33.20	22.425	55

Table 5- CA17.1: Site Access Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.660**	.925**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.660**	1	.422**
	Sig. (2-tailed)	.000		.001
	N	55	55	55
Impact	Pearson Correlation	.925**	.422**	1
	Sig. (2-tailed)	.000	.001	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA17.2: Site Access: Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17808.620	2	8904.310	442.693	.000[b]
	Residual	1045.926	52	20.114		
	Total	18854.545	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA17.3: Site Access: linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-17.168	1.665		-10.311	.000
	Probability	.285	.031	.328	9.104	.000
	Impact	.656	.030	.787	21.841	.000

a. Dependent Variable: Risk

Table 5- CA17.4: Site Access regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-7.77	64.61	19.91	18.160	55
Residual	-18.822	9.674	.000	4.401	55
Std. Predicted Value	-1.524	2.461	.000	1.000	55
Std. Residual	-4.197	2.157	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA17.6: Site Access regression Residuals Statistics showing the Mean value of population Error.

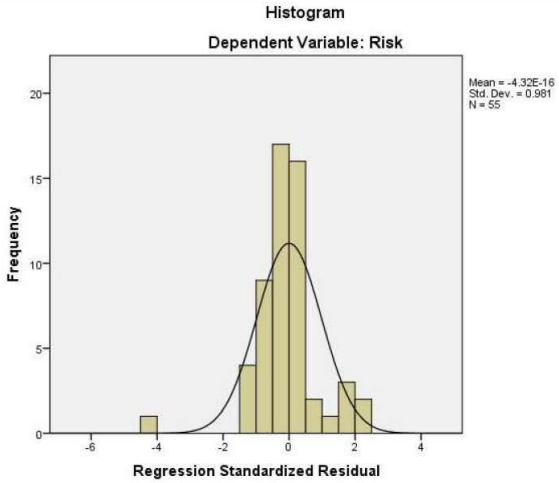


Figure 5- CA17.3: Normality of Site Access Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.972[a]	.945	.942	4.485	1.979

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA17.5: Site Access regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

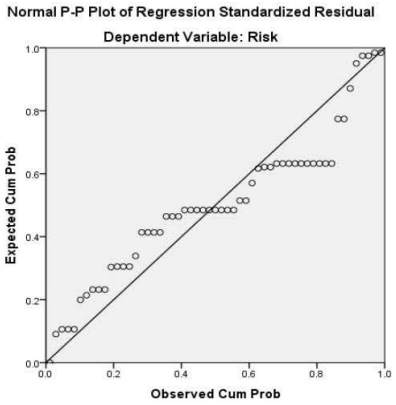


Figure 5- CA17.1: Site Access normal Predicted Probability of the residual.

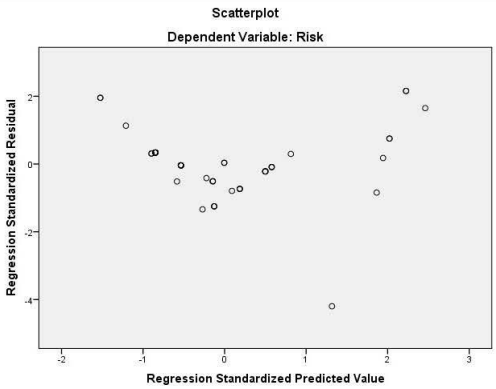


Figure 5- CA17.2: Homoscedasticity of Site Access normal Error (i.e. Constant Variance).

18- **Frame Structure:**

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.003, P-value= 0.983 (P-value > α), So H_I is ***Rejected***.
- r= 0.003 (< 0.3), indicate that no linear relationship exist between Risk and Probability variables.
- Therefore, there is no evidence that between Risk and Probability Correlation Exists, but the relationship may be proved in the regression analysis.

Risk vs. Impact:

- r= 0.884, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.884 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA18.1c} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA18.1c} = -18.767 + 0.272 X_{prob} + 0.616 X_{imp} \quad \text{(Eq.5-CA18c)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA18c is equal to **18.5%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA18.5c, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	18.45	13.281	51
Probability	64.61	21.304	51
Impact	31.90	22.886	51

Table 5- CA18.1c: Frame Structure Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.003	.884**
	Sig. (2-tailed)		.983	.000
	N	51	51	51
Probability	Pearson Correlation	.003	1	-.408**
	Sig. (2-tailed)	.983		.003
	N	51	51	51
Impact	Pearson Correlation	.884**	-.408**	1
	Sig. (2-tailed)	.000	.003	
	N	51	51	51

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA18.2c: Frame Structure Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8292.320	2	4146.160	378.135	.000[b]
	Residual	526.308	48	10.965		
	Total	8818.627	50			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA18.3c: Frame Structure linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-18.767	2.013		-9.324	.000
	Probability	.272	.024	.436	11.290	.000
	Impact	.616	.022	1.062	27.500	.000

a. Dependent Variable: Risk

Table 5- CA18.4c: Frame Structure regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-2.10	49.56	18.45	12.878	51
Residual	-5.582	6.444	.000	3.244	51
Std. Predicted Value	-1.596	2.415	.000	1.000	51
Std. Residual	-1.686	1.946	.000	.980	51

a. Dependent Variable: Risk

Table 5- CA18.6c: Frame Structure regression Residuals Statistics showing the Mean value of population Error.

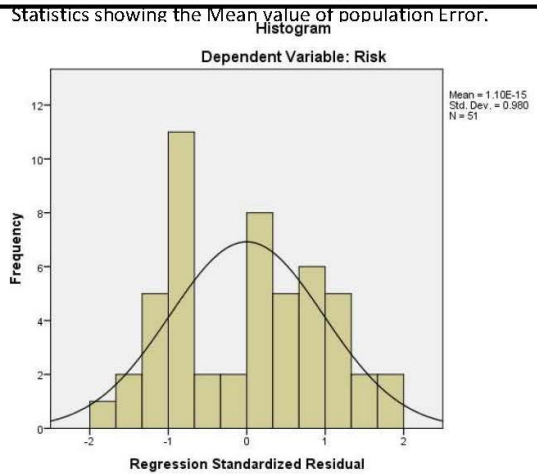


Figure 5- CA18.3c: Normality of Frame Structure Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.970[a]	.940	.938	3.311	1.503

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA18.5c: Frame Structure regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

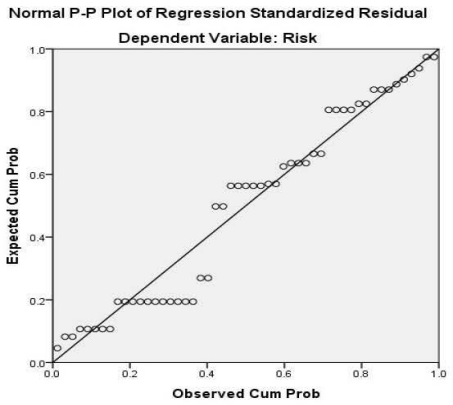


Figure 5- CA18.1c: Frame Structure normal Predicted Probability of the residual.

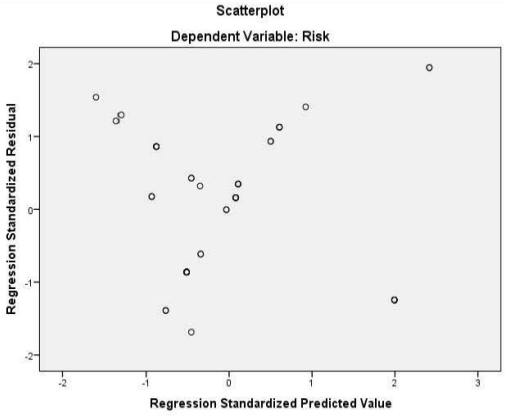


Figure 5- CA18.2c: Homoscedasticity of Frame Structure normal Error (i.e. Constant Variance).

19- **Foundation Type**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.092, P-value= 0.514 (P-value > α), So H_I is ***Rejected***.
- r= 0.092 (< 0.3), indicate that no linear relationship exist between Risk and Probability variables.
- Therefore, there is no evidence that between Risk and Probability Correlation Exists, but the relationship may be proved in the regression analysis.

Risk vs. Impact:

- r= 0.941, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.941 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA19.1b} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA19.1b} = -15.876 + 0.597 X_{prob} + 0.257 X_{imp} \quad \text{(Eq.5-CA19b)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA19b is equal to **18.9%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA19.5b, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	18.87	13.951	53
Probability	61.83	14.135	53
Impact	31.62	23.050	53

Table 5- CA19.1b: Foundation Type Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.092	.941**
	Sig. (2-tailed)		.514	.000
	N	53	53	53
Probability	Pearson Correlation	.092	1	-.171
	Sig. (2-tailed)	.514		.221
	N	53	53	53
Impact	Pearson Correlation	.941**	-.171	1
	Sig. (2-tailed)	.000	.221	
	N	53	53	53

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA19.2b: Foundation Type Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9634.674	2	4817.337	496.222	.000[b]
	Residual	485.402	50	9.708		
	Total	10120.075	52			

a. Dependent Variable: Risk

b. Predictors: (Constant), Probability, Impact

Table 5- CA19.3b: Foundation Type linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-15.876	2.149		-7.387	.000
	Impact	.597	.019	.986	31.364	.000
	Probability	.257	.031	.260	8.276	.000

a. Dependent Variable: Risk

Table 5- CA19.4b: Foundation Type regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.976[a]	.952	.950	3.116	1.913

a. Predictors: (Constant), Probability, Impact

b. Dependent Variable: Risk

Table 5- CA19.5b: Foundation Type regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-5.19	51.12	18.87	13.612	53
Residual	-7.030	8.884	.000	3.055	53
Std. Predicted Value	-1.767	2.369	.000	1.000	53
Std. Residual	-2.256	2.851	.000	.981	53

a. Dependent Variable: Risk

Table 5- CA19.6b: Foundation Type regression Residuals Statistics showing the Mean value of population Error.

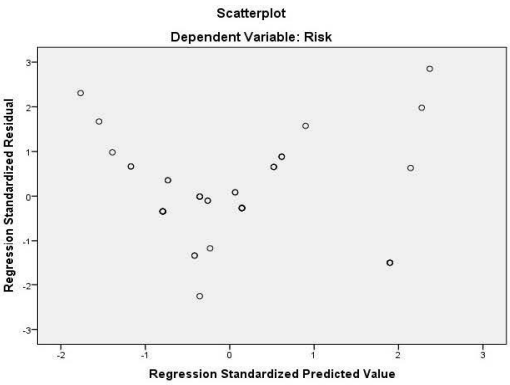


Figure 5- CA19.2b: Homoscedasticity of Foundation Type normal Error (i.e. Constant Variance).

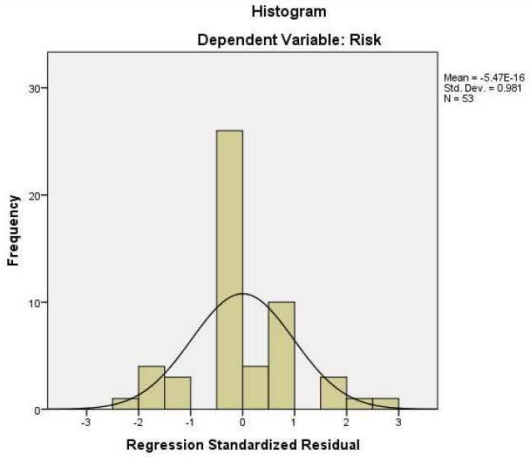


Figure 5- CA19.3b: Normality of Foundation Type Error distribution (i.e. Bell Shaped).

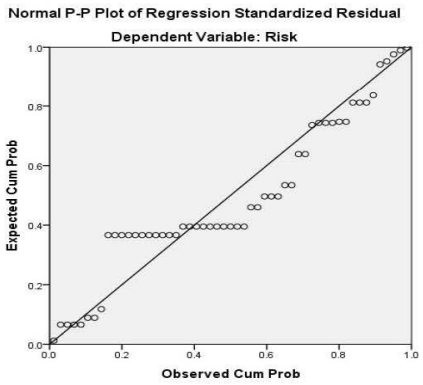


Figure 5- CA19.1b: Foundation Type normal Predicted Probability of the residual.

20- Ground Conditions:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_l: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.247, P-value= 0.069 (P-value < α), So H_l is ***Rejected***.
- r= 0.247 (< 0.3), indicate that no linear relationship exist between Risk and Probability variables.
- Therefore, there is no evidence that between Risk and Probability Correlation Exists, but the relationship may be proved in the regression analysis.

Risk vs. Impact:

- r= 0.932, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.932 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA20.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA20.1} = -19.644 + 0.295 X_{prob} + 0.674 X_{imp} \quad \text{(Eq.5-CA20)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA20 is equal to **30.3%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA20.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.1% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	30.31	17.055	55
Probability	71.13	16.599	55
Impact	42.98	23.907	55

Table 5- CA20.1: Ground Conditions Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.247	.932**
	Sig. (2-tailed)		.069	.000
	N	55	55	55
Probability	Pearson Correlation	.247	1	-.043
	Sig. (2-tailed)	.069		.757
	N	55	55	55
Impact	Pearson Correlation	.932**	-.043	1
	Sig. (2-tailed)	.000	.757	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA20.2: Ground Conditions Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14936.904	2	7468.452	503.813	.000[b]
	Residual	770.841	52	14.824		
	Total	15707.745	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA20.3: Ground Conditions linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-19.644	2.528		-7.772	.000
	Probability	.295	.032	.287	9.345	.000
	Impact	.674	.022	.944	30.708	.000

a. Dependent Variable: Risk

Table 5- CA20.4: Ground Conditions regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-7.42	60.82	30.31	16.632	55
Residual	-9.007	11.183	.000	3.778	55
Std. Predicted Value	-2.268	1.834	.000	1.000	55
Std. Residual	-2.339	2.904	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA20.6: Ground Conditions regression Residuals Statistics showing the Mean value of population Error.

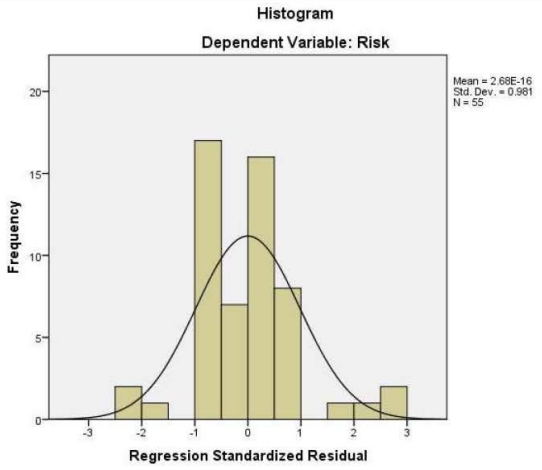


Figure 5- CA20.3: Normality of Ground Conditions Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.975[a]	.951	.949	3.850	1.708

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA20.5: Ground Conditions regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

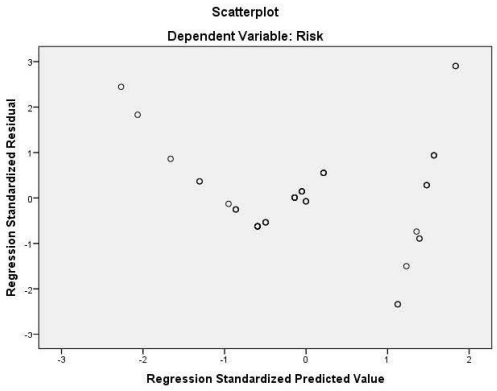


Figure 5- CA20.2: Homoscedasticity of Ground Conditions normal Error (i.e. Constant Variance).

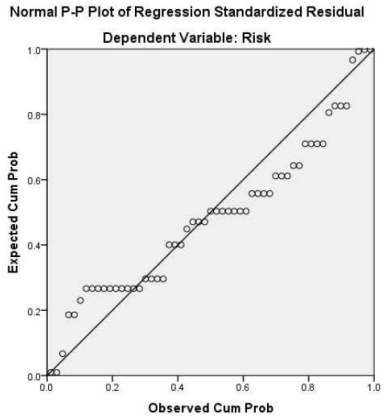


Figure 5- CA20.1: Ground Conditions normal Predicted Probability of the residual.

21- **Type of Soil:**

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.434, P-value= 0.001 (P-value < α), So H_O is ***Rejected***.
- r= 0.434 (0.3 to 0.5), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.830, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.830 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA21.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA21.1} = -30.697 + 0.495 X_{prob} + 0.607 X_{imp} \quad \text{(Eq.5-CA21)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA21 is equal to **28.3%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA21.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	28.27	18.006	55
Probability	67.35	17.553	55
Impact	42.20	25.412	55

Table 5- CA21.1: Type of Soil Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.434**	.830**
	Sig. (2-tailed)		.001	.000
	N	55	55	55
Probability	Pearson Correlation	.434**	1	-.057
	Sig. (2-tailed)	.001		.679
	N	55	55	55
Impact	Pearson Correlation	.830**	-.057	1
	Sig. (2-tailed)	.000	.679	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA21.2: Type of Soil Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16112.588	2	8056.294	300.453	.000[b]
	Residual	1394.321	52	26.814		
	Total	17506.909	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA21.3: Type of Soil linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-30.697	3.091		-9.930	.000
	Probability	.495	.040	.483	12.312	.000
	Impact	.607	.028	.857	21.866	.000

a. Dependent Variable: Risk

Table 5- CA21.4: Type of Soil regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.959[a]	.920	.917	5.178	1.693

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA21.5: Type of Soil regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

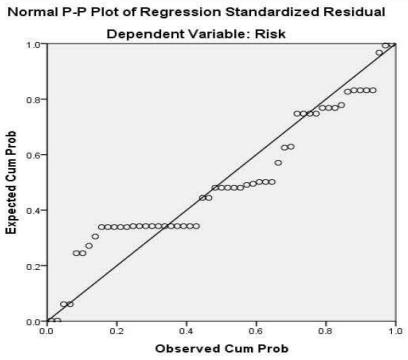


Figure 5- CA21.1: Type of Soil normal Predicted Probability of the residual.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-12.81	62.45	28.27	17.274	55
Residual	-14.841	14.809	.000	5.081	55
Std. Predicted Value	-2.378	1.978	.000	1.000	55
Std. Residual	-2.866	2.860	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA21.6: Type of Soil regression Residuals Statistics showing the Mean value of population Error.

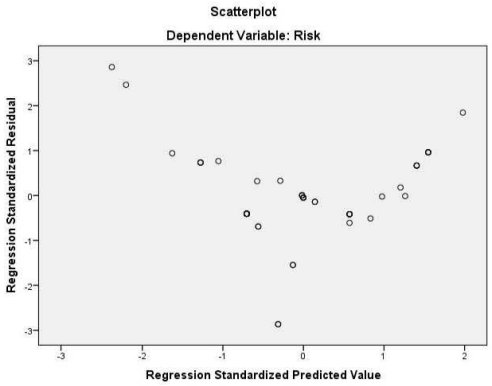


Figure 5- CA21.2: Homoscedasticity of Type of Soil normal Error (i.e. Constant Variance).

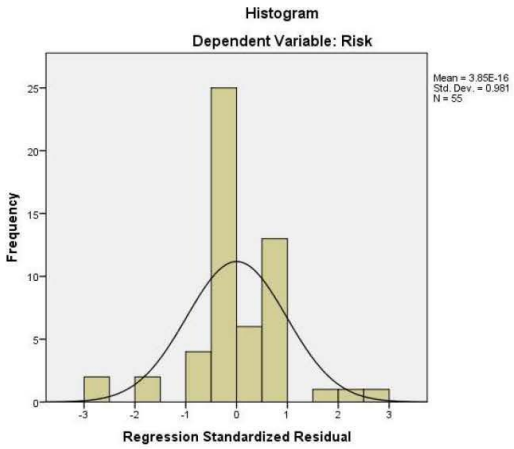


Figure 5- CA21.3: Normality of Type of Soil Error distribution (i.e. Bell Shaped).

22- **Mark-up Size**:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.630, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.630 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.927, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.927 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA22.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA22.1} = -15.493 + 0.309\, X_{prob} + 0.556\, X_{imp} \quad \text{(Eq.5-CA22)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA22 is equal to **17.9%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA22.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.9% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	17.85	16.672	55
Probability	50.44	17.728	55
Impact	31.96	24.077	55

Table 5- CA22.1: Mark-up Size Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.630**	.927**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.630**	1	.375**
	Sig. (2-tailed)	.000		.005
	N	55	55	55
Impact	Pearson Correlation	.927**	.375**	1
	Sig. (2-tailed)	.000	.005	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA22.2: Mark-up Size Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14276.308	2	7138.154	506.716	.000[b]
	Residual	732.528	52	14.087		
	Total	15008.836	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA22.3: Mark-up Size linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-15.493	1.545		-10.026	.000
	Probability	.309	.031	.328	9.928	.000
	Impact	.556	.023	.803	24.307	.000

a. Dependent Variable: Risk

Table 5- CA22.4: Mark-up Size regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.975[a]	.951	.949	3.753	1.737

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA22.5: Mark-up Size regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.67	56.79	17.85	16.260	55
Residual	-14.272	15.212	.000	3.683	55
Std. Predicted Value	-1.139	2.395	.000	1.000	55
Std. Residual	-3.802	4.053	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA22.6: Mark-up Size regression Residuals Statistics showing the Mean value of population Error.

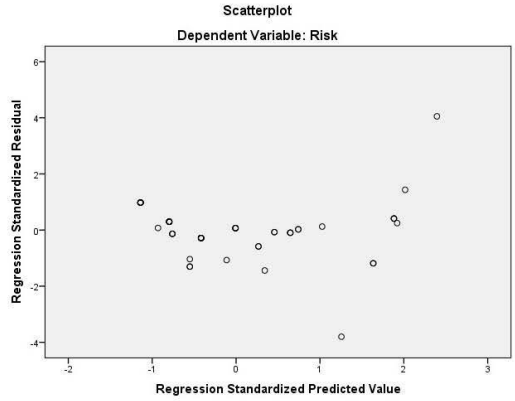


Figure 5- CA1.2: Homoscedasticity of Mark-up Size normal Error (i.e. Constant Variance).

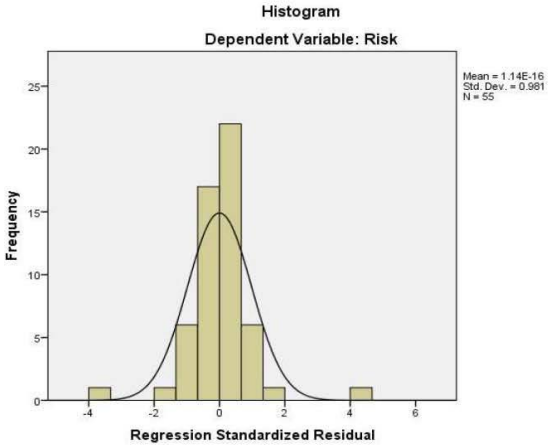


Figure 5- CA1.3: Normality of Mark-up Size Error distribution (i.e. Bell Shaped).

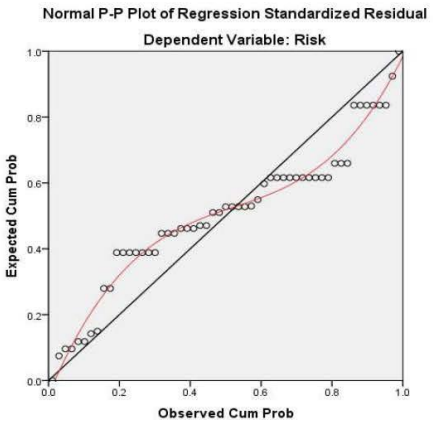


Figure 5- CA22.1: Mark-up Size normal Predicted Probability of the residual.

23- Need for Work:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.383, P-value= 0.004 (P-value < α), So H_O is ***Rejected***.
- r= 0.383 (0.3 to 0.5), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.881, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.881 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA23.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA23.1} = -18.179 + 0.322\, X_{prob} + 0.560\, X_{imp} \quad \text{(Eq.5-CA23)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA23 is equal to **17.7%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA23.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 93.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	17.67	14.934	55
Probability	51.93	18.638	55
Impact	34.13	23.702	55

Table 5- CA23.1: Need for Work Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.383**	.881**
	Sig. (2-tailed)		.004	.000
	N	55	55	55
Probability	Pearson Correlation	.383**	1	-.022
	Sig. (2-tailed)	.004		.876
	N	55	55	55
Impact	Pearson Correlation	.881**	-.022	1
	Sig. (2-tailed)	.000	.876	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA23.2: Need for Work Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11287.339	2	5643.669	387.794	.000[b]
	Residual	756.770	52	14.553		
	Total	12044.109	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA23.3: Need for Work linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-18.179	1.721		-10.561	.000
	Probability	.322	.028	.402	11.562	.000
	Impact	.560	.022	.889	25.579	.000

a. Dependent Variable: Risk

Table 5- CA23.4: Need for Work regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-2.91	55.64	17.67	14.458	55
Residual	-7.417	16.357	.000	3.744	55
Std. Predicted Value	-1.424	2.626	.000	1.000	55
Std. Residual	-1.944	4.288	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA23.6: Need for Work regression Residuals Statistics showing the Mean value of population Error.

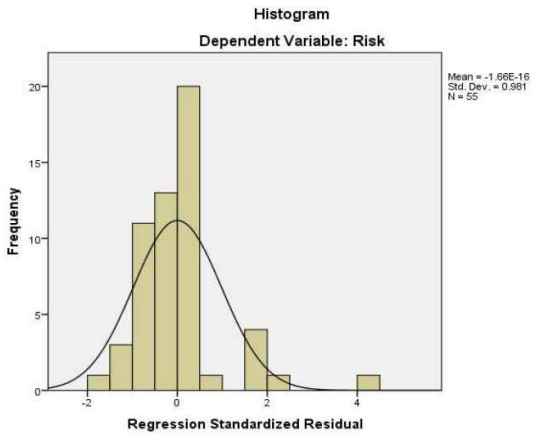


Figure 5- CA23.3: Normality of Need for Work Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.968[a]	.937	.935	3.815	1.996

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA23.5: Need for Work regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

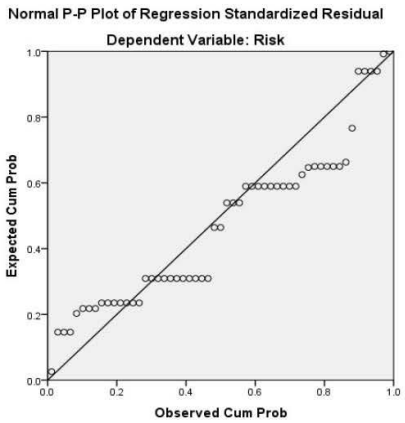


Figure 5- CA23.1: Need for Work normal Predicted Probability of the residual.

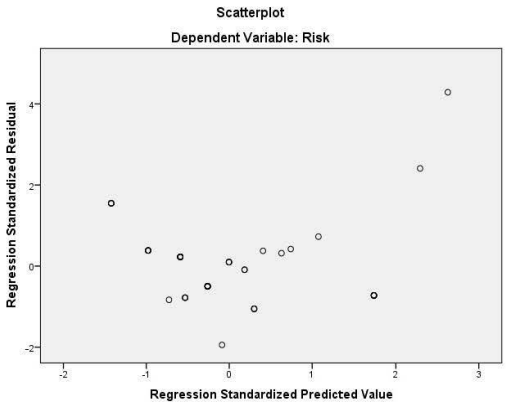


Figure 5- CA23.2: Homoscedasticity of Need for Work normal Error (i.e. Constant Variance).

24- **Deadline Requirements**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_1: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.659, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.659 (> 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.703, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.703 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA24.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA24.1} = -36.991 + 0.646\, X_{prob} + 0.572\, X_{imp} \quad \text{(Eq.5-CA24)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA24 is equal to **36.7%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA24.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92.5% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	36.71	20.623	55
Probability	59.27	20.950	55
Impact	61.93	25.242	55

Table 5- CA24.1: Deadline Requirements Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.659**	.703**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.659**	1	.005
	Sig. (2-tailed)	.000		.973
	N	55	55	55
Impact	Pearson Correlation	.703**	.005	1
	Sig. (2-tailed)	.000	.973	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA24.2: Deadline Requirements Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21240.095	2	10620.047	319.723	.000[b]
	Residual	1727.251	52	33.216		
	Total	22967.345	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA24.3: Deadline Requirements linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-36.991	3.032		-12.202	.000
	Probability	.646	.037	.656	17.246	.000
	Impact	.572	.031	.700	18.414	.000

a. Dependent Variable: Risk

Table 5- CA24.4: Deadline Requirements regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-24.81	66.89	36.71	19.833	55
Residual	-12.331	25.814	.000	5.656	55
Std. Predicted Value	-3.102	1.522	.000	1.000	55
Std. Residual	-2.140	4.479	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA24.6: Deadline Requirements regression Residuals Statistics showing the Mean value of population Error.

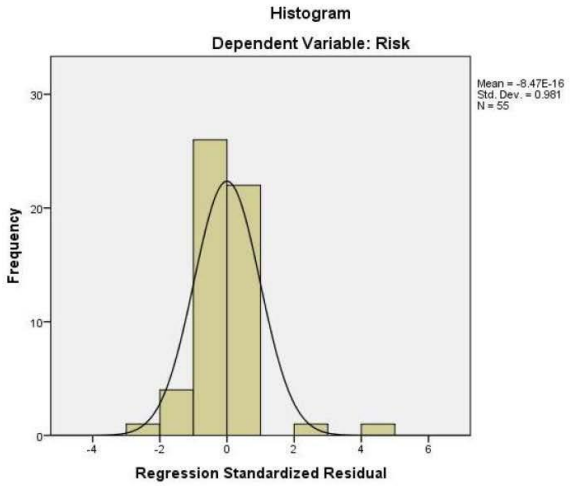


Figure 5- CA24.3: Normality of Deadline Requirements Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.962[a]	.925	.922	5.763	1.768

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA24.5: Deadline Requirements regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

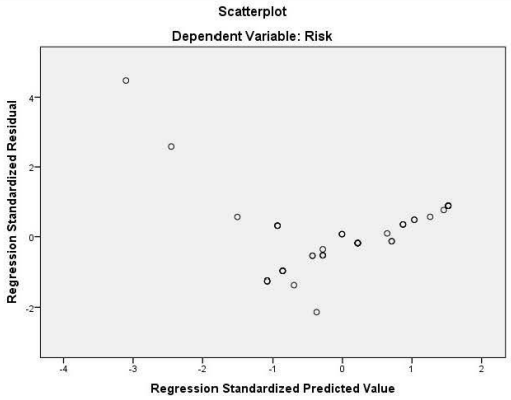


Figure 5- CA24.2: Homoscedasticity of Deadline Requirements normal Error (i.e. Constant Variance).

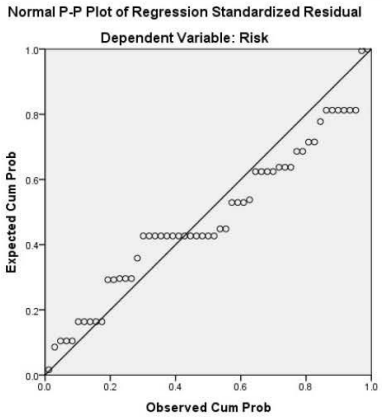


Figure 5- CA24.1: Deadline Requirements normal Predicted Probability of the residual.

25- Number of Stories:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.601, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.601 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.893, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.893 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA25.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA25.1} = -19.151 + 0.402\, X_{prob} + 0.502\, X_{imp} \quad \text{(Eq.5-CA25)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA25 is equal to **22%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA25.5b, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.8% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	22.02	15.841	55
Probability	50.80	15.847	55
Impact	41.33	24.947	55

Table 5- CA25.1: Number of Stories Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.601**	.893**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.601**	1	.252
	Sig. (2-tailed)	.000		.063
	N	55	55	55
Impact	Pearson Correlation	.893**	.252	1
	Sig. (2-tailed)	.000	.063	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA25.2: Number of Stories Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12845.622	2	6422.811	473.498	.000[b]
	Residual	705.359	52	13.565		
	Total	13550.982	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA25.3: Number of Stories linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-19.151	1.738		-11.018	.000
	Probability	.402	.033	.402	12.289	.000
	Impact	.502	.021	.791	24.201	.000

a. Dependent Variable: Risk

Table 5- CA25.4: Number of Stories regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-2.08	57.19	22.02	15.423	55
Residual	-9.096	14.806	.000	3.614	55
Std. Predicted Value	-1.562	2.281	.000	1.000	55
Std. Residual	-2.470	4.020	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA25.6: Number of Stories regression Residuals Statistics showing the Mean value of population Error.

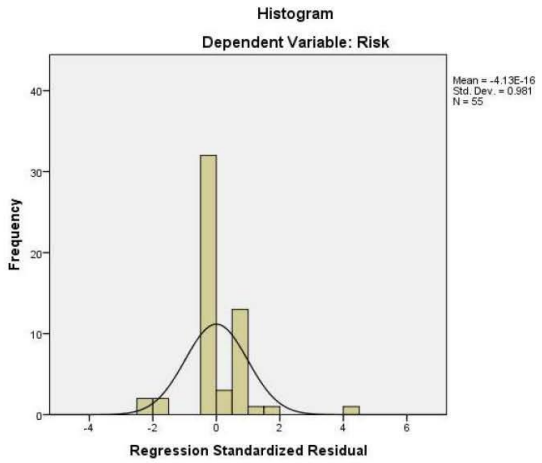


Figure 5- CA25.3: Normality of Number of Stories Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.974[a]	.948	.946	3.683	2.124

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA25.5: Number of Stories regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

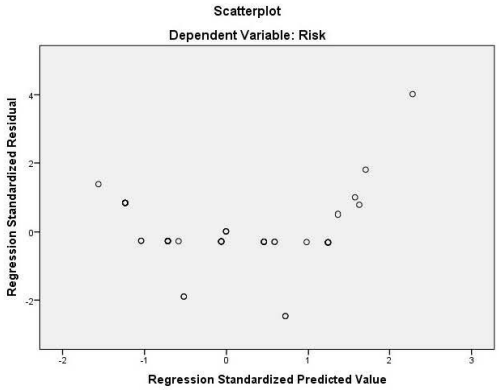


Figure 5- CA25.2: Homoscedasticity of Number of Stories normal Error (i.e. Constant Variance).

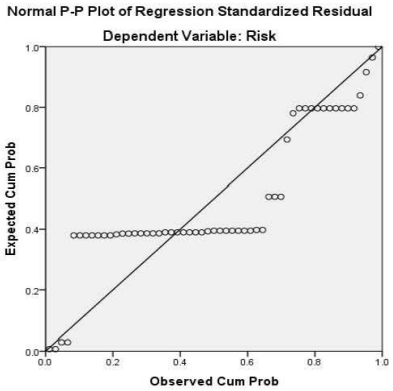


Figure 5- CA25.1: Number of Stories normal Predicted Probability of the residual.

26- **Project Duration**:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.749, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.749 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.849, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.849 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA26.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA26.1} = -36.626 + 0.660\, X_{prob} + 0.568\, X_{imp} \quad \text{(Eq.5-CA26)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA26 is equal to **33.4%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA26.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 97.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	33.35	21.961	55
Probability	61.20	17.608	55
Impact	52.07	26.201	55

Table 5- CA26.1: Project Duration Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.749**	.849**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.749**	1	.325*
	Sig. (2-tailed)	.000		.016
	N	55	55	55
Impact	Pearson Correlation	.849**	.325*	1
	Sig. (2-tailed)	.000	.016	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CA26.2: Project Duration Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25314.561	2	12657.281	904.246	.000[b]
	Residual	727.875	52	13.998		
	Total	26042.436	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA26.3: Project Duration linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-36.626	1.897		-19.304	.000
	Probability	.660	.031	.529	21.595	.000
	Impact	.568	.021	.678	27.642	.000

a. Dependent Variable: Risk

Table 5- CA26.4: Project Duration regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.986[a]	.972	.971	3.741	2.127

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA26.5: Project Duration regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	7.74	68.22	33.35	21.652	55
Residual	-13.844	3.783	.000	3.671	55
Std. Predicted Value	-1.183	1.611	.000	1.000	55
Std. Residual	-3.700	1.011	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA26.6: Project Duration regression Residuals Statistics showing the Mean value of population Error.

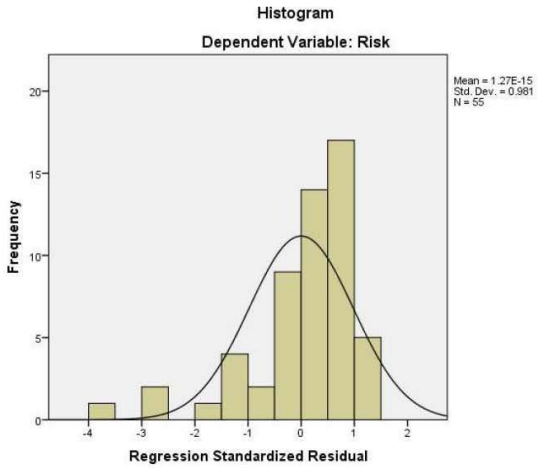


Figure 5- CA26.3: Normality of Project Duration Error distribution (i.e. Bell Shaped).

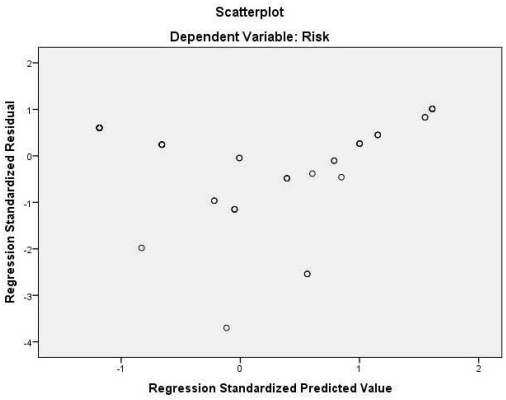


Figure 5- CA26.2: Homoscedasticity of Project Duration normal Error (i.e. Constant Variance).

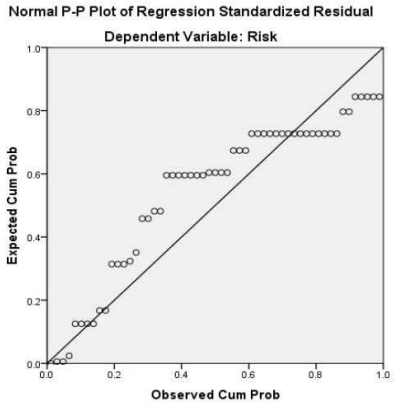


Figure 5- CA26.1: Project Duration normal Predicted Probability of the residual.

27- Gross Floor Area:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.566, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.566 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.769, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.769 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA27.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA27.1} = -21.393 + 0.433\, X_{prob} + 0.494\, X_{imp} \quad \text{(Eq.5-CA27)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA27 is equal to **21.5%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA27.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 88.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	21.45	16.726	55
Probability	53.22	20.813	55
Impact	40.00	25.386	55

Table 5- CA27.1: Gross Floor Area Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.566**	.769**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.566**	1	.035
	Sig. (2-tailed)	.000		.799
	N	55	55	55
Impact	Pearson Correlation	.769**	.035	1
	Sig. (2-tailed)	.000	.799	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA27.2: Gross Floor Area Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13331.966	2	6665.983	195.211	.000[b]
	Residual	1775.671	52	34.148		
	Total	15107.636	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA27.3: Gross Floor Area linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-21.393	2.481		-8.624	.000
	Probability	.433	.038	.539	11.339	.000
	Impact	.494	.031	.750	15.775	.000

a. Dependent Variable: Risk

Table 5- CA27.4: Gross Floor Area regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-12.11	57.18	21.45	15.713	55
Residual	-14.497	14.823	.000	5.734	55
Std. Predicted Value	-2.136	2.273	.000	1.000	55
Std. Residual	-2.481	2.537	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA27.6: Gross Floor Area regression Residuals Statistics showing the Mean value of population Error.

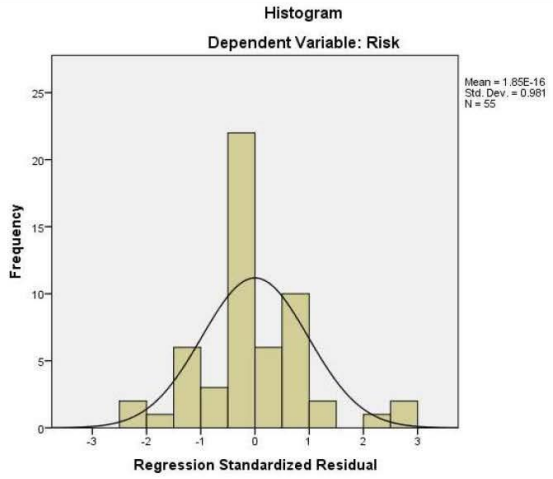


Figure 5- CA27.3: Normality of Gross Floor Area Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.939[a]	.882	.878	5.844	1.867

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA27.5: Gross Floor Area regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

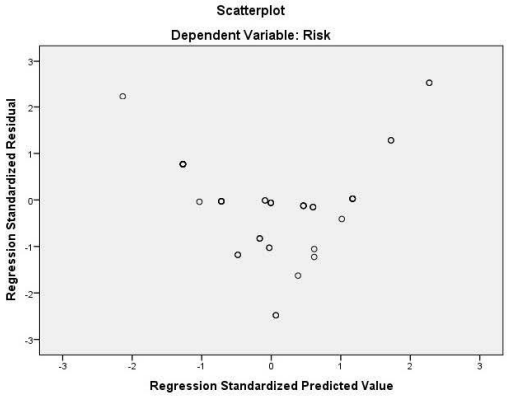


Figure 5- CA27.2: Homoscedasticity of Gross Floor Area normal Error (i.e. Constant Variance).

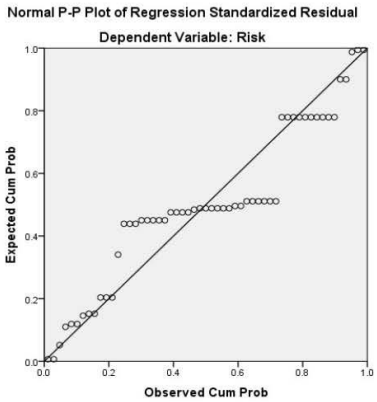


Figure 5- CA27.1: Gross Floor Area normal Predicted Probability of the residual.

28- Equipment Required:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_l: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.378, P-value= 0.004 (P-value < α), So H_o is ***Rejected***.
- r= 0.378 (0.3 to 0.5), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.941, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.941 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA28.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA28.1} = -17.916 + 0.315 X_{prob} + 0.596 X_{imp} \quad \text{(Eq.5-CA28)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA28 is equal to **25.8%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA28.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.5% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	25.80	18.664	55
Probability	60.05	15.846	55
Impact	41.62	28.444	55

Table 5- CA28.1: Equipment Required Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.378**	.941**
	Sig. (2-tailed)		.004	.000
	N	55	55	55
Probability	Pearson Correlation	.378**	1	.122
	Sig. (2-tailed)	.004		.376
	N	55	55	55
Impact	Pearson Correlation	.941**	.122	1
	Sig. (2-tailed)	.000	.376	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CA28.2: Equipment Required Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17971.552	2	8985.776	556.761	.000[b]
	Residual	839.248	52	16.139		
	Total	18810.800	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA28.3: Equipment Required linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-17.916	2.211		-8.101	.000
	Probability	.315	.035	.267	9.061	.000
	Impact	.596	.019	.908	30.772	.000

a. Dependent Variable: Risk

Table 5- CA28.4: Equipment Required regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.977[a]	.955	.954	4.017	2.148

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA28.5: Equipment Required regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-8.81	58.10	25.80	18.243	55
Residual	-7.391	13.897	.000	3.942	55
Std. Predicted Value	-1.897	1.771	.000	1.000	55
Std. Residual	-1.840	3.459	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA28.6: Equipment Required regression Residuals Statistics showing the Mean value of population Error.

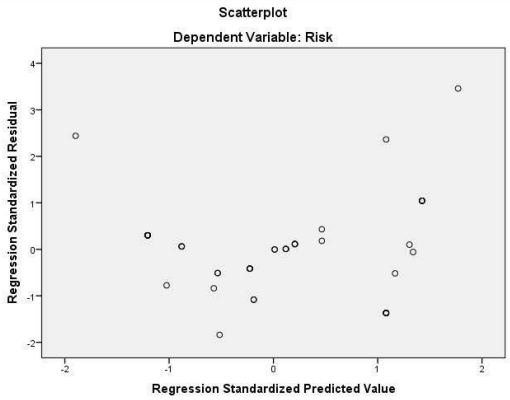


Figure 5- CA28.2: Homoscedasticity of Equipment Required normal Error (i.e. Constant Variance).

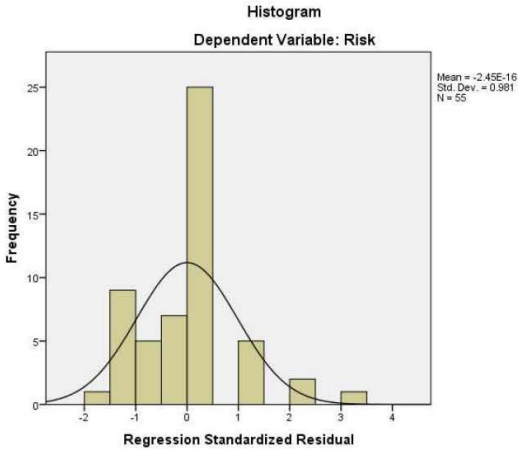


Figure 5- CA28.3: Normality of Equipment Required Error distribution (i.e. Bell Shaped).

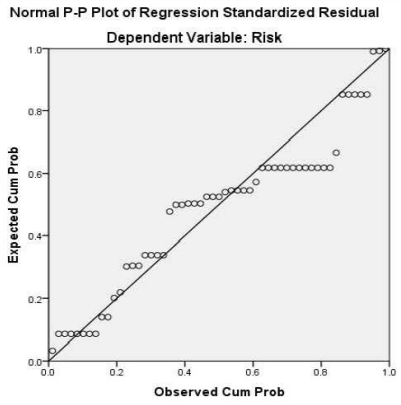


Figure 5- CA28.1: Equipment Required normal Predicted Probability of the residual.

29- Construction Technology:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.652, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.652 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.891, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.891 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CA29.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CA29.1} = -30.265 + 0.509 X_{prob} + 0.621 X_{imp} \quad \text{(Eq.5-CA29)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA29 is equal to **30.7%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CA29.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	30.67	21.461	55
Probability	62.58	17.517	55
Impact	46.89	26.356	55

Table 5- CA29.1: Construction Technology Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.652**	.891**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Probability	Pearson Correlation	.652**	1	.311*
	Sig. (2-tailed)	.000		.021
	N	55	55	55
Impact	Pearson Correlation	.891**	.311*	1
	Sig. (2-tailed)	.000	.021	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CA29.2: Construction Technology Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	23636.959	2	11818.480	498.367	.000[b]
	Residual	1233.150	52	23.714		
	Total	24870.109	54			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CA29.3: Construction Technology linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-30.265	2.501		-12.103	.000
	Probability	.509	.040	.415	12.778	.000
	Impact	.621	.026	.762	23.464	.000

Table 5- CA29.4: Construction Technology regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.975[a]	.950	.949	4.870	1.699

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CA29.5: Construction Technology regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-8.80	65.17	30.67	20.922	55
Residual	-10.654	11.799	.000	4.779	55
Std. Predicted Value	-1.887	1.649	.000	1.000	55
Std. Residual	-2.188	2.423	.000	.981	55

a. Dependent Variable: Risk

Table 5- CA29.6: Construction Technology regression Residuals Statistics showing the Mean value of population

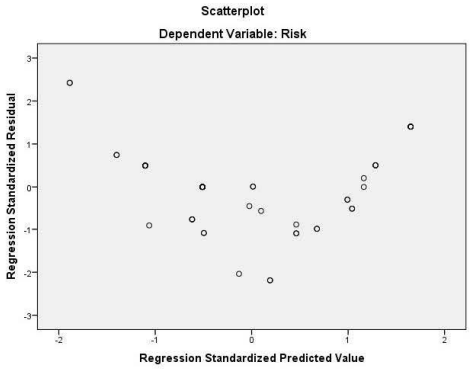


Figure 5- CA29.2: Homoscedasticity of Construction Technology normal Error (i.e. Constant Variance).

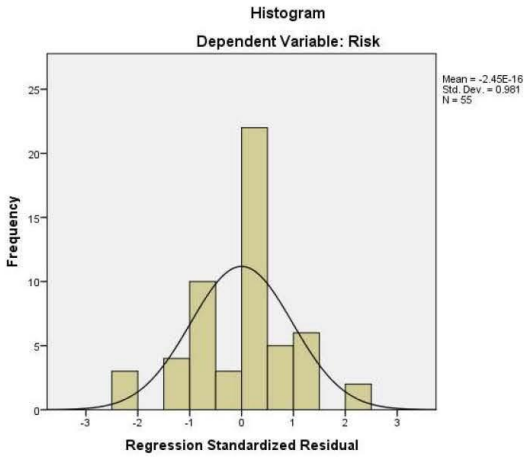


Figure 5- CA29.3: Normality of Construction Technology Error distribution (i.e. Bell Shaped).

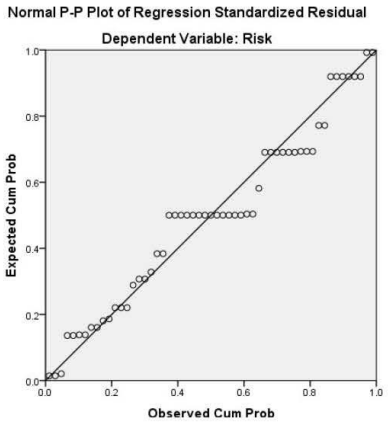


Figure 5- CA29.1: Construction Technology normal Predicted Probability of the residual.

B- Construction Political Risks' Factors:

1- Change in Law:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.744, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.744 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.802, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.802 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CB1.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CB1.1} = -26.362 + 0.546 X_{prob} + 0.517 X_{imp} \quad \text{(Eq.5-CB1)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CB1 is equal to **27.4%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CB1.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92.1% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	27.44	23.599	54
Probability	54.19	23.909	54
Impact	46.89	29.045	54

Table 5- CB1.1: Change in Law Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.744**	.802**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.744**	1	.300*
	Sig. (2-tailed)	.000		.027
	N	54	54	54
Impact	Pearson Correlation	.802**	.300*	1
	Sig. (2-tailed)	.000	.027	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CB1.2: Change in Law Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	27196.017	2	13598.009	299.010	.000[b]
	Residual	2319.316	51	45.477		
	Total	29515.333	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CB1.3: Change in Law linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-26.362	2.464		-10.698	.000
	Probability	.546	.041	.553	13.443	.000
	Impact	.517	.033	.636	15.449	.000

a. Dependent Variable: Risk

Table 5- CB1.4: Change in Law regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.960[a]	.921	.918	6.744	1.782

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CB1.5: Change in Law regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-7.40	64.10	27.44	22.652	54
Residual	-18.945	9.399	.000	6.615	54
Std. Predicted Value	-1.538	1.618	.000	1.000	54
Std. Residual	-2.809	1.394	.000	.981	54

a. Dependent Variable: Risk

Table 5- CB1.6: Change in Law regression Residuals Statistics showing the Mean value of population Error.

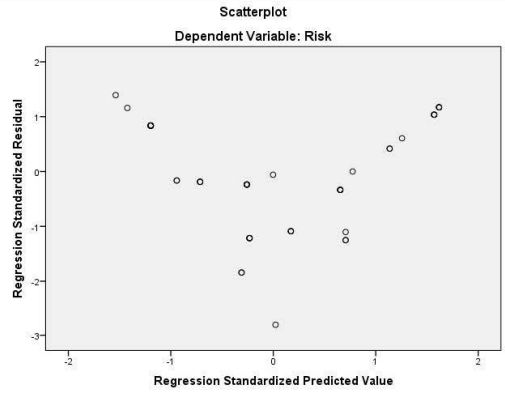


Figure 5- CB1.2: Homoscedasticity of Change in Law normal Error (i.e. Constant Variance).

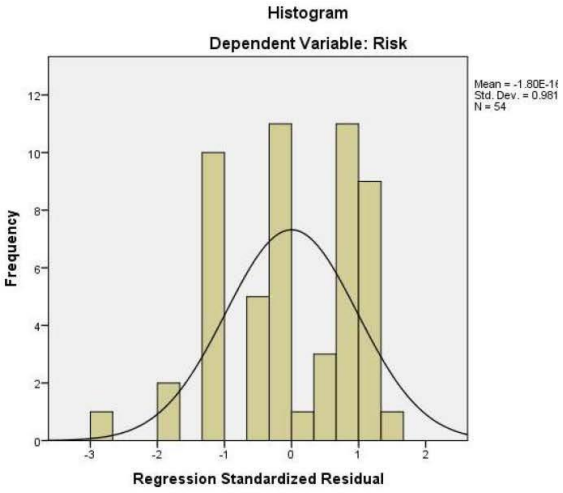


Figure 5- CB1.3: Normality of Change in Law Error distribution (i.e. Bell Shaped).

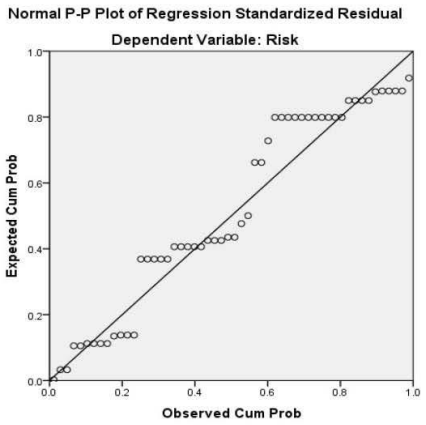


Figure 5- CB1.1: Change in Law normal Predicted Probability of the residual.

2- **Delay in Project Approvals and Permits**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.598, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.598 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.846, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.846 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CB2.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CB2.1} = -39.873 + 0.622\, X_{prob} + 0.644\, X_{imp} \quad \text{(Eq.5-CB2)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CB2 is equal to **41.4%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CB2.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 96.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	41.41	20.110	54
Probability	68.30	16.145	54
Impact	60.19	24.456	54

Table 5- CB2.1: Delay in Project Approvals and Permits Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.598**	.846**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.598**	1	.125
	Sig. (2-tailed)	.000		.368
	N	54	54	54
Impact	Pearson Correlation	.846**	.125	1
	Sig. (2-tailed)	.000	.368	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CB2.2: Delay in Project Approvals and Permits Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20611.578	2	10305.789	639.832	.000[b]
	Residual	821.459	51	16.107		
	Total	21433.037	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CB2.3: Delay in Project Approvals and Permits regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-39.873	2.625		-15.192	.000
	Probability	.622	.034	.500	18.079	.000
	Impact	.644	.023	.784	28.364	.000

a. Dependent Variable: Risk

Table 5- CB2.4: Delay in Project Approvals and Permits regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-2.32	67.68	41.41	19.720	54
Residual	-11.903	7.318	.000	3.937	54
Std. Predicted Value	-2.217	1.332	.000	1.000	54
Std. Residual	-2.966	1.823	.000	.981	54

a. Dependent Variable: Risk

Table 5- CB2.6: Delay in Project Approvals and Permits regression Residuals Statistics showing the Mean value of

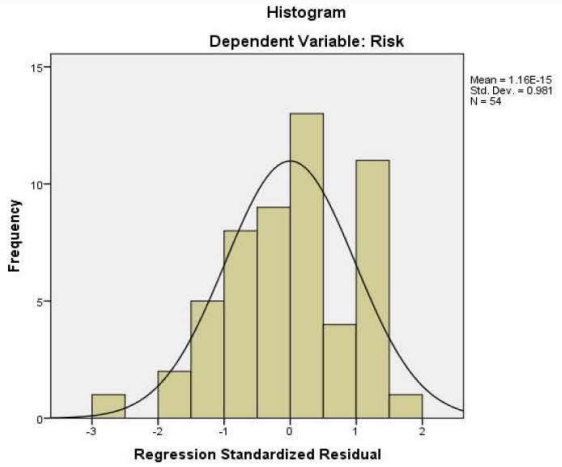


Figure 5- CB2.3: Normality of Delay in Project Approvals and Permits Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.981[a]	.962	.960	4.013	1.796

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CB2.5: Delay in Project Approvals and Permits regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

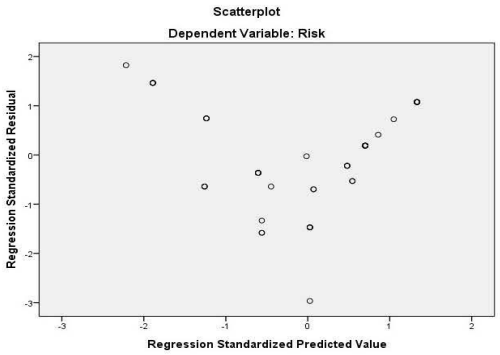


Figure 5- CB2.2: Homoscedasticity of Delay in Project Approvals and Permits normal Error (i.e. Constant Variance).

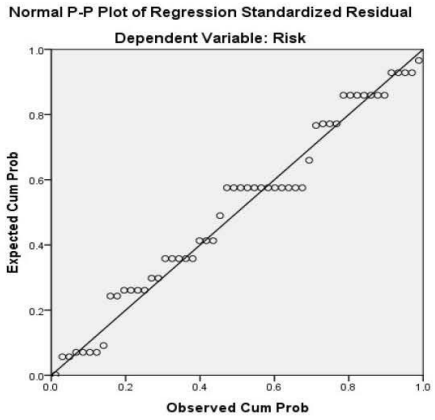


Figure 5- CB2.1: Delay in Project Approvals and Permits normal Predicted Probability of the residual.

3- **Poor Public Decision Making Process**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.547, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.547 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.837, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.837 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CB3.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CB3.1} = -28.624 + 0.528\, X_{prob} + 0.549\, X_{imp} \quad \text{(Eq.5-CB3)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CB3 is equal to **31.5%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CB3.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.6% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	31.54	17.959	54
Probability	58.02	16.883	54
Impact	53.85	26.361	54

Table 5- CB3.1: Poor Public Decision Making Process Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.547**	.837**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.547**	1	.064
	Sig. (2-tailed)	.000		.646
	N	54	54	54
Impact	Pearson Correlation	.837**	.064	1
	Sig. (2-tailed)	.000	.646	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CB3.2: Poor Public Decision Making Process Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16168.374	2	8084.187	445.698	.000[b]
	Residual	925.052	51	18.138		
	Total	17093.426	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CB3.3: Poor Public Decision Making Process linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-28.624	2.349		-12.183	.000
	Probability	.528	.035	.496	15.194	.000
	Impact	.549	.022	.806	24.678	.000

a. Dependent Variable: Risk

Table 5- CB3.4: Poor Public Decision Making Process regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-7.31	62.76	31.54	17.466	54
Residual	-7.105	10.309	.000	4.178	54
Std. Predicted Value	-2.224	1.788	.000	1.000	54
Std. Residual	-1.668	2.421	.000	.981	54

a. Dependent Variable: Risk

Table 5- CB3.6: Poor Public Decision Making Process regression Residuals Statistics showing the Mean value of population Error.

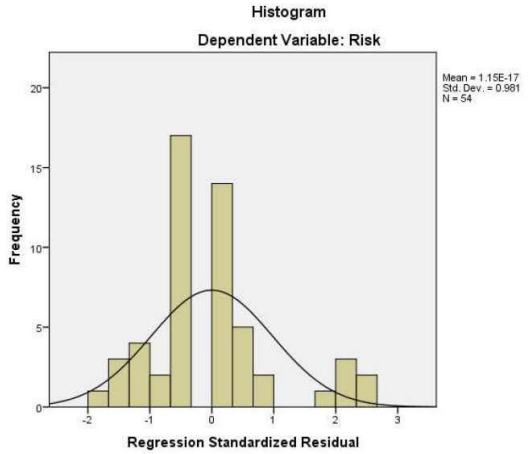


Figure 5- CB3.3: Normality of Poor Public Decision Making Process Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.973[a]	.946	.944	4.259	1.965

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CB3.5: Poor Public Decision Making Process regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

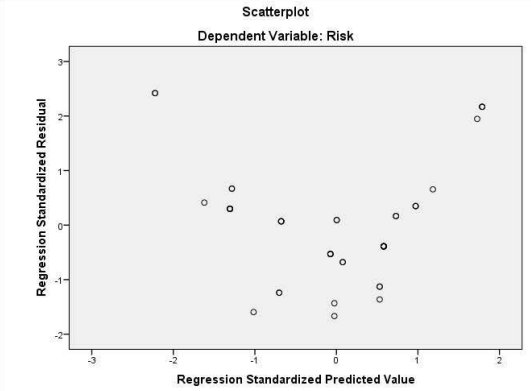


Figure 5- CB3.2: Homoscedasticity of Poor Public Decision Making Process normal Error (i.e. Constant Variance).

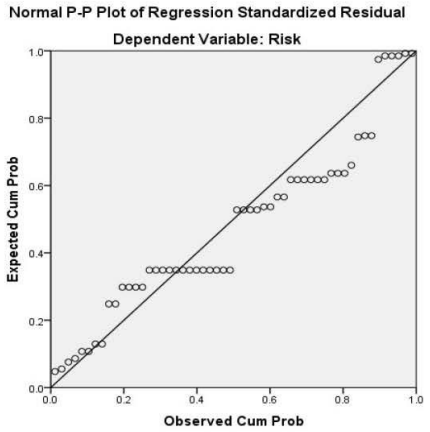


Figure 5- CB3.1: Poor Public Decision Making Process normal Predicted Probability of the residual.

4- **Government Intervention**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.633, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.633 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.866, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.866 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CB4.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CB4.1} = -24.614 + 0.451\, X_{prob} + 0.575\, X_{imp} \quad \text{(Eq.5-CB4)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CB4 is equal to **30.6%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CB4.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	30.57	19.296	54
Probability	60.65	19.331	54
Impact	48.44	25.431	54

Table 5- CB4.1: Government Intervention Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.633**	.866**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.633**	1	.240
	Sig. (2-tailed)	.000		.081
	N	54	54	54
Impact	Pearson Correlation	.866**	.240	1
	Sig. (2-tailed)	.000	.081	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CB4.2: Government Intervention Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18583.435	2	9291.717	412.150	.000[b]
	Residual	1149.769	51	22.544		
	Total	19733.204	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CB4.3: Government Intervention linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-24.614	2.281		-10.789	.000
	Probability	.451	.035	.452	12.975	.000
	Impact	.575	.026	.757	21.758	.000

a. Dependent Variable: Risk

Table 5- CB4.4: Government Intervention regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-5.34	61.94	30.57	18.725	54
Residual	-9.892	10.056	.000	4.658	54
Std. Predicted Value	-1.918	1.675	.000	1.000	54
Std. Residual	-2.083	2.118	.000	.981	54

a. Dependent Variable: Risk

Table 5- CB4.6: Government Intervention regression Residuals Statistics showing the Mean value of population Error.

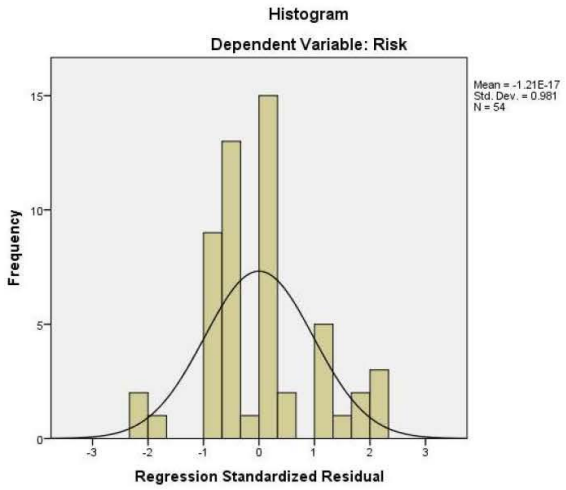


Figure 5- CB4.3: Normality of Government Intervention Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.970[a]	.942	.939	4.748	2.008

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CB4.5: Government Intervention regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

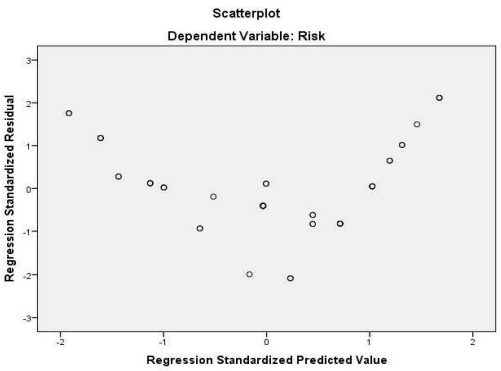


Figure 5- CB4.2: Homoscedasticity of Government Intervention normal Error (i.e. Constant Variance).

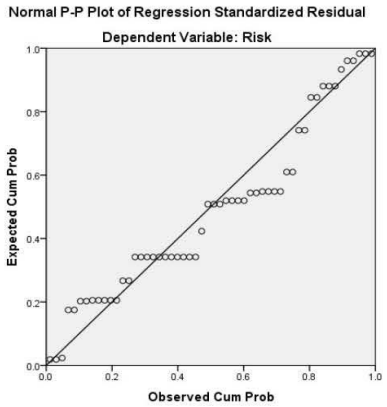


Figure 5- CB4.1: Government Intervention normal Predicted Probability of the residual.

5- **Unstable Government**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.850, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.850 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.713, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.713 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CB5.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CB5.1} = -31.328 + 0.699 X_{prob} + 0.466 X_{imp} \quad \text{(Eq.5-CB5)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CB5 is equal to **36.7%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CB5.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.5% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	36.65	25.307	54
Probability	56.22	25.314	54
Impact	61.56	27.430	54

Table 5- CB5.1: Unstable Government Data Descriptive Statistics of Risk, Pr1bability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.850**	.713**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.850**	1	.298*
	Sig. (2-tailed)	.000		.028
	N	54	54	54
Impact	Pearson Correlation	.713**	.298*	1
	Sig. (2-tailed)	.000	.028	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CB5.2: Unstable Government Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	32403.071	2	16201.536	536.111	.000[b]
	Residual	1541.243	51	30.220		
	Total	33944.315	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CB5.3: Unstable Government linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-31.328	2.222		-14.099	.000
	Probability	.699	.031	.699	22.371	.000
	Impact	.466	.029	.505	16.147	.000

a. Dependent Variable: Risk

Table 5- CB5.4: Unstable Government regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.977[a]	.955	.953	5.497	1.789

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CB5.5: Unstable Government regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-19.68	68.85	36.65	24.726	54
Residual	-15.270	20.679	.000	5.393	54
Std. Predicted Value	-2.278	1.303	.000	1.000	54
Std. Residual	-2.778	3.762	.000	.981	54

a. Dependent Variable: Risk

Table 5- CB5.6: Unstable Government regression Residuals Statistics showing the Mean value of population Error.

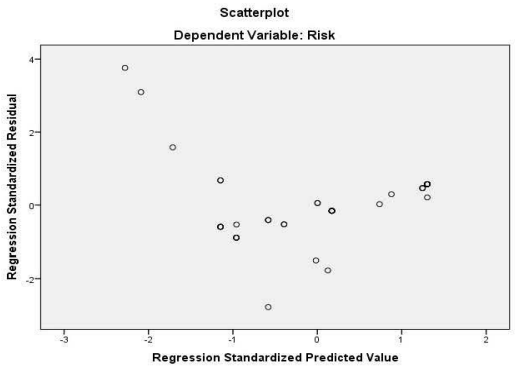


Figure 5- CB5.2: Homoscedasticity of Unstable Government normal Error (i.e. Constant Variance).

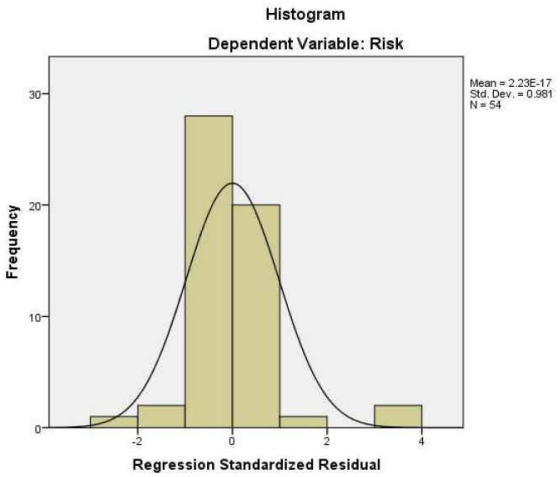


Figure 5- CB5.3: Normality of Unstable Government Error distribution (i.e. Bell Shaped).

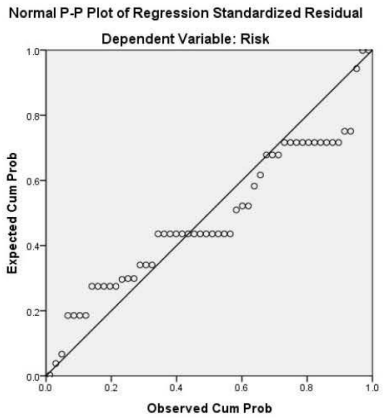


Figure 5- CB5.1: Unstable Government normal Predicted Probability of the residual.

6- **Government Reliability**:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.698, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.698 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.848, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.848 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CB6.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CB6.1} = -29.046 + 0.524\, X_{prob} + 0.592\, X_{imp} \quad \text{(Eq.5-CB6)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CB6 is equal to **38.3%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CB6.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 93.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	38.26	23.664	54
Probability	61.28	21.902	54
Impact	59.41	27.977	54

Table 5- CB6.1: Government Reliability Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.698**	.848**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.698**	1	.304*
	Sig. (2-tailed)	.000		.025
	N	54	54	54
Impact	Pearson Correlation	.848**	.304*	1
	Sig. (2-tailed)	.000	.025	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CB6.2: Government Reliability Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	27664.121	2	13832.060	349.875	.000[b]
	Residual	2016.250	51	39.534		
	Total	29680.370	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CB6.3: Government Reliability linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-29.046	2.811		-10.333	.000
	Probability	.524	.041	.485	12.669	.000
	Impact	.592	.032	.700	18.267	.000

a. Dependent Variable: Risk

Table 5- CB6.4: Government Reliability regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-17.88	65.51	38.26	22.847	54
Residual	-15.557	18.882	.000	6.168	54
Std. Predicted Value	-2.457	1.193	.000	1.000	54
Std. Residual	-2.474	3.003	.000	.981	54

a. Dependent Variable: Risk

Table 5- CB6.6: Government Reliability regression Residuals Statistics showing the Mean value of population Error.

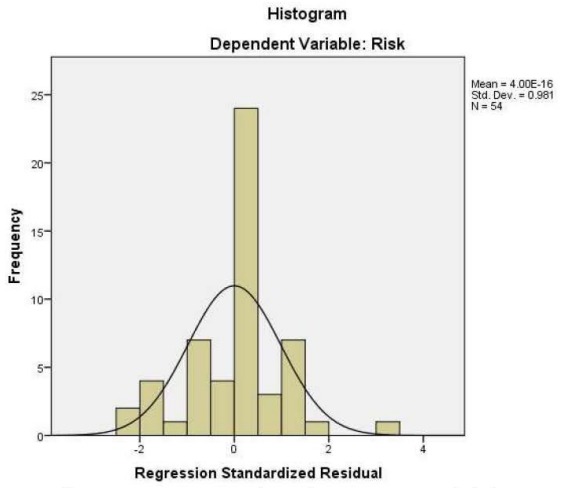


Figure 5- CB6.3: Normality of Government Reliability Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.965[a]	.932	.929	6.288	2.145

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CB6.5: Government Reliability regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

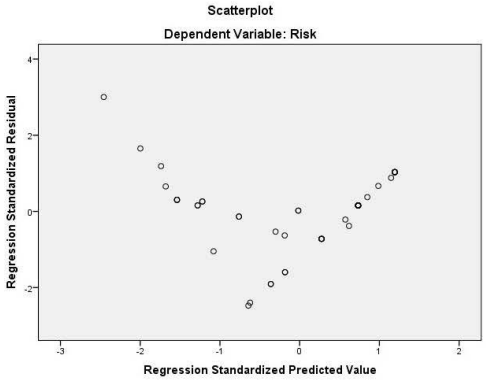


Figure 5- CB6.2: Homoscedasticity of Government Reliability normal Error (i.e. Constant Variance).

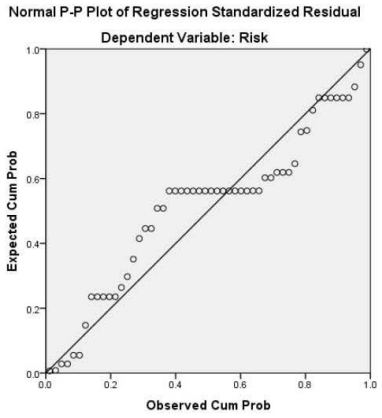


Figure 5- CB6.1: Government Reliability normal Predicted Probability of the residual.

7- **Inconsistencies in Government Policies**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_1: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.834, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.834 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.806, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.806 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CB7.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CB7.1} = -28.005 + 0.622\, X_{prob} + 0.477\, X_{imp} \quad \text{(Eq.5-CB7)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CB7 is equal to **29.4%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CB7.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 93.8% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	29.35	22.868	54
Probability	53.52	21.929	54
Impact	50.37	26.204	54

Table 5- CB7.1: Inconsistencies in Government Policies Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.834**	.806**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.834**	1	.433**
	Sig. (2-tailed)	.000		.001
	N	54	54	54
Impact	Pearson Correlation	.806**	.433**	1
	Sig. (2-tailed)	.000	.001	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CB7.2: Inconsistencies in Government Policies Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	26005.748	2	13002.874	387.677	.000[b]
	Residual	1710.567	51	33.541		
	Total	27716.315	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CB7.3: Inconsistencies in Government Policies linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-28.005	2.230		-12.557	.000
	Probability	.622	.040	.597	15.465	.000
	Impact	.477	.034	.547	14.174	.000

a. Dependent Variable: Risk

Table 5- CB7.4: Inconsistencies in Government Policies regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-17.01	66.20	29.35	22.151	54
Residual	-13.337	18.007	.000	5.681	54
Std. Predicted Value	-2.093	1.664	.000	1.000	54
Std. Residual	-2.303	3.109	.000	.981	54

a. Dependent Variable: Risk

Table 5- CB7.6: Inconsistencies in Government Policies regression Residuals Statistics showing the Mean value of population Error.

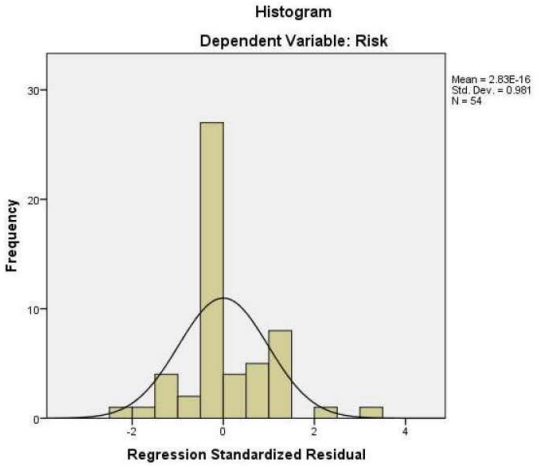


Figure 5- CB7.3: Normality of Inconsistencies in Government Policies Error distribution (i.e. Bell

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.969[a]	.938	.936	5.791	1.775

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CB7.5: Inconsistencies in Government Policies regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

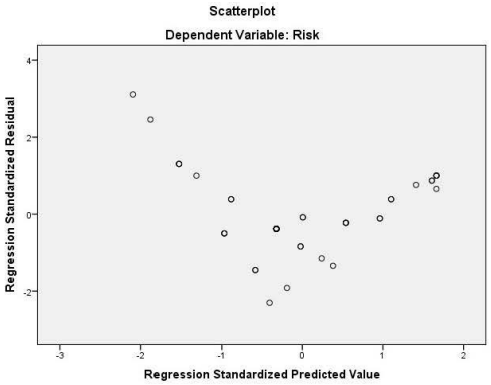


Figure 5- CB7.2: Homoscedasticity of Inconsistencies in Government Policies normal Error (i.e. Constant Variance).

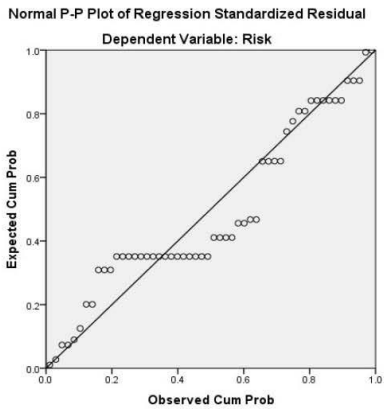


Figure 5- CB7.1: Inconsistencies in Government Policies normal Predicted Probability of the residual.

8- **Strong Political Opposition / Hostility**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.812, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.812 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.736, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.736 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CB8.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CB8.1} = -25.278 + 0.589\, X_{prob} + 0.468\, X_{imp} \quad \text{(Eq.5-CB8)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CB8 is equal to **27.1%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CB8.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 91.4% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	27.07	23.768	54
Probability	46.89	25.960	54
Impact	52.85	27.026	54

Table 5- CB8.1: Strong Political Opposition / Hostility Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.812**	.736**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.812**	1	.317*
	Sig. (2-tailed)	.000		.020
	N	54	54	54
Impact	Pearson Correlation	.736**	.317*	1
	Sig. (2-tailed)	.000	.020	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CB8.2: Strong Political Opposition / Hostility Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	27366.824	2	13683.412	271.024	.000[b]
	Residual	2574.880	51	50.488		
	Total	29941.704	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CB8.3: Strong Political Opposition / Hostility linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-25.278	2.464		-10.261	.000
	Probability	.589	.040	.643	14.863	.000
	Impact	.468	.038	.532	12.288	.000

a. Dependent Variable: Risk

Table 5- CB8.4: Strong Political Opposition / Hostility regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.956[a]	.914	.911	7.105	1.961

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CB8.5: Strong Political Opposition / Hostility regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-14.71	65.17	27.07	22.723	54
Residual	-23.425	15.708	.000	6.970	54
Std. Predicted Value	-1.839	1.677	.000	1.000	54
Std. Residual	-3.297	2.211	.000	.981	54

a. Dependent Variable: Risk

Table 5- CB8.6: Strong Political Opposition / Hostility regression Residuals Statistics showing the Mean value of population Error.

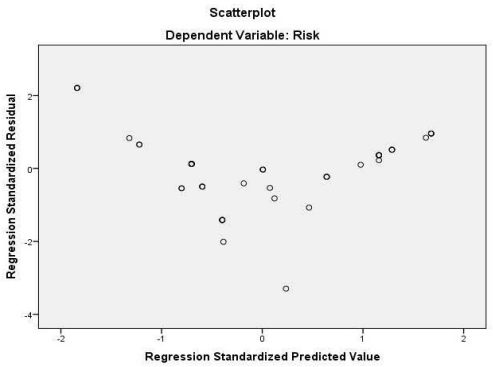


Figure 5- CB8.2: Homoscedasticity of Strong Political Opposition / Hostility normal Error (i.e. Constant

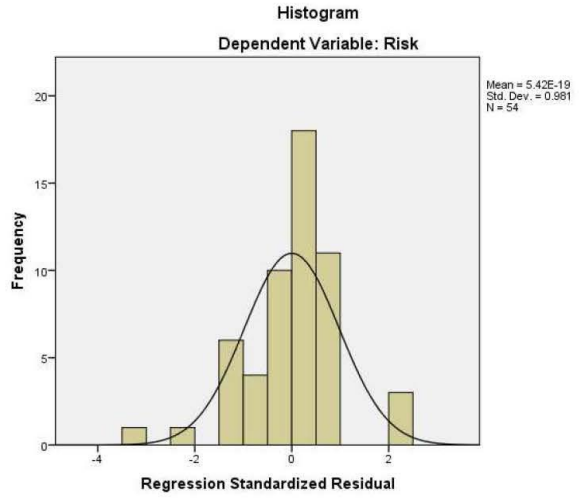


Figure 5- CB8.3: Normality of Strong Political Opposition / Hostility Error distribution (i.e. Bell Shaped).

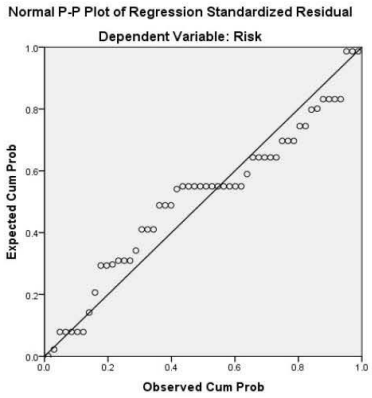


Figure 5- CB8.1: Strong Political Opposition / Hostility normal Predicted Probability of the residual.

9- **Expropriation/ Nationalization of Assets**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.775, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.775 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.687, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.687 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CB9.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CB9.1} = -25.173 + 0.577\, X_{prob} + 0.449\, X_{imp} \quad \text{(Eq.5-CB9)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CB9 is equal to **26.4%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CB9.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 89.3% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	26.44	22.576	54
Probability	52.69	25.945	54
Impact	47.33	27.803	54

Table 5- CB9.1: Expropriation/ Nationalization of Assets Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.775**	.687**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.775**	1	.202
	Sig. (2-tailed)	.000		.142
	N	54	54	54
Impact	Pearson Correlation	.687**	.202	1
	Sig. (2-tailed)	.000	.142	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CB9.2: Expropriation/ Nationalization of Assets Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	24114.415	2	12057.208	212.120	.000[b]
	Residual	2898.918	51	56.842		
	Total	27013.333	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CB9.3: Expropriation/ Nationalization of Assets linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-25.173	2.709		-9.291	.000
	Probability	.577	.041	.663	14.147	.000
	Impact	.449	.038	.553	11.796	.000

a. Dependent Variable: Risk

Table 5- CB9.4: Expropriation/ Nationalization of Assets regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-14.92	62.62	26.44	21.330	54
Residual	-13.435	15.920	.000	7.396	54
Std. Predicted Value	-1.939	1.696	.000	1.000	54
Std. Residual	-1.782	2.112	.000	.981	54

a. Dependent Variable: Risk

Table 5- CB9.6: Expropriation/ Nationalization of Assets regression Residuals Statistics showing the Mean value of population Error.

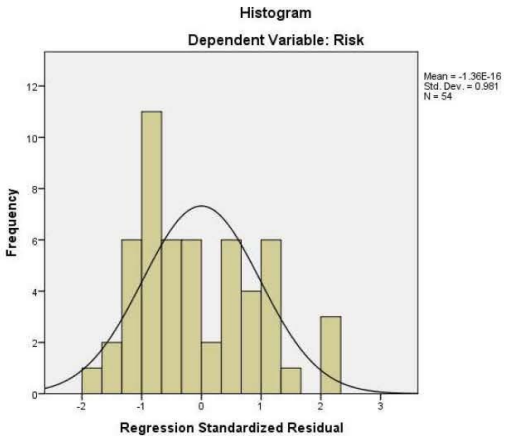


Figure 5- CB9.3: Normality of Expropriation/ Nationalization of Assets Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.945[a]	.893	.888	7.539	1.563

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CB9.5: Expropriation/ Nationalization of Assets regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

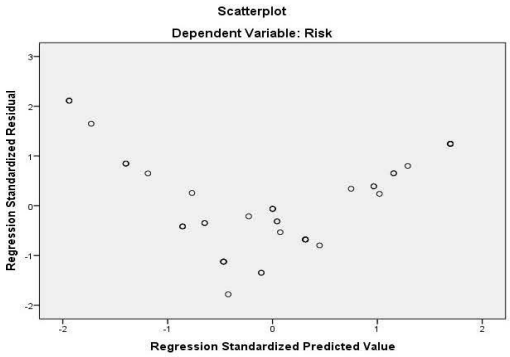


Figure 5- CB9.2: Homoscedasticity of Expropriation/ Nationalization of Assets normal Error (i.e. Constant Variance).

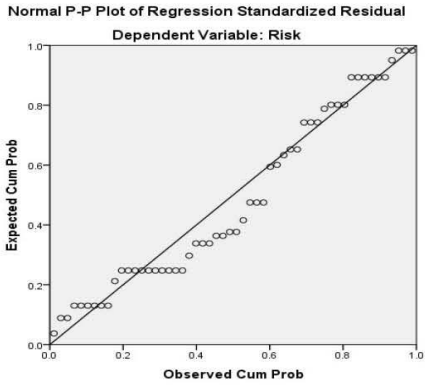


Figure 5- CB9.1: Expropriation/ Nationalization of Assets normal Predicted Probability of the residual.

10- **Inability of Concessionaire**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.160, P-value= 0.247 (P-value > α), So H_I is ***Rejected***.
- r= 0.160 (< 0.3), indicate that no linear relationship exist between Risk and Probability variables.
- Therefore, there is no evidence that between Risk and Probability Correlation Exists, but it may be proved in the regression analysis.

Risk vs. Impact:

- r= 0.752, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.752 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CB10.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CB10.1} = -6.461 + 0.106 X_{prob} + 0.520 X_{imp} \quad \text{(Eq.5-CB10)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CB10 is equal to **22.6%**. This result shall be reflected in the systems dynamics model equations.

- Finally, from Table 5-CB10.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 63.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	22.56	19.908	54
Probability	56.81	48.348	54
Impact	44.20	30.037	54

Table 5- CB10.1: Inability of Concessionaire Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.160	.752**
	Sig. (2-tailed)		.247	.000
	N	54	54	54
Probability	Pearson Correlation	.160	1	-.125
	Sig. (2-tailed)	.247		.370
	N	54	54	54
Impact	Pearson Correlation	.752**	-.125	1
	Sig. (2-tailed)	.000	.370	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CB10.2: Inability of Concessionaire Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13266.514	2	6633.257	43.714	.000[b]
	Residual	7738.819	51	151.742		
	Total	21005.333	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CB10.3: Inability of Concessionaire linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-6.461	3.792		-1.704	.094
	Probability	.106	.035	.258	3.010	.004
	Impact	.520	.057	.785	9.158	.000

a. Dependent Variable: Risk

Table 5- CB10.4: Inability of Concessionaire regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.20	44.69	22.56	15.821	54
Residual	-33.965	27.308	.000	12.084	54
Std. Predicted Value	-1.438	1.399	.000	1.000	54
Std. Residual	-2.757	2.217	.000	.981	54

a. Dependent Variable: Risk

Table 5- CB10.6: Inability of Concessionaire regression Residuals Statistics showing the Mean value of population Error.

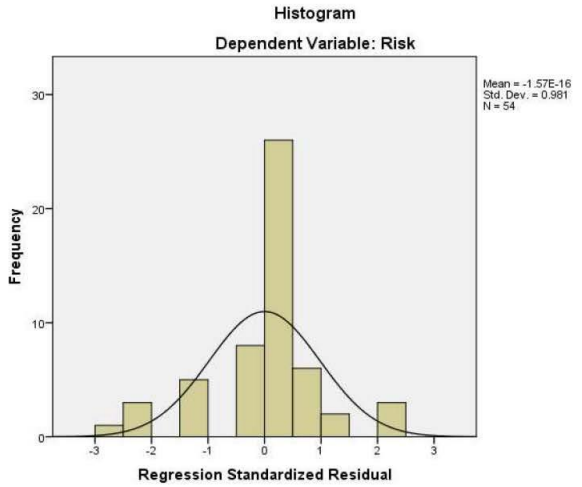


Figure 5- CB10.3: Normality of Inability of Concessionaire Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.795[a]	.632	.617	12.318	2.079

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CB10.5: Inability of Concessionaire regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

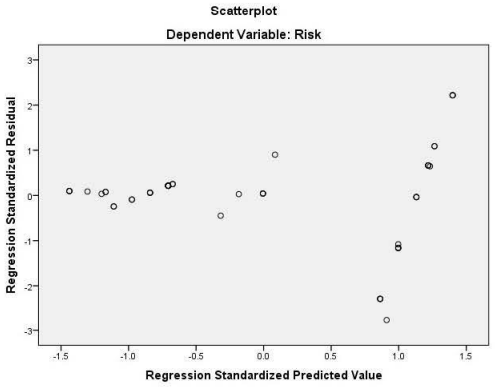


Figure 5- CB10.2: Homoscedasticity of Inability of Concessionaire normal Error (i.e. Constant Variance).

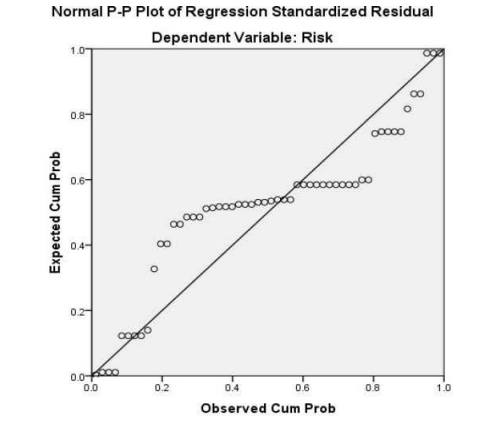


Figure 5- CB10.1: Inability of Concessionaire normal Predicted Probability of the residual.

C- Construction Legal Factors:

1- Change in Tax Regulation:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.915, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.915 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.920, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.920 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CC1.1c} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CC1.1c} = -26.870 + 0.598\, X_{prob} + 0.506\, X_{imp} \quad \text{(Eq.5-CC1c)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CC1c is equal to **30.5%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CC1.5c, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 97.8% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	30.47	22.963	49
Probability	52.22	20.140	49
Impact	51.59	24.613	49

Table 5- CC1.1c: Change in Tax Regulation Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.915**	.920**
	Sig. (2-tailed)		.000	.000
	N	49	49	49
Probability	Pearson Correlation	.915**	1	.719**
	Sig. (2-tailed)	.000		.000
	N	49	49	49
Impact	Pearson Correlation	.920**	.719**	1
	Sig. (2-tailed)	.000	.000	
	N	49	49	49

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CC1.2c: Change in Tax Regulation Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	24764.355	2	12382.178	1043.476	.000[b]
	Residual	545.849	46	11.866		
	Total	25310.204	48			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CC1.3c: Change in Tax Regulation linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-26.870	1.390		-19.332	.000
	Probability	.598	.036	.525	16.838	.000
	Impact	.506	.029	.542	17.402	.000

a. Dependent Variable: Risk

Table 5- CC1.4c: Change in Tax Regulation regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-3.87	67.44	30.47	22.714	49
Residual	-7.238	6.866	.000	3.372	49
Std. Predicted Value	-1.512	1.628	.000	1.000	49
Std. Residual	-2.101	1.993	.000	.979	49

a. Dependent Variable: Risk

Table 5- CC1.6c: Change in Tax Regulation regression Residuals Statistics showing the Mean value of population

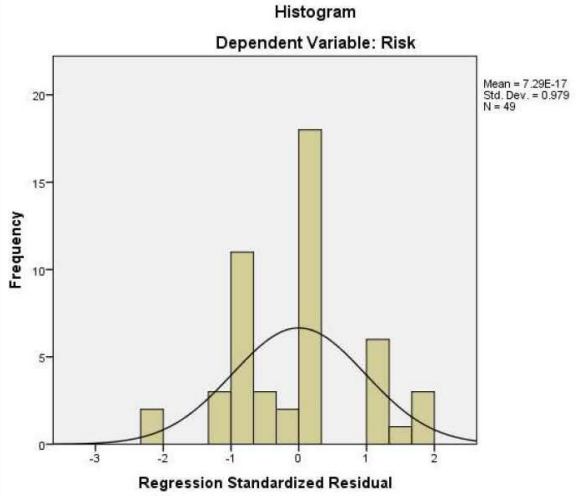


Figure 5- CC1.3c: Normality of Change in Tax Regulation Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.989[a]	.978	.977	3.445	1.513

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CC1.5c: Change in Tax Regulation regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

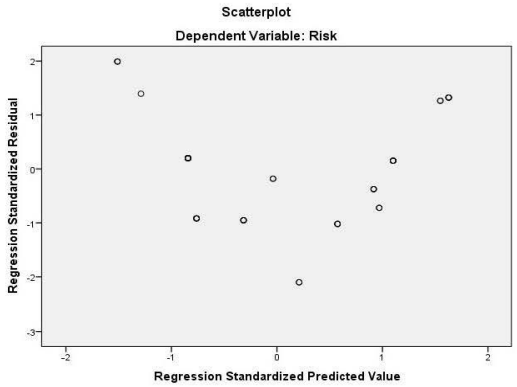


Figure 5- CC1.2c: Homoscedasticity of Change in Tax Regulation normal Error (i.e. Constant Variance).

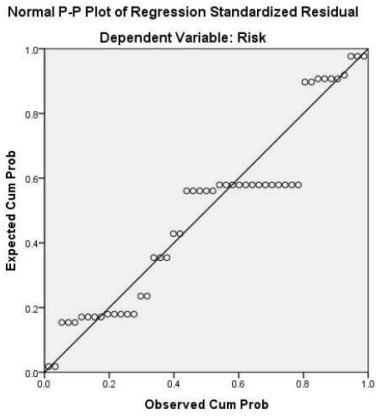


Figure 5- CC1.1c: Change in Tax Regulation normal Predicted Probability of the residual.

2- Corruption and Lack of Respect for Law:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.796, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.796 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.746, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.746 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CC2.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CC2.1} = -25.470 + 0.609 X_{prob} + 0.445 X_{imp} \quad \text{(Eq.5-CC2)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CC2 is equal to **31%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CC2.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 91.8% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	30.96	22.622	54
Probability	52.33	23.399	54
Impact	55.19	28.384	54

Table 5- CC2.1: Corruption and Lack of Respect for Law Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.796**	.746**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.796**	1	.298*
	Sig. (2-tailed)	.000		.029
	N	54	54	54
Impact	Pearson Correlation	.746**	.298*	1
	Sig. (2-tailed)	.000	.029	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CC2.2: Corruption and Lack of Respect for Law Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	24900.620	2	12450.310	285.853	.000[b]
	Residual	2221.306	51	43.555		
	Total	27121.926	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CC2.3: Corruption and Lack of Respect for Law linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-25.470	2.528		-10.075	.000
	Probability	.609	.041	.630	15.006	.000
	Impact	.445	.033	.558	13.305	.000

a. Dependent Variable: Risk

Table 5- CC2.4: Corruption and Lack of Respect for Law regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-14.93	64.95	30.96	21.675	54
Residual	-15.384	15.930	.000	6.474	54
Std. Predicted Value	-2.117	1.568	.000	1.000	54
Std. Residual	-2.331	2.414	.000	.981	54

a. Dependent Variable: Risk

Table 5- CC2.6: Corruption and Lack of Respect for Law regression Residuals Statistics showing the Mean value of population Error.

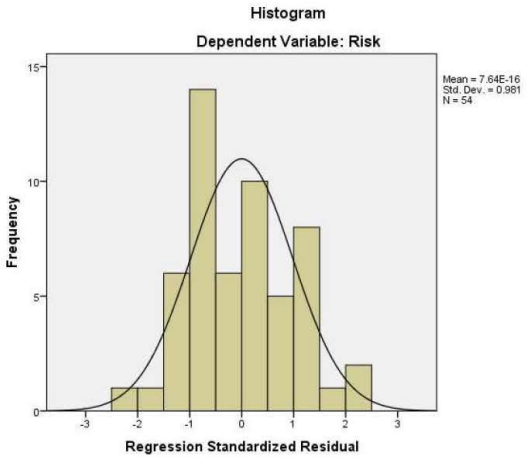


Figure 5- CC2.3: Normality of Corruption and Lack of Respect for Law Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.958[a]	.918	.915	6.600	1.925

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CC2.5: Corruption and Lack of Respect for Law regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

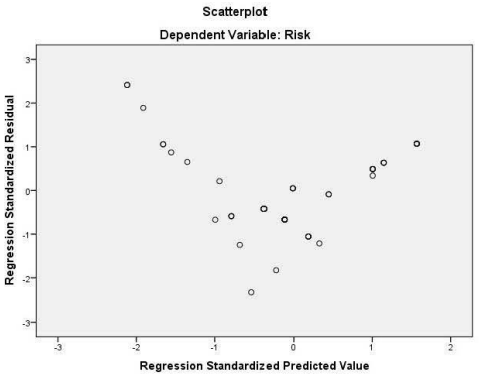


Figure 5- CC2.2: Homoscedasticity of Corruption and Lack of Respect for Law normal Error (i.e. Constant Variance).

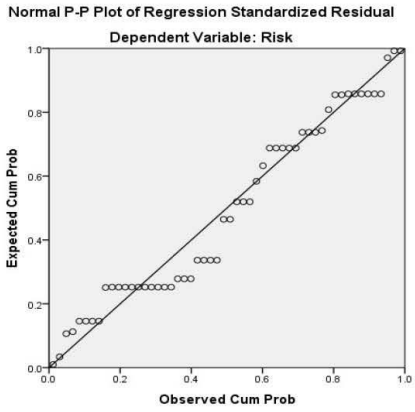


Figure 5- CC2.1: Corruption and Lack of Respect for Law normal Predicted Probability of the residual.

3- **Legislation Change**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_1: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.727, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.727 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.888, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.888 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CC3.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CC3.1} = -23.051 + 0.481 X_{prob} + 0.522 X_{imp} \quad \text{(Eq.5-CC3)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CC3 is equal to **25.6%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CC3.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 93.8% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	25.56	19.411	54
Probability	53.11	17.245	54
Impact	44.20	26.267	54

Table 5- CC3.1: Legislation Change Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.727**	.888**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.727**	1	.424**
	Sig. (2-tailed)	.000		.001
	N	54	54	54
Impact	Pearson Correlation	.888**	.424**	1
	Sig. (2-tailed)	.000	.001	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CC3.2: Legislation Change Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18724.222	2	9362.111	383.474	.000[b]
	Residual	1245.111	51	24.414		
	Total	19969.333	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CC3.3: Legislation Change linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-23.051	2.214		-10.413	.000
	Probability	.481	.043	.427	11.057	.000
	Impact	.522	.029	.707	18.297	.000

a. Dependent Variable: Risk

Table 5- CC3.4: Legislation Change regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-6.02	61.98	25.56	18.796	54
Residual	-15.525	10.025	.000	4.847	54
Std. Predicted Value	-1.680	1.938	.000	1.000	54
Std. Residual	-3.142	2.029	.000	.981	54

a. Dependent Variable: Risk

Table 5- CC3.6: Legislation Change regression Residuals Statistics showing the Mean value of population Error.

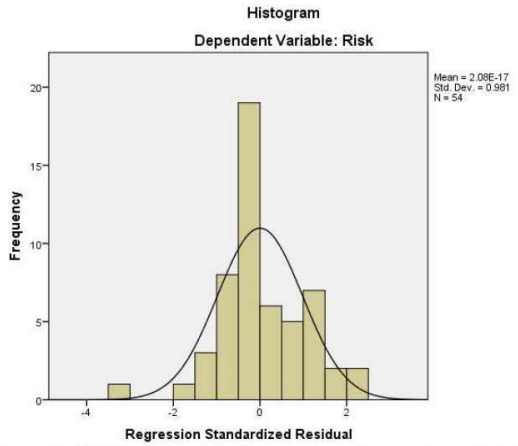


Figure 5- CC3.3: Normality of Legislation Change Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.968[a]	.938	.935	4.941	1.888

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CC3.5: Legislation Change regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

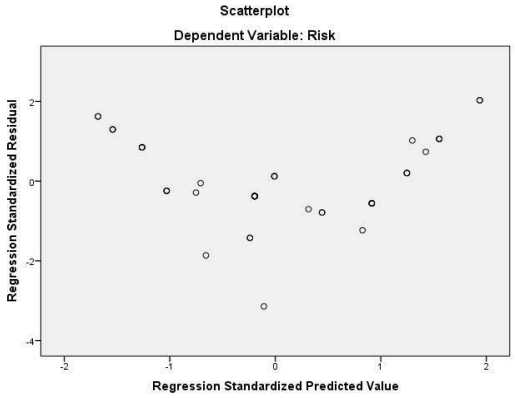


Figure 5- CC3.2: Homoscedasticity of Legislation Change normal Error (i.e. Constant Variance).

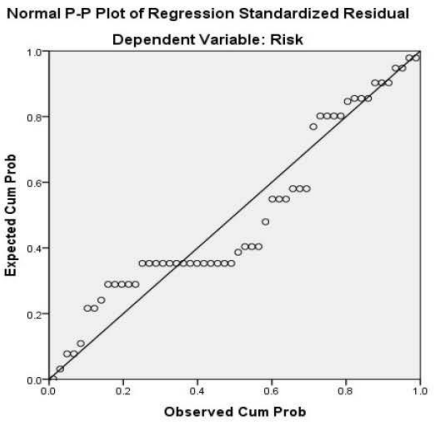


Figure 5- CC3.1: Legislation Change normal Predicted Probability of the residual.

4- Import / Export Restrictions:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.731, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.731 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.865, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.865 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CC4.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CC4.1} = -23.137 + 0.511 X_{prob} + 0.493 X_{imp} \quad \text{(Eq.5-CC4)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CC4 is equal to **22.8%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CC4.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	22.83	19.872	54
Probability	47.37	18.417	54
Impact	44.13	27.741	54

Table 5- CC4.1: Import / Export Restrictions Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.731**	.865**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.731**	1	.374**
	Sig. (2-tailed)	.000		.005
	N	54	54	54
Impact	Pearson Correlation	.865**	.374**	1
	Sig. (2-tailed)	.000	.005	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CC4.2: Import / Export Restrictions Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19712.276	2	9856.138	412.959	.000[b]
	Residual	1217.224	51	23.867		
	Total	20929.500	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CC4.3: Import / Export Restrictions linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-23.137	1.905		-12.146	.000
	Probability	.511	.039	.474	13.011	.000
	Impact	.493	.026	.688	18.903	.000

a. Dependent Variable: Risk

Table 5- CC4.4: Import / Export Restrictions regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-5.34	62.31	22.83	19.285	54
Residual	-13.416	9.692	.000	4.792	54
Std. Predicted Value	-1.461	2.047	.000	1.000	54
Std. Residual	-2.746	1.984	.000	.981	54

a. Dependent Variable: Risk

Table 5- CC4.6: Import / Export Restrictions regression Residuals Statistics showing the Mean value of population Error.

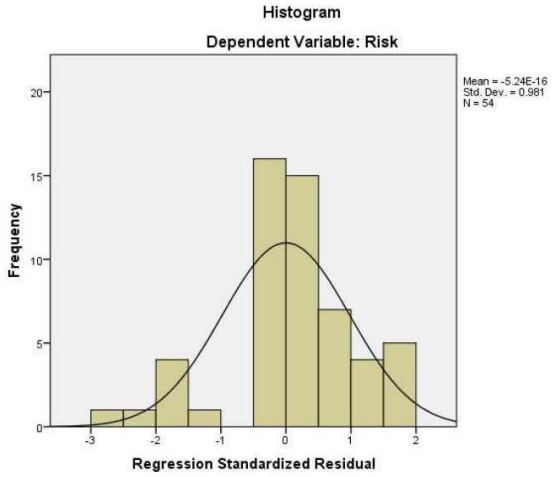


Figure 5- CC4.3: Normality of Import / Export Restrictions Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.970[a]	.942	.940	4.885	1.927

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CC4.5: Import / Export Restrictions regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

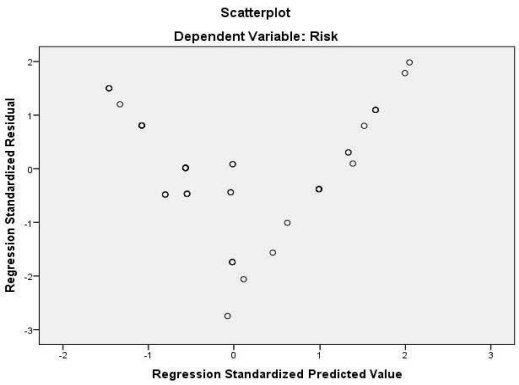


Figure 5- CC4.2: Homoscedasticity of Import / Export Restrictions normal Error (i.e. Constant Variance).

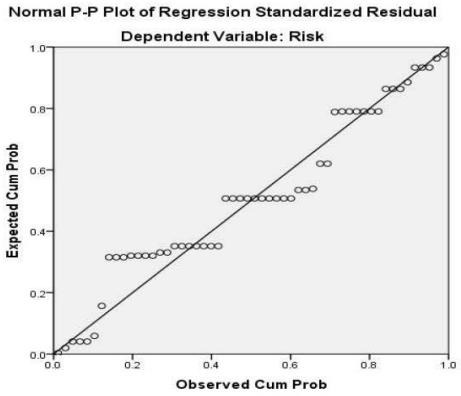


Figure 5- CC4.1: Import / Export Restrictions normal Predicted Probability of the residual.

5- Rate of Return Restrictions:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.779, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.779 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.898, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.898 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CC5.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CC5.1} = -15.100 + 0.424 X_{prob} + 0.440 X_{imp} \quad \text{(Eq.5-CC5)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CA1 is equal to **18.61%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CC5.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92.5% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	18.61	19.755	54
Probability	40.35	19.147	54
Impact	37.76	30.240	54

Table 5- CC5.1: Rate of Return Restrictions Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.779**	.898**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.779**	1	.548**
	Sig. (2-tailed)	.000		.000
	N	54	54	54
Impact	Pearson Correlation	.898**	.548**	1
	Sig. (2-tailed)	.000	.000	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CC5.2: Rate of Return Restrictions Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19126.701	2	9563.351	313.425	.000[b]
	Residual	1556.132	51	30.512		
	Total	20682.833	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CC5.3: Rate of Return Restrictions linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-15.100	1.769		-8.536	.000
	Probability	.424	.047	.411	8.954	.000
	Impact	.440	.030	.673	14.662	.000

a. Dependent Variable: Risk

Table 5- CC5.4: Rate of Return Restrictions regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-12.90	58.23	18.61	18.997	54
Residual	-12.780	13.902	.000	5.419	54
Std. Predicted Value	-1.659	2.086	.000	1.000	54
Std. Residual	-2.314	2.517	.000	.981	54

a. Dependent Variable: Risk

Table 5- CC5.6: Rate of Return Restrictions regression Residuals Statistics showing the Mean value of population Error.

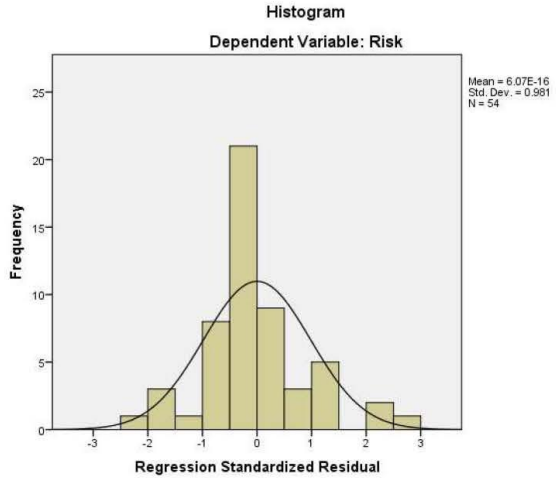


Figure 5- CC5.3: Normality of Rate of Return Restrictions Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.962[a]	.925	.922	5.524	1.937

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CC5.5: Rate of Return Restrictions regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

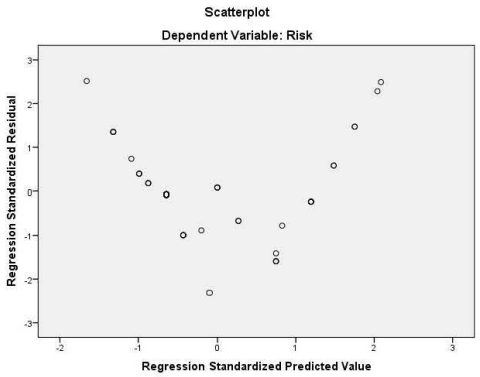


Figure 5- CC5.2: Homoscedasticity of Rate of Return Restrictions normal Error (i.e. Constant Variance).

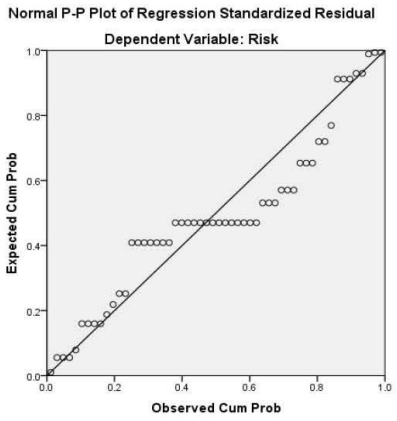


Figure 5- CC5.1: Rate of Return Restrictions normal Predicted Probability of the residual.

6- Industrial Regulatory Change:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.818, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.818 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.889, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.889 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CC6.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CC6.1} = -21.128 + 0.524 X_{prob} + 0.455 X_{imp} \quad \text{(Eq.5-CC6)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CC6 is equal to **25%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CC6.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 93.6% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	24.98	20.551	54
Probability	48.74	18.167	54
Impact	45.19	28.300	54

Table 5- CC6.1: Industrial Regulatory Change Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.818**	.889**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.818**	1	.567**
	Sig. (2-tailed)	.000		.000
	N	54	54	54
Impact	Pearson Correlation	.889**	.567**	1
	Sig. (2-tailed)	.000	.000	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CC6.2: Industrial Regulatory Change Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20962.235	2	10481.118	375.708	.000[b]
	Residual	1422.746	51	27.897		
	Total	22384.981	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CC6.3: Industrial Regulatory Change linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-21.128	2.076		-10.177	.000
	Probability	.524	.048	.463	10.814	.000
	Impact	.455	.031	.627	14.630	.000

a. Dependent Variable: Risk

Table 5- CC6.4: Industrial Regulatory Change regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-11.34	62.45	24.98	19.888	54
Residual	-7.005	12.336	.000	5.181	54
Std. Predicted Value	-1.826	1.884	.000	1.000	54
Std. Residual	-1.326	2.336	.000	.981	54

a. Dependent Variable: Risk

Table 5- CC6.6: Industrial Regulatory Change regression Residuals Statistics showing the Mean value of population Error.

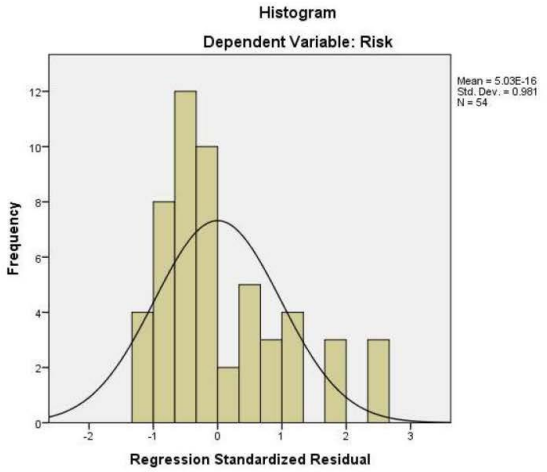


Figure 5- CC6.3: Normality of Industrial Regulatory Change Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.968[a]	.936	.934	5.282	1.592

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CC6.5: Industrial Regulatory Change regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

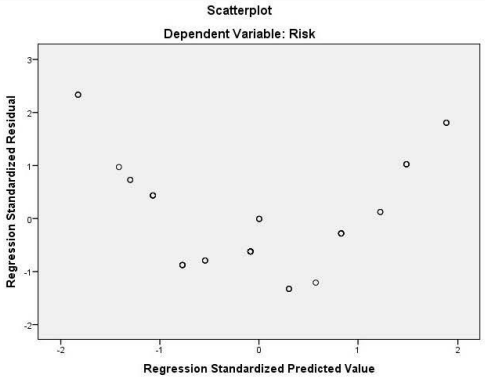


Figure 5- CC6.2: Homoscedasticity of Industrial Regulatory Change normal Error (i.e. Constant Variance).

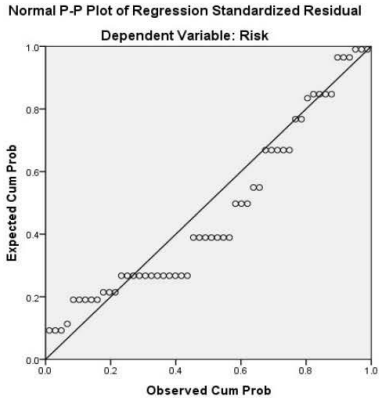


Figure 5- CC6.1: Industrial Regulatory Change normal Predicted Probability of the residual.

D- Construction Economic Change Cost Factors:

1- Interest Rate Volatility:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.750, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.750 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.948, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.948 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CD1.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CD1.1} = -16.208 + 0.330\, X_{prob} + 0.571\, X_{imp} \quad \text{(Eq.5-CD1)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CD1 is equal to **22.7%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CD1.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 96.1% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	22.67	20.536	54
Probability	50.80	19.073	54
Impact	38.67	27.731	54

Table 5- CD1.1: Interest Rate Volatility Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.750**	.948**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.750**	1	.574**
	Sig. (2-tailed)	.000		.000
	N	54	54	54
Impact	Pearson Correlation	.948**	.574**	1
	Sig. (2-tailed)	.000	.000	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CD1.2: Interest Rate Volatility Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21488.357	2	10744.179	634.467	.000[b]
	Residual	863.643	51	16.934		
	Total	22352.000	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CD1.3: Interest Rate Volatility linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-16.208	1.609		-10.074	.000
	Probability	.330	.036	.307	9.126	.000
	Impact	.571	.025	.772	22.952	.000

a. Dependent Variable: Risk

Table 5- CD1.4: Interest Rate Volatility regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-3.44	59.24	22.67	20.136	54
Residual	-6.950	12.764	.000	4.037	54
Std. Predicted Value	-1.297	1.816	.000	1.000	54
Std. Residual	-1.689	3.102	.000	.981	54

a. Dependent Variable: Risk

Table 5- CD1.6: Interest Rate Volatility regression Residuals Statistics showing the Mean value of population Error.

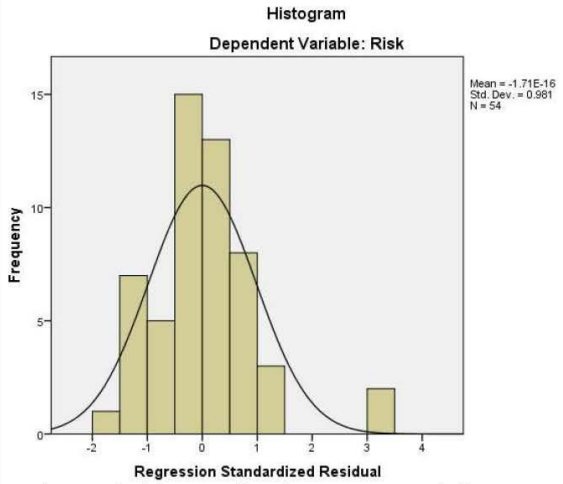


Figure 5- CD1.3: Normality of Interest Rate Volatility Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.980[a]	.961	.960	4.115	2.098

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CD1.5: Interest Rate Volatility regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

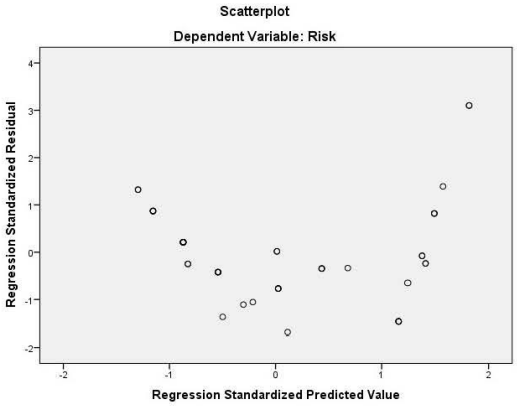


Figure 5- CD1.2: Homoscedasticity of Interest Rate Volatility normal Error (i.e. Constant Variance).

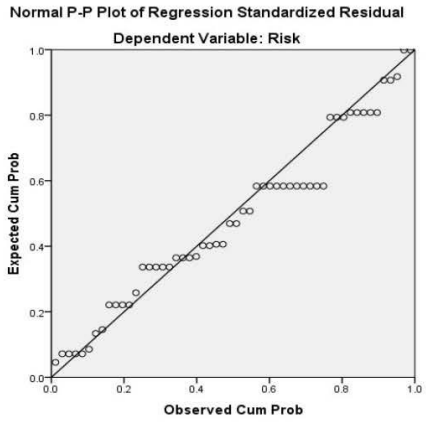


Figure 5- CD1.1: Interest Rate Volatility normal Predicted Probability of the residual.

2- Inflation Rate Volatility:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: $\rho = 0$, (i.e. No Correlation between variables),
H_i: $\rho \neq 0$, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.481, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.481 (0.3 to 0.5), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.960, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.960 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CD2.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CD2.1} = -19.016 + 0.311 X_{prob} + 0.643 X_{imp} \quad \text{(Eq.5-CD2)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CD2 is equal to **22.2.9%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CD2.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 96.8% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	26.22	21.914	54
Probability	60.35	15.883	54
Impact	41.17	30.539	54

Table 5- CD2.1: Inflation Rate Volatility Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.481**	.960**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.481**	1	.285*
	Sig. (2-tailed)	.000		.036
	N	54	54	54
Impact	Pearson Correlation	.960**	.285*	1
	Sig. (2-tailed)	.000	.036	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CD2.2: Inflation Rate Volatility Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	24640.015	2	12320.008	774.444	.000[b]
	Residual	811.318	51	15.908		
	Total	25451.333	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CD2.3: Inflation Rate Volatility linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-19.016	2.157		-8.817	.000
	Probability	.311	.036	.226	8.648	.000
	Impact	.643	.019	.895	34.328	.000

a. Dependent Variable: Risk

Table 5- CD2.4: Inflation Rate Volatility regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-6.46	60.40	26.22	21.562	54
Residual	-7.953	11.596	.000	3.913	54
Std. Predicted Value	-1.516	1.585	.000	1.000	54
Std. Residual	-1.994	2.907	.000	.981	54

a. Dependent Variable: Risk

Table 5- CD2.6: Inflation Rate Volatility regression Residuals Statistics showing the Mean value of population Error.

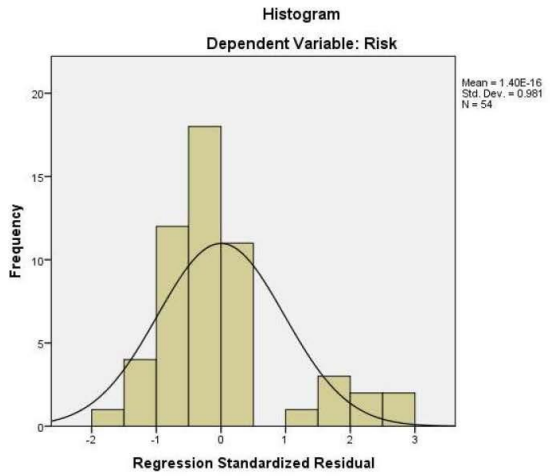


Figure 5- CD2.3: Normality of Inflation Rate Volatility Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.984[a]	.968	.967	3.989	1.979

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CD2.5: Inflation Rate Volatility regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

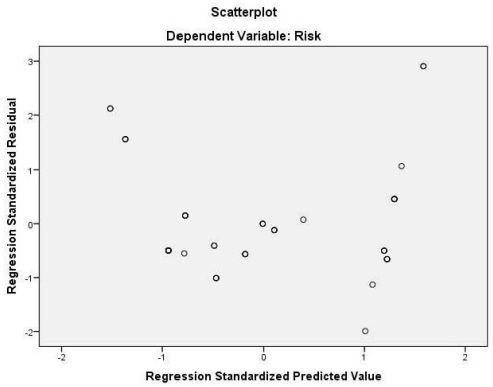


Figure 5- CD2.2: Homoscedasticity of Inflation Rate Volatility normal Error (i.e. Constant Variance).

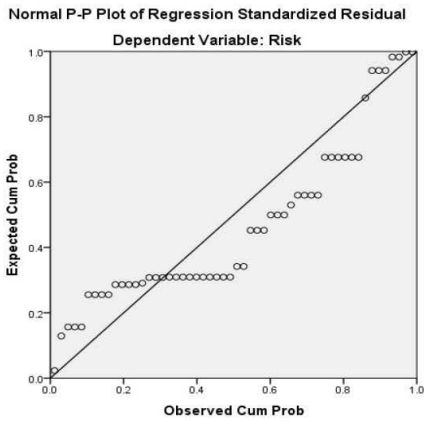


Figure 5- CD2.1: Inflation Rate Volatility normal Predicted Probability of the residual.

3- Foreign Exchange and Convertibility:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.707, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.707(> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.807, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.807 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CD3.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CD3.1} = -20.731 + 0.503 X_{prob} + 0.439 X_{imp} \quad \text{(Eq.5-CD3)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CD3 is equal to **20.6%.** This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CD3.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is auto correlated data.
- This Model is reflecting 91.6% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	20.63	17.709	54
Probability	43.78	18.755	54
Impact	44.11	26.982	54

Table 5- CD3.1: Foreign Exchange and Convertibility Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.707**	.807**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.707**	1	.261
	Sig. (2-tailed)	.000		.057
	N	54	54	54
Impact	Pearson Correlation	.807**	.261	1
	Sig. (2-tailed)	.000	.057	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CD3.2: Foreign Exchange and Convertibility Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15221.601	2	7610.801	277.450	.000[b]
	Residual	1398.992	51	27.431		
	Total	16620.593	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CD3.3: Foreign Exchange and Convertibility linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-20.731	1.978		-10.480	.000
	Probability	.503	.040	.532	12.653	.000
	Impact	.439	.028	.668	15.886	.000

a. Dependent Variable: Risk

Table 5- CD3.4: Foreign Exchange and Convertibility regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-11.32	59.61	20.63	16.947	54
Residual	-12.652	12.389	.000	5.138	54
Std. Predicted Value	-1.885	2.300	.000	1.000	54
Std. Residual	-2.416	2.365	.000	.981	54

a. Dependent Variable: Risk

Table 5- CD3.6: Foreign Exchange and Convertibility regression Residuals Statistics showing the Mean value of population Error.

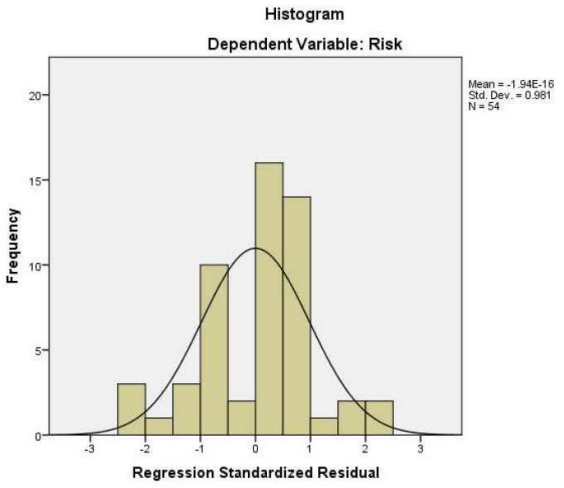


Figure 5- CD3.3: Normality of Foreign Exchange and Convertibility Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.957[a]	.916	.913	5.237	2.034

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CD3.5: Foreign Exchange and Convertibility regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

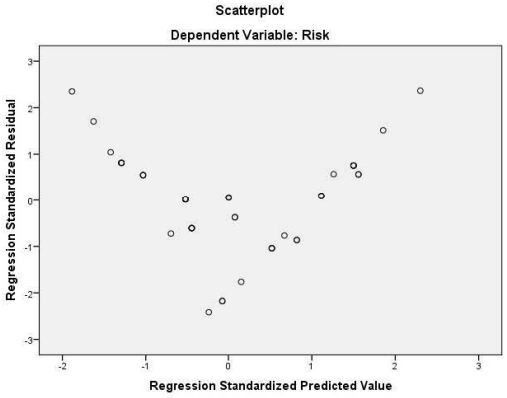


Figure 5- CD3.2: Homoscedasticity of Foreign Exchange and Convertibility normal Error (i.e. Constant Variance).

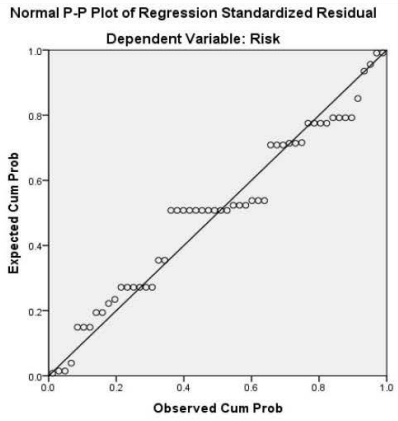


Figure 5- CD3.1: Foreign Exchange and Convertibility normal Predicted Probability of the residual.

4- Poor Financial Market:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.751, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.751 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.832, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.832 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CD4.1c} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CD4.1c} = -27.743 + 0.545 X_{prob} + 0.536 X_{imp} \quad \text{(Eq.5-CA1)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CD4c is equal to **30.5%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CD4.5c, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 93.6% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	30.45	19.669	51
Probability	58.31	18.984	51
Impact	49.29	23.869	51

Table 5- CD4.1c: Poor Financial Market Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.751**	.832**
	Sig. (2-tailed)		.000	.000
	N	51	51	51
Probability	Pearson Correlation	.751**	1	.346*
	Sig. (2-tailed)	.000		.013
	N	51	51	51
Impact	Pearson Correlation	.832**	.346*	1
	Sig. (2-tailed)	.000	.013	
	N	51	51	51

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CD4.2c: Poor Financial Market Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18110.234	2	9055.117	352.684	.000[b]
	Residual	1232.393	48	25.675		
	Total	19342.627	50			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CD4.3c: Poor Financial Market linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-27.743	2.436		-11.389	.000
	Probability	.545	.040	.526	13.547	.000
	Impact	.536	.032	.650	16.741	.000

a. Dependent Variable: Risk

Table 5- CD4.4c: Poor Financial Market regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-6.03	64.17	30.45	19.032	51
Residual	-8.770	9.033	.000	4.965	51
Std. Predicted Value	-1.917	1.772	.000	1.000	51
Std. Residual	-1.731	1.783	.000	.980	51

a. Dependent Variable: Risk

Table 5- CD4.6c: Poor Financial Market regression Residuals Statistics showing the Mean value of population Error.

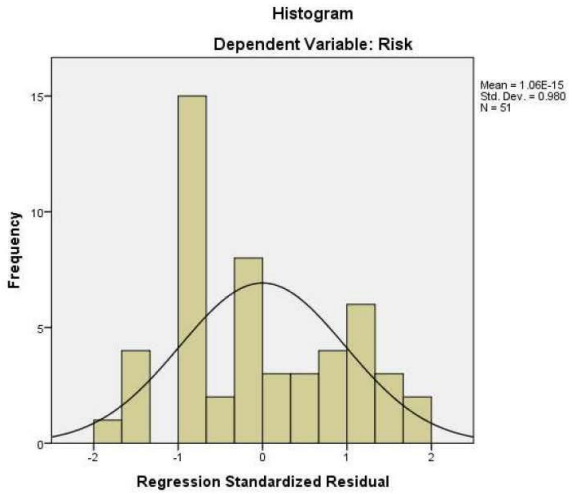


Figure 5- CD4.3c: Normality of Poor Financial Market Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.968[a]	.936	.934	5.067	1.543

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CD4.5c: Poor Financial Market regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

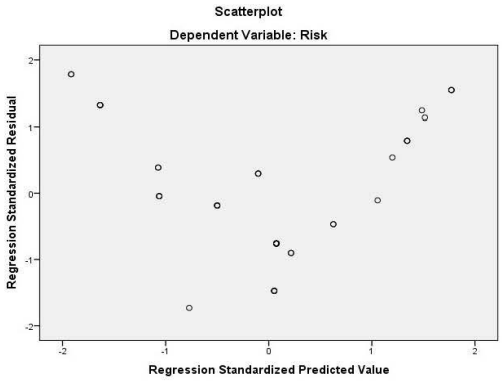


Figure 5- CD4.2c: Homoscedasticity of Poor Financial Market normal Error (i.e. Constant Variance).

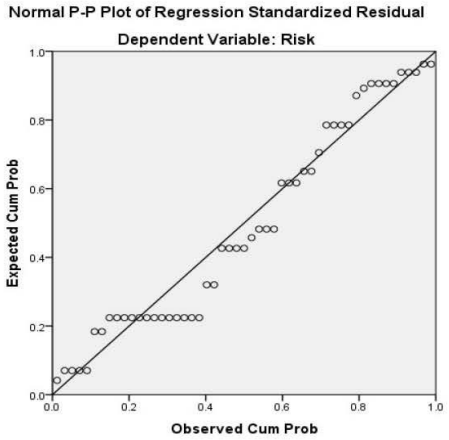


Figure 5- CD4.1c: Poor Financial Market normal Predicted Probability of the residual.

E- Construction Natural Cost Factors:

1- Force Majeure:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)
Risk vs. Probability:

- r= 0.660, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.660 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.673, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.673 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CE1.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CE1.1} = -20.450 + 0.487\, X_{prob} + 0.425\, X_{imp} \quad \text{(Eq.5-CE1)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CE1 is equal to **18.4%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CE1.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 83.9% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	18.35	18.789	54
Probability	44.37	24.187	54
Impact	40.46	28.355	54

Table 5- CE1.1: Force Majeure Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.660**	.673**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.660**	1	.051
	Sig. (2-tailed)	.000		.713
	N	54	54	54
Impact	Pearson Correlation	.673**	.051	1
	Sig. (2-tailed)	.000	.713	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CE1.2: Force Majeure Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15818.017	2	7909.009	139.460	.000[b]
	Residual	2892.298	51	56.712		
	Total	18710.315	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CE1.3: Force Majeure linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-20.450	2.561		-7.986	.000
	Probability	.487	.043	.627	11.370	.000
	Impact	.425	.037	.641	11.634	.000

a. Dependent Variable: Risk

Table 5- CE1.4: Force Majeure regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-11.33	57.37	18.35	17.276	54
Residual	-18.624	14.627	.000	7.387	54
Std. Predicted Value	-1.718	2.259	.000	1.000	54
Std. Residual	-2.473	1.942	.000	.981	54

a. Dependent Variable: Risk

Table 5- CE1.6: Force Majeure regression Residuals Statistics showing the Mean value of population Error.

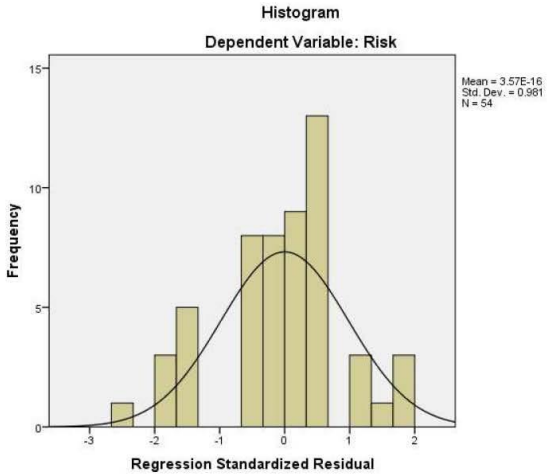


Figure 5- CE1.3: Normality of Force Majeure Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.919[a]	.845	.839	7.531	2.121

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CE1.5: Force Majeure regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

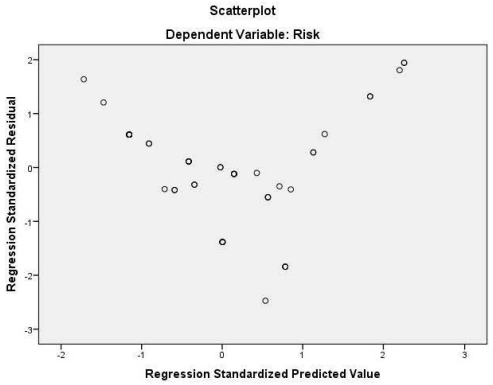


Figure 5- CE1.2: Homoscedasticity of Force Majeure normal Error (i.e. Constant Variance).

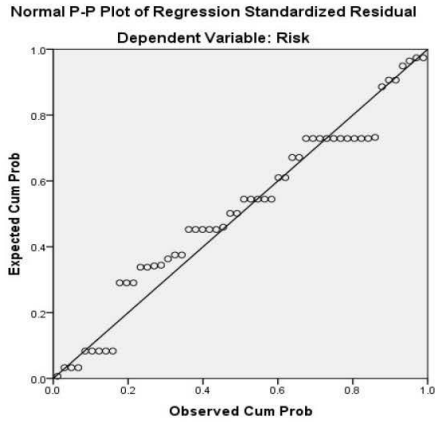


Figure 5- CE1.1: Force Majeure normal Predicted Probability of the residual.

2- **Environment**:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.615, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.615 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.874, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.874 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CE2.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CE2.1} = -17.785 + 0.366 X_{prob} + 0.513 X_{imp} \quad \text{(Eq.5-CE2)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CE2 is equal to **18.1%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CE2.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92.1% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	18.07	17.122	54
Probability	49.46	19.209	54
Impact	33.85	25.488	54

Table 5- CE2.1: Environment Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.615**	.874**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.615**	1	.268
	Sig. (2-tailed)	.000		.050
	N	54	54	54
Impact	Pearson Correlation	.874**	.268	1
	Sig. (2-tailed)	.000	.050	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CE2.2: Environment Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14311.528	2	7155.764	297.628	.000[b]
	Residual	1226.176	51	24.043		
	Total	15537.704	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CE2.3: Environment linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-17.412	1.911		-9.111	.000
	Probability	.366	.036	.411	10.057	.000
	Impact	.513	.027	.764	18.721	.000

a. Dependent Variable: Risk

Table 5- CE2.4: Environment regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-8.62	56.61	18.07	16.433	54
Residual	-10.646	15.393	.000	4.810	54
Std. Predicted Value	-1.624	2.345	.000	1.000	54
Std. Residual	-2.171	3.139	.000	.981	54

a. Dependent Variable: Risk

Table 5- CE2.6: Environment regression Residuals Statistics showing the Mean value of population Error.

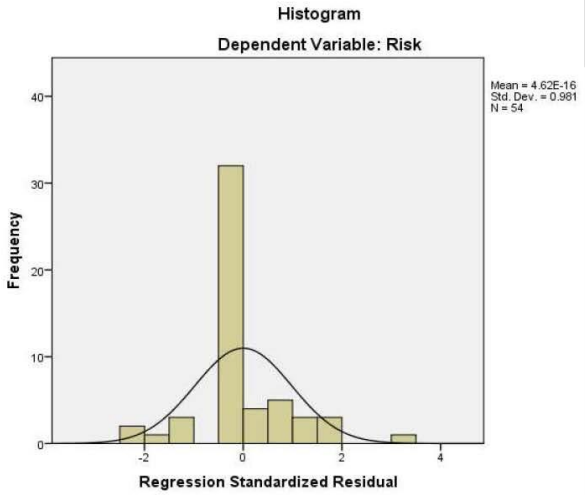


Figure 5- CE2.3: Normality of Environment Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.960[a]	.921	.918	4.903	1.754

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CE2.5: Environment regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

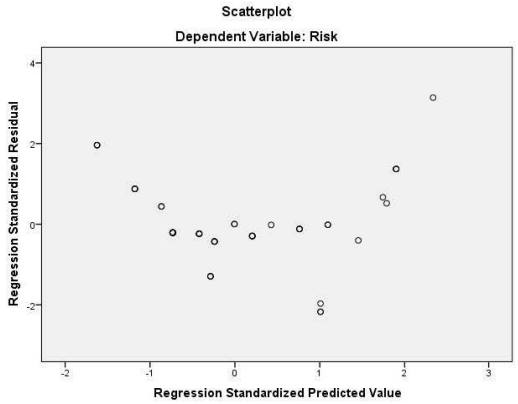


Figure 5- CE2.2: Homoscedasticity of Environment normal Error (i.e. Constant Variance).

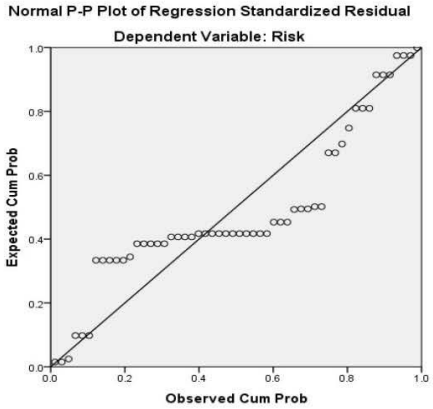


Figure 5- CE2.1: Environment normal Predicted Probability of the residual.

3- **Weather**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.513, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.513 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.919, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.919 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CE3.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CE3.1} = -15.315 + 0.245 X_{prob} + 0.649 X_{imp} \quad \text{(Eq.5-CE3)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CE3 is equal to **17.4%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CE3.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.9% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	17.44	16.317	54
Probability	54.78	17.327	54
Impact	29.81	21.912	54

Table 5- CE3.1: Weather Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.513**	.947**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.513**	1	.291*
	Sig. (2-tailed)	.000		.033
	N	54	54	54
Impact	Pearson Correlation	.947**	.291*	1
	Sig. (2-tailed)	.000	.033	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CE3.2: Weather Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13539.131	2	6769.565	603.366	.000[b]
	Residual	572.203	51	11.220		
	Total	14111.333	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CE3.3: Weather linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-15.315	1.539		-9.951	.000
	Probability	.245	.028	.260	8.815	.000
	Impact	.649	.022	.872	29.589	.000

a. Dependent Variable: Risk

Table 5- CE3.4: Weather regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-4.73	58.65	17.44	15.983	54
Residual	-5.997	13.353	.000	3.286	54
Std. Predicted Value	-1.387	2.578	.000	1.000	54
Std. Residual	-1.790	3.987	.000	.981	54

a. Dependent Variable: Risk

Table 5- CE3.6: Weather regression Residuals Statistics showing the Mean value of population Error.

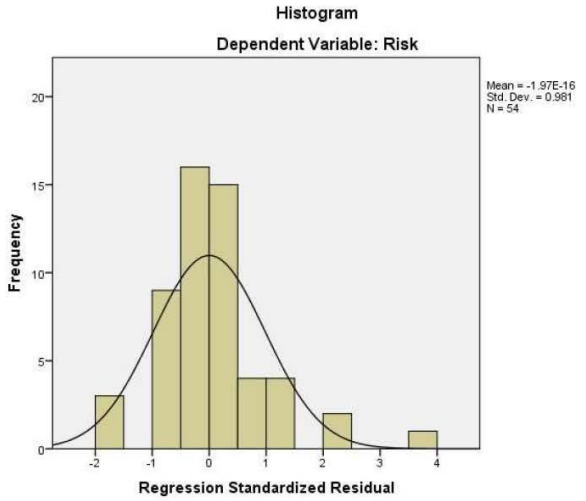


Figure 5- CE3.3: Normality of Weather Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.980[a]	.959	.958	3.350	2.286

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CE3.5: Weather regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

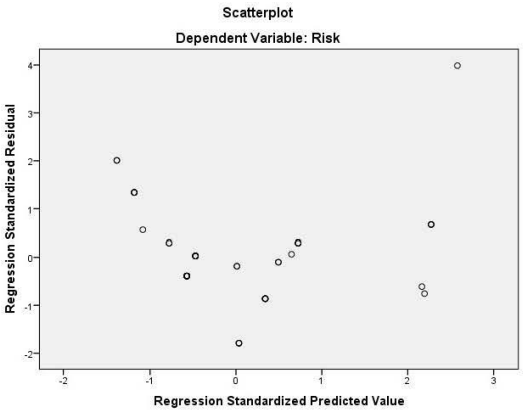


Figure 5- CE3.2: Homoscedasticity of Weather normal Error (i.e. Constant Variance).

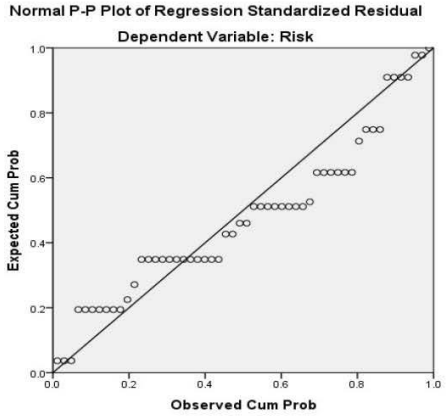


Figure 5- CE3.1: Weather normal Predicted Probability of the residual.

4- **Geotechnical Condition**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.085, P-value= 0.541 (P-value > α), So H_i is ***Rejected***.
- r= 0.085 (< 0.3), indicate that no linear relationship exist between Risk and Probability variables.
- Therefore, there is no evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.923, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.923 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CE4.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CE4.1} = -17.785 + 0.254\, X_{prob} + 0.628\, X_{imp} \quad \text{(Eq.5-CE4)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CE4 is equal to **23.7%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CE4.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92.9% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	23.69	18.247	54
Probability	62.91	20.330	54
Impact	39.63	28.481	54

Table 5- CE4.1: Geotechnical Condition Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.085	.923**
	Sig. (2-tailed)		.541	.000
	N	54	54	54
Probability	Pearson Correlation	.085	1	-.202
	Sig. (2-tailed)	.541		.143
	N	54	54	54
Impact	Pearson Correlation	.923**	-.202	1
	Sig. (2-tailed)	.000	.143	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CE4.2: Geotechnical Condition Correlation significance analysis of Risk, Probability and Impact

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16390.504	2	8195.252	332.996	.000[b]
	Residual	1255.144	51	24.611		
	Total	17645.648	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CE4.3: Geotechnical Condition linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-17.185	2.621		-6.556	.000
	Probability	.254	.034	.283	7.423	.000
	Impact	.628	.024	.980	25.706	.000

a. Dependent Variable: Risk

Table 5- CE4.4: Geotechnical Condition regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-8.36	55.92	23.69	17.586	54
Residual	-16.677	16.079	.000	4.866	54
Std. Predicted Value	-1.822	1.833	.000	1.000	54
Std. Residual	-3.362	3.241	.000	.981	54

a. Dependent Variable: Risk

Table 5- CE4.6: Geotechnical Condition regression Residuals Statistics showing the Mean value of population Error.

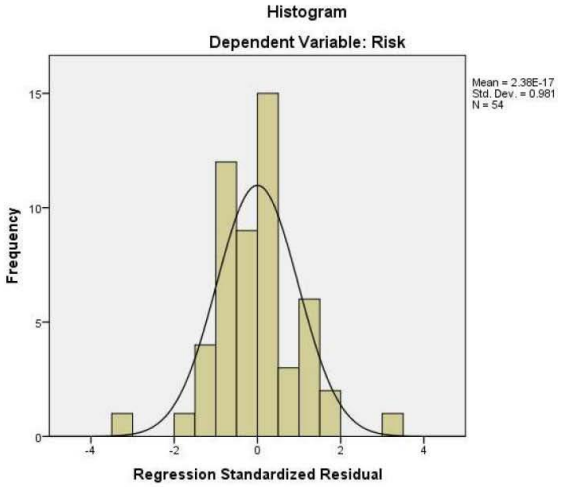


Figure 5- CE4.3: Normality of Geotechnical Condition Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.964[a]	.929	.926	4.961	1.633

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CE4.5: Geotechnical Condition regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

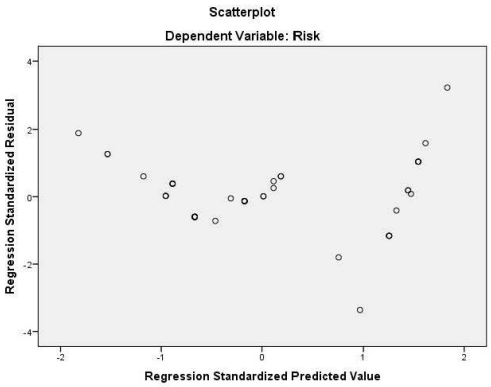


Figure 5- CE4.2: Homoscedasticity of Geotechnical Condition normal Error (i.e. Constant Variance).

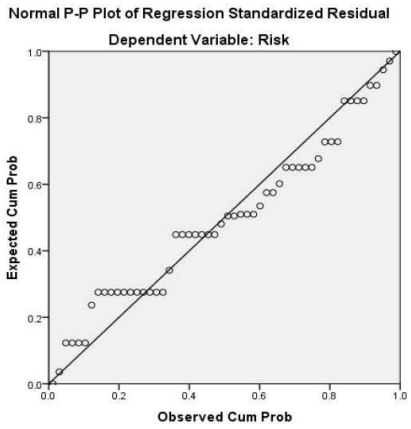


Figure 5- CE4.1: Geotechnical Condition normal Predicted Probability of the residual.

F- Construction Market Cost Factors:

1- Market Supply:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.737, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.737 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.872, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.872 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CF1.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CF1.1} = -18.239 + 0.446 X_{prob} + 0.473 X_{imp} \quad \text{(Eq.5-CF1)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CF1 is equal to **25.1%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CF1.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 91.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	25.11	20.860	54
Probability	50.72	20.559	54
Impact	43.81	29.993	54

Table 5- CF1.1: Market Supply Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.737**	.872**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.737**	1	.437**
	Sig. (2-tailed)	.000		.001
	N	54	54	54
Impact	Pearson Correlation	.872**	.437**	1
	Sig. (2-tailed)	.000	.001	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CF1.2: Market Supply Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21145.824	2	10572.912	281.208	.000[b]
	Residual	1917.509	51	37.598		
	Total	23063.333	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CF1.3: Market Supply and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-18.239	2.268		-8.042	.000
	Probability	.446	.046	.440	9.795	.000
	Impact	.473	.031	.680	15.155	.000

a. Dependent Variable: Risk

Table 5- CF1.4: Market Supply regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.958[a]	.917	.914	6.132	1.704

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CF1.5: Market Supply regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-4.32	59.75	25.11	19.974	54
Residual	-17.635	12.252	.000	6.015	54
Std. Predicted Value	-1.473	1.734	.000	1.000	54
Std. Residual	-2.876	1.998	.000	.981	54

a. Dependent Variable: Risk

Table 5- CF1.6: Market Supply regression Residuals Statistics showing the Mean value of population Error.

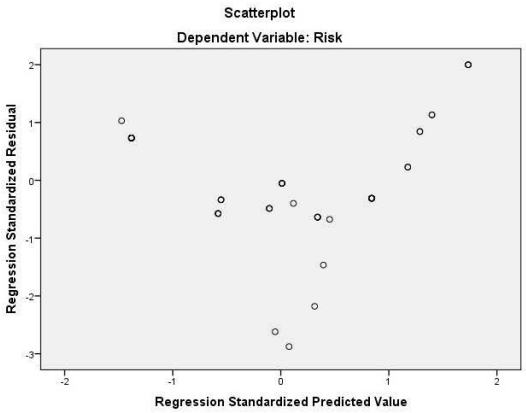


Figure 5- CF1.2: Homoscedasticity of Market Supply normal Error (i.e. Constant Variance).

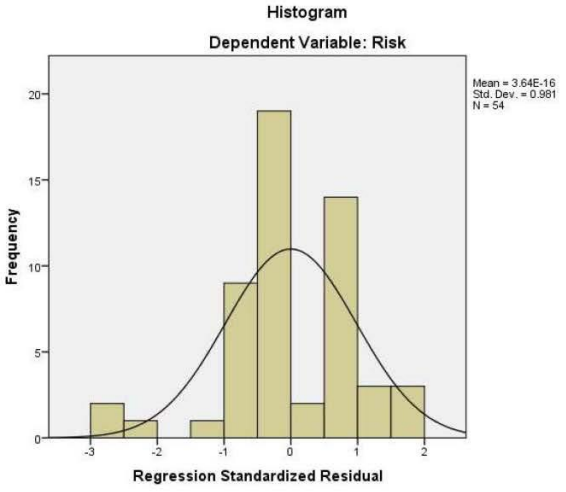


Figure 5- CF1.3: Normality of Market Supply Error distribution (i.e. Bell Shaped).

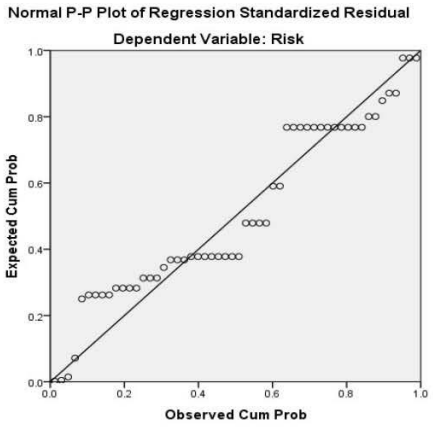


Figure 5- CF1.1: Market Supply normal Predicted Probability of the residual.

2- **Market Demand**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.787, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.787 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.958, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.958 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CF2.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CF2.1} = -21.383 + 0.379 X_{prob} + 0.654 X_{imp} \quad \text{(Eq.5-CF2)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CF2 is equal to **27.1%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CF2.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 96.6% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	27.07	23.514	54
Probability	60.30	17.917	54
Impact	39.09	27.706	54

Table 5- CF2.1: Market Demand Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.787**	.958**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.787**	1	.646**
	Sig. (2-tailed)	.000		.000
	N	54	54	54
Impact	Pearson Correlation	.958**	.646**	1
	Sig. (2-tailed)	.000	.000	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CF2.1: Market Demand Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	28312.423	2	14156.211	728.317	.000[b]
	Residual	991.281	51	19.437		
	Total	29303.704	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CF2.1: Market Demand linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-21.383	2.209		-9.678	.000
	Probability	.379	.044	.289	8.565	.000
	Impact	.654	.029	.771	22.844	.000

a. Dependent Variable: Risk

Table 5- CF2.4: Market Demand regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-6.73	65.11	27.07	23.113	54
Residual	-9.936	8.729	.000	4.325	54
Std. Predicted Value	-1.463	1.646	.000	1.000	54
Std. Residual	-2.254	1.980	.000	.981	54

a. Dependent Variable: Risk

Table 5- CF2.6: Market Demand regression Residuals Statistics showing the Mean value of population Error.

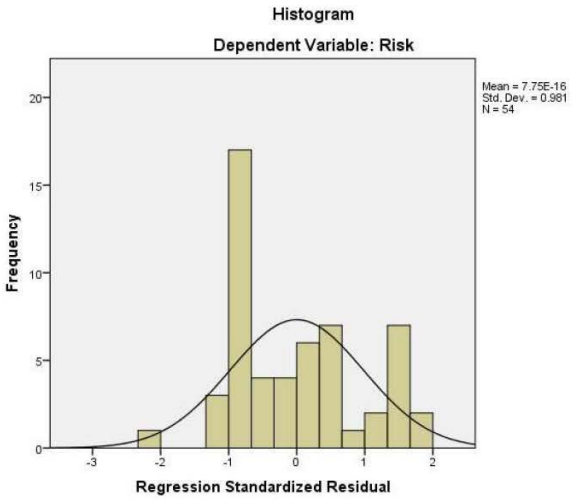


Figure 5- CF2.3: Normality of Market Demand Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.983[a]	.966	.965	4.409	1.772

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CF2.5: Market Demand regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

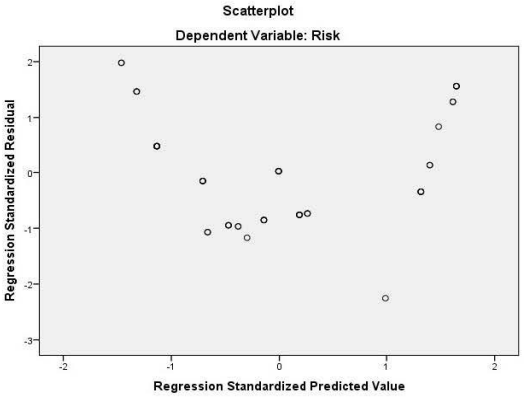


Figure 5- CF2.2: Homoscedasticity of Market Demand normal Error (i.e. Constant Variance).

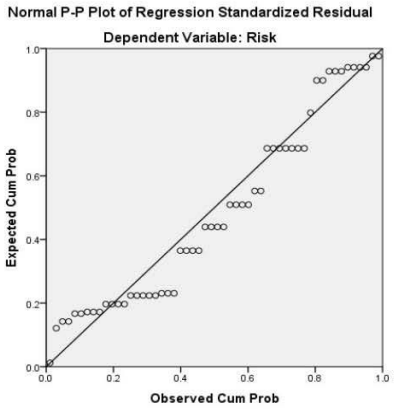


Figure 5- CF2.1: Market Demand normal Predicted Probability of the residual.

3- **Fluctuation of Material Cost by Public/Private**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.721, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.721 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.889, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.889 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CF3.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CF3.1} = -26.299 + 0.523\, X_{prob} + 0.541\, X_{imp} \quad \text{(Eq.5-CF3)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CF3 is equal to **24.8%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CF3.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.1% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	24.81	20.746	54
Probability	55.94	17.304	54
Impact	40.37	27.452	54

Table 5- CF3.1: Fluctuation of Material Cost by Public/ Private Data Descriptive Statistics of Risk, Probability and

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.721**	.889**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.721**	1	.397**
	Sig. (2-tailed)	.000		.003
	N	54	54	54
Impact	Pearson Correlation	.889**	.397**	1
	Sig. (2-tailed)	.000	.003	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CF3.2: Fluctuation of Material Cost by Public/ Private Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21688.867	2	10844.433	493.245	.000[b]
	Residual	1121.281	51	21.986		
	Total	22810.148	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CF3.3: Fluctuation of Material Cost by Public/ Private linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-26.299	2.182		-12.053	.000
	Probability	.523	.041	.437	12.906	.000
	Impact	.541	.026	.716	21.152	.000

a. Dependent Variable: Risk

Table 5- CF3.4: Fluctuation of Material Cost by Public/ Private regression coefficients of Probability and Impact

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-7.89	64.07	24.81	20.229	54
Residual	-8.774	9.892	.000	4.600	54
Std. Predicted Value	-1.617	1.941	.000	1.000	54
Std. Residual	-1.871	2.110	.000	.981	54

a. Dependent Variable: Risk

Table 5- CF3.6: Fluctuation of Material Cost by Public/ Private Regression Residuals Statistics showing the Mean value of population Error.

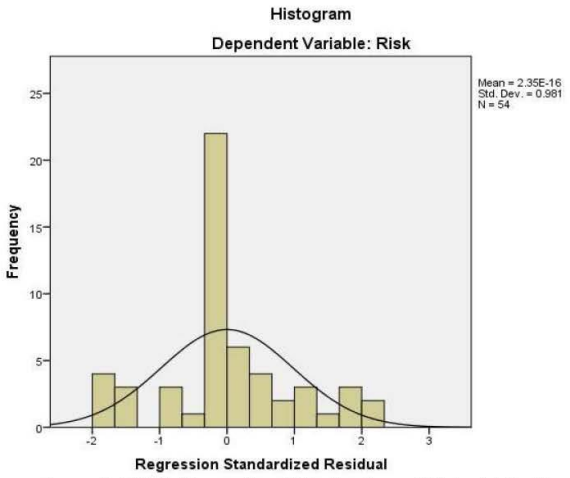


Figure 5- CF3.3: Normality of Fluctuation of Material Cost by Public/ Private Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.975[a]	.951	.949	4.689	1.726

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CF3.5: Fluctuation of Material Cost by Public/ Private regression Model Summary showing how much in percentage (%) the population is represented

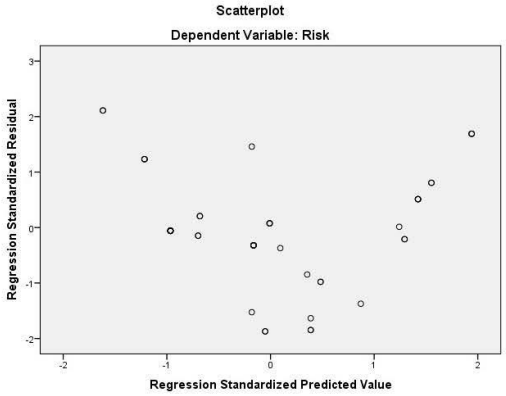


Figure 5- CF3.2: Homoscedasticity of Fluctuation of Material Cost by Public/ Private normal Error (i.e. Constant Variance).

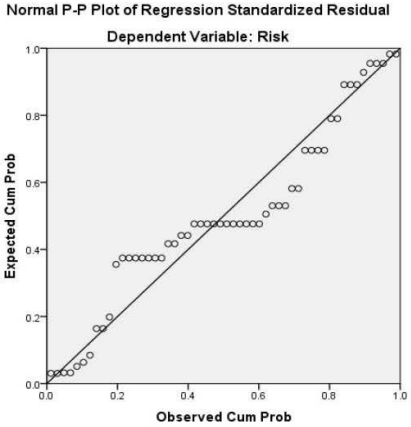


Figure 5- CF3.1: Fluctuation of Material Cost by Public/ Private normal Predicted Probability of the residual.

4- **Value of Production Effort**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.675, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.675 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.886, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.886 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CF4.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CF4.1} = -20.887 + 0.429\, X_{prob} + 0.529\, X_{imp} \quad \text{(Eq.5-CF4)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CF4 is equal to **22.3%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CF4.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 91.6% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	22.30	20.355	54
Probability	55.00	18.556	54
Impact	37.04	28.316	54

Table 5- CF4.1: Value of Production Effort Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.675**	.886**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.675**	1	.386**
	Sig. (2-tailed)	.000		.004
	N	54	54	54
Impact	Pearson Correlation	.886**	.386**	1
	Sig. (2-tailed)	.000	.004	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CF4.2: Value of Production Effort Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20109.707	2	10054.854	277.255	.000[b]
	Residual	1849.552	51	36.266		
	Total	21959.259	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CF4.3: Value of Production Effort linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-20.887	2.589		-8.067	.000
	Probability	.429	.048	.391	8.883	.000
	Impact	.529	.032	.735	16.695	.000

a. Dependent Variable: Risk

Table 5- CF4.4: Value of Production Effort regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-5.37	60.03	22.30	19.479	54
Residual	-23.445	11.971	.000	5.907	54
Std. Predicted Value	-1.420	1.937	.000	1.000	54
Std. Residual	-3.893	1.988	.000	.981	54

a. Dependent Variable: Risk

Table 5- CF4.6: Value of Production Effort Regression Residuals Statistics showing the Mean value of population Error.

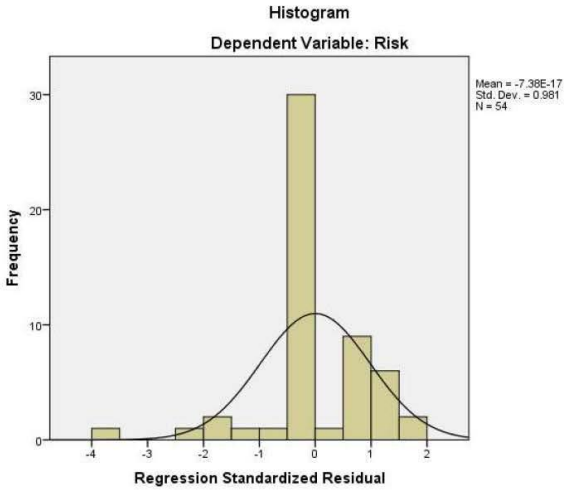


Figure 5- CF4.3: Normality of Value of Production Effort Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.957[a]	.916	.912	6.022	2.236

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CF4.5: Value of Production Effort regression Model Summary showing how much in percentage (%) the population is represented by the integrated

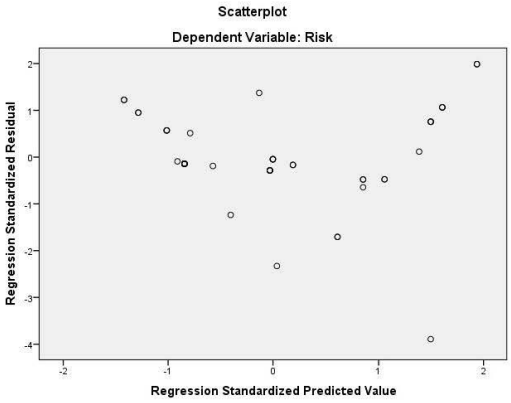


Figure 5- CF4.2: Homoscedasticity of Value of Production Effort normal Error (i.e. Constant Variance).

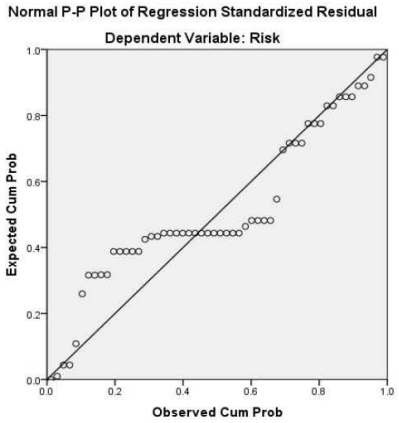


Figure 5- CF4.1: Value of Production Effort normal Predicted Probability of the residual.

G- Project Selection Cost Factors:

1- Public Opposition to Projects:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.779, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.779 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.779, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.779 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CG1.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CG1.1} = -13.799 + 0.432\, X_{prob} + 0.401\, X_{imp} \quad \text{(Eq.5-CG1)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CG1 is equal to **18.5%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CG1.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 86.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	18.54	20.705	54
Probability	39.98	26.701	54
Impact	37.57	28.754	54

Table 5- CG1.1: Public Opposition to Projects Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.779**	.779**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.779**	1	.398**
	Sig. (2-tailed)	.000		.003
	N	54	54	54
Impact	Pearson Correlation	.779**	.398**	1
	Sig. (2-tailed)	.000	.003	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CG1.2: Public Opposition to Projects Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19710.377	2	9855.188	166.923	.000[b]
	Residual	3011.049	51	59.040		
	Total	22721.426	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CG1.3: Public Opposition to Projects linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-13.799	2.064		-6.686	.000
	Probability	.432	.043	.557	10.021	.000
	Impact	.401	.040	.557	10.023	.000

a. Dependent Variable: Risk

Table 5- CG1.4: Public Opposition to Projects regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-5.47	57.15	18.54	19.285	54
Residual	-15.088	14.847	.000	7.537	54
Std. Predicted Value	-1.245	2.002	.000	1.000	54
Std. Residual	-1.964	1.932	.000	.981	54

a. Dependent Variable: Risk

Table 5- CG1.6: Public Opposition to Projects Regression Residuals Statistics showing the Mean value of population

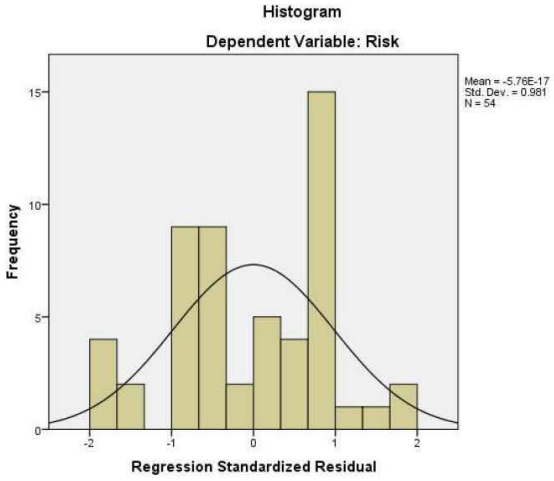


Figure 5- CG1.3: Normality of Public Opposition to Projects Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.931[a]	.867	.862	7.684	2.200

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CG1.5: Public Opposition to Projects regression Model Summary showing how much in percentage (%) the population is represented by the

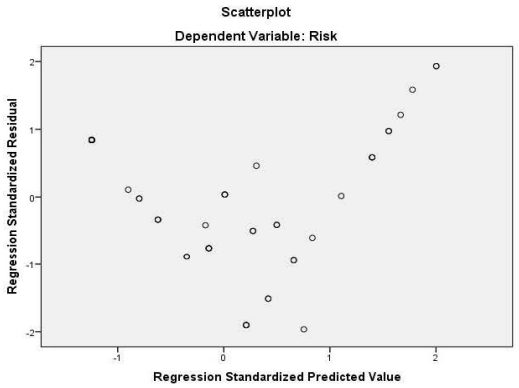


Figure 5- CG1.2: Homoscedasticity of Public Opposition to Projects normal Error (i.e. Constant Variance).

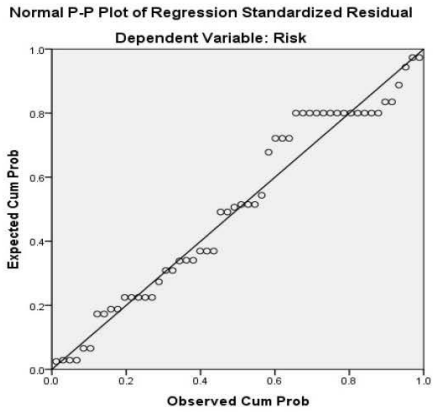


Figure 5- CG1.1: Public Opposition to Projects normal Predicted Probability of the residual.

2- **Uncompetitive Tender**:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_l: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.689, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.689 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.946, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.946 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CG2.1f} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CG2.1f} = -30.589 + 0.446 X_{prob} + 0.738 X_{imp} \quad \text{(Eq.5-CG2f)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CG2f is equal to **25.5%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CG2.5f, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 98.5% of the studied population.

	Mean	Std. Deviation	N
Risk	25.50	20.831	44
Probability	62.86	15.736	44
Impact	38.05	22.485	44

Table 5- CG2.1f: Uncompetitive Tender Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.689**	.946**
	Sig. (2-tailed)		.000	.000
	N	44	44	44
Probability	Pearson Correlation	.689**	1	.443**
	Sig. (2-tailed)	.000		.003
	N	44	44	44
Impact	Pearson Correlation	.946**	.443**	1
	Sig. (2-tailed)	.000	.003	
	N	44	44	44

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CG2.2f: Uncompetitive Tender Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18380.851	2	9190.425	1354.695	.000[b]
	Residual	278.149	41	6.784		
	Total	18659.000	43			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CG2.3f: Uncompetitive Tender linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-30.589	1.635		-18.708	.000
	Probability	.446	.028	.337	15.831	.000
	Impact	.738	.020	.796	37.446	.000

a. Dependent Variable: Risk

Table 5- CG2.4f: Uncompetitive Tender regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.93	68.55	25.50	20.675	44
Residual	-3.635	5.925	.000	2.543	44
Std. Predicted Value	-1.278	2.082	.000	1.000	44
Std. Residual	-1.396	2.275	.000	.976	44

a. Dependent Variable: Risk

Table 5- CG2.6f: Uncompetitive Tender Regression Residuals Statistics showing the Mean value of population Error.

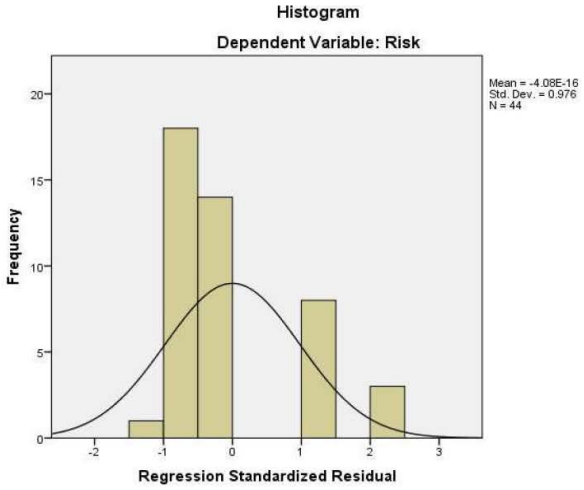


Figure 5- CG2.3f: Normality of Uncompetitive Tender Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.993[a]	.985	.984	2.605	1.604

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CG2.5f: Uncompetitive Tender regression Model Summary showing how much in percentage (%) the population is represented by the integrated

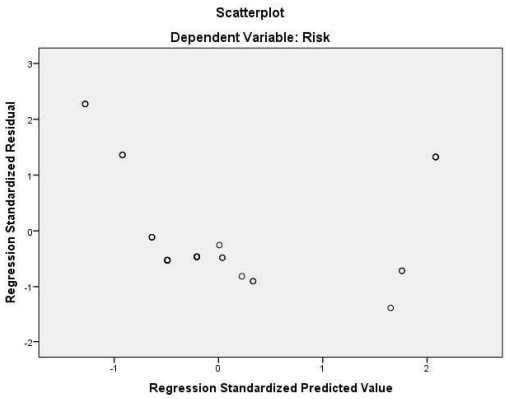


Figure 5- CG2.2f: Homoscedasticity of Uncompetitive Tender normal Error (i.e. Constant Variance).

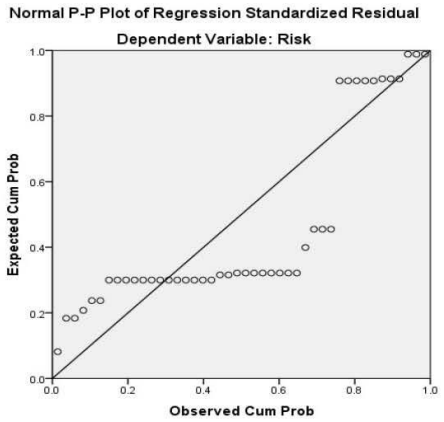


Figure 5- CG2.1f: Uncompetitive Tender normal Predicted Probability of the residual.

3- Level of Demand for the Project:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.726, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.726 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.761, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.761 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CG3.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CG3.1} = -23.854 + 0.532\, X_{prob} + 0.466\, X_{imp} \quad \text{(Eq.5-CG3)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CG3 is equal to **24.2%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CG3.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 91% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	24.19	19.179	54
Probability	50.06	21.244	54
Impact	45.89	26.075	54

Table 5- CG3.1: Level of Demand for the Project Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.726**	.761**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.726**	1	.215
	Sig. (2-tailed)	.000		.119
	N	54	54	54
Impact	Pearson Correlation	.761**	.215	1
	Sig. (2-tailed)	.000	.119	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CG3.2: Level of Demand for the Project Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17740.583	2	8870.291	257.686	.000[b]
	Residual	1755.565	51	34.423		
	Total	19496.148	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CG3.3: Level of Demand for the Project linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-23.854	2.305		-10.348	.000
	Probability	.532	.039	.589	13.700	.000
	Impact	.466	.032	.634	14.739	.000

a. Dependent Variable: Risk

Table 5- CG3.4: Level of Demand for the Project regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.954[a]	.910	.906	5.867	1.598

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CG3.5: Level of Demand for the Project regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-13.87	61.35	24.19	18.296	54
Residual	-15.366	14.869	.000	5.755	54
Std. Predicted Value	-2.080	2.031	.000	1.000	54
Std. Residual	-2.619	2.534	.000	.981	54

a. Dependent Variable: Risk

Table 5- CG3.6: Level of Demand for the Project Regression Residuals Statistics showing the Mean value of population Error.

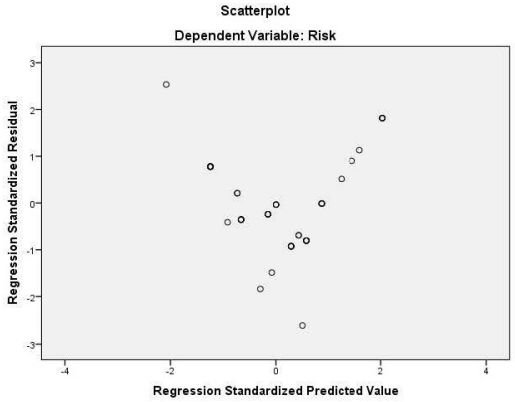


Figure 5- CG3.2: Homoscedasticity of Level of Demand for the Project normal Error (i.e. Constant Variance).

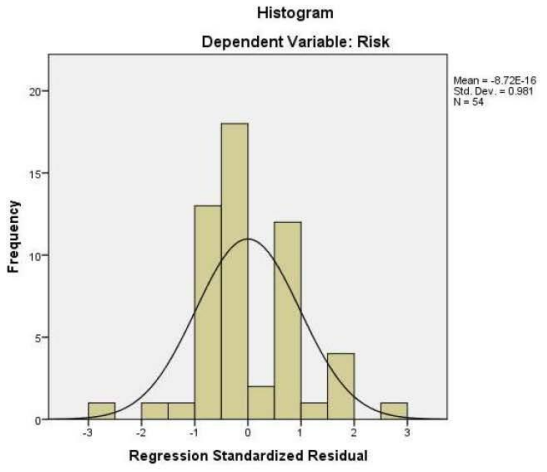


Figure 5- CG3.3: Normality of Level of Demand for the Project Error distribution (i.e. Bell Shaped).

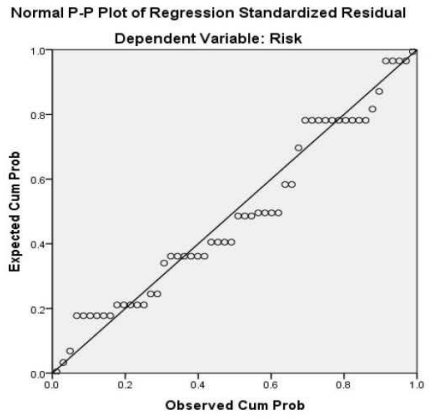


Figure 5- CG3.1: Level of Demand for the Project normal Predicted Probability of the residual.

4- **Land Acquisition**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.706, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.706 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.826, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.826 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CG4.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CG4.1} = -17.187 + 0.377\, X_{prob} + 0.520\, X_{imp} \quad \text{(Eq.5-CG4)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CG4 is equal to **25%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CG4.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 87% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	25.00	18.473	54
Probability	53.43	22.771	54
Impact	42.33	23.257	54

Table 5- CG4.1: Land Acquisition Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.706**	.826**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.706**	1	.368**
	Sig. (2-tailed)	.000		.006
	N	54	54	54
Impact	Pearson Correlation	.826**	.368**	1
	Sig. (2-tailed)	.000	.006	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CG4.2: Land Acquisition Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15727.687	2	7863.843	170.061	.000[b]
	Residual	2358.313	51	46.241		
	Total	18086.000	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CG4.3: Land Acquisition linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-17.187	2.566		-6.699	.000
	Probability	.377	.044	.465	8.557	.000
	Impact	.520	.043	.655	12.043	.000

a. Dependent Variable: Risk

Table 5- CG4.4: Land Acquisition regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-8.21	58.40	25.00	17.226	54
Residual	-20.200	23.009	.000	6.671	54
Std. Predicted Value	-1.928	1.939	.000	1.000	54
Std. Residual	-2.971	3.384	.000	.981	54

a. Dependent Variable: Risk

Table 5- CG4.6: Land Acquisition Regression Residuals Statistics showing the Mean value of population Error.

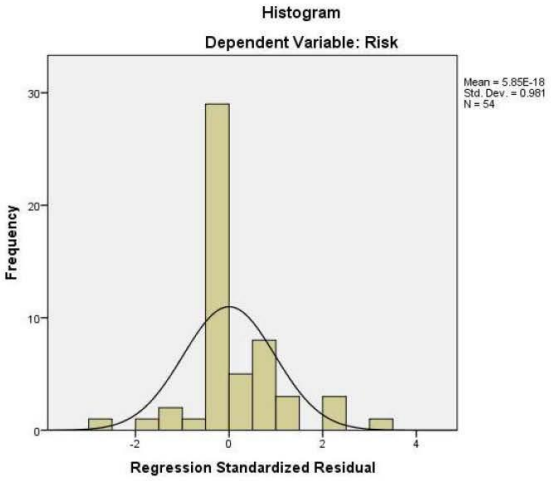


Figure 5- CG4.3: Normality of Land Acquisition Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.933[a]	.870	.864	6.800	1.857

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CG4.5: Land Acquisition regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

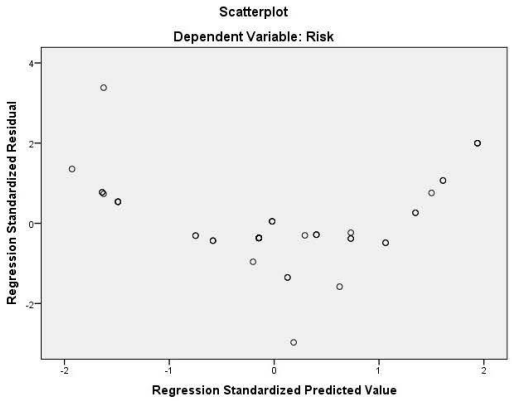


Figure 5- CG4.2: Homoscedasticity Land Acquisition normal Error (i.e. Constant Variance).

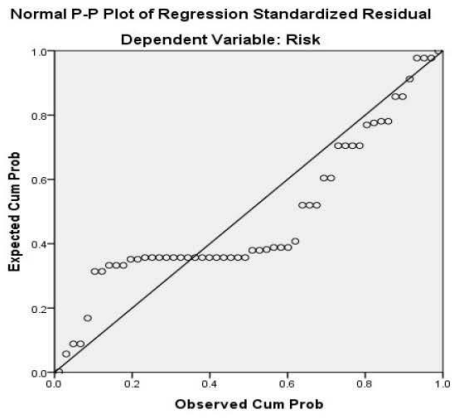


Figure 5- CG4.1: Land Acquisition normal Predicted Probability of the residual.

5- **Competition Risk**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.654, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.654 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.930, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.930 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CG5.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CG5.1} = -17.931 + 0.334\, X_{prob} + 0.594\, X_{imp} \quad \text{(Eq.5-CG5)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CG5 is equal to **19.6%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CG5.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.9% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	19.61	18.296	54
Probability	57.65	17.397	54
Impact	30.80	24.541	54

Table 5- CG5.1: Competition Risk Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.654**	.930**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.654**	1	.422**
	Sig. (2-tailed)	.000		.001
	N	54	54	54
Impact	Pearson Correlation	.930**	.422**	1
	Sig. (2-tailed)	.000	.001	
	N	54	54	54

** Correlation is significant at the 0.01 level (2-tailed).

Table 5- CG5.2: Competition Risk Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16830.564	2	8415.282	471.486	.000[b]
	Residual	910.270	51	17.848		
	Total	17740.833	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CG5.3: Competition Risk linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-17.931	2.009		-8.925	.000
	Probability	.334	.037	.318	9.079	.000
	Impact	.594	.026	.796	22.768	.000

a. Dependent Variable: Risk

Table 5- CG5.4: Competition Risk regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-1.97	59.63	19.61	17.820	54
Residual	-15.594	12.366	.000	4.144	54
Std. Predicted Value	-1.211	2.246	.000	1.000	54
Std. Residual	-3.691	2.927	.000	.981	54

a. Dependent Variable: Risk

Table 5- CG5.6: Competition Risk Regression Residuals Statistics showing the Mean value of population Error.

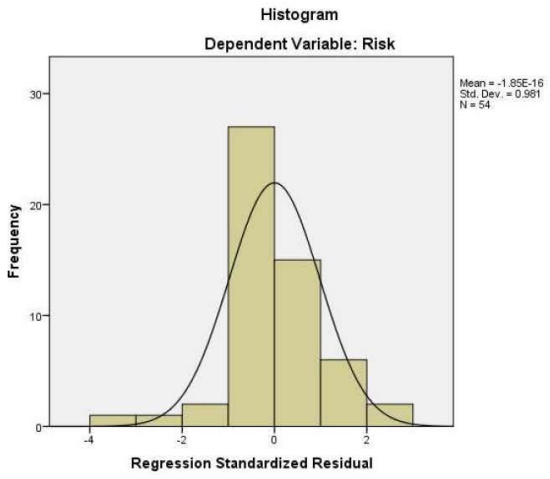


Figure 5- CG5.3: Normality of Competition Risk Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.974[a]	.949	.947	4.225	1.836

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CG5.5: Competition Risk regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

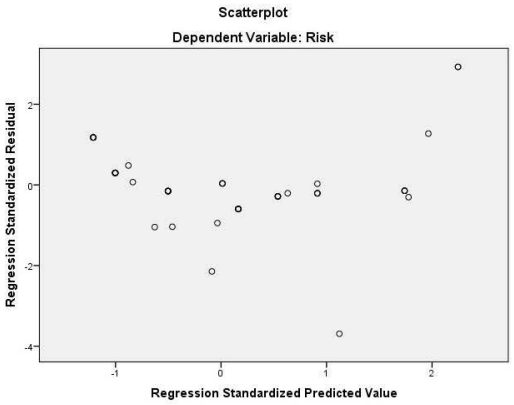


Figure 5- CG5.2: Homoscedasticity Competition Risk normal Error (i.e. Constant Variance).

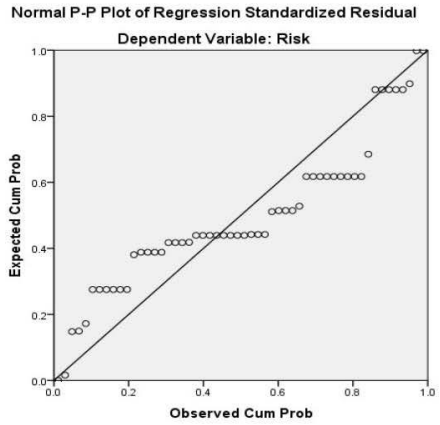


Figure 5- CG5.1: Competition Risk normal Predicted Probability of the residual.

H- Construction Project Finance Cost Factors:

1- Inaccurate Estimates:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.778, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.778 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.804, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.804 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CH1.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CH1.1} = -34.293 + 0.598 X_{prob} + 0.603 X_{imp} \quad \text{(Eq.5-CH1)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CH1 is equal to **31.4%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CH1.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	31.41	22.055	54
Probability	55.98	21.589	54
Impact	53.44	22.811	54

Table 5- CH1.1: Inaccurate Estimates Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.778**	.804**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.778**	1	.309*
	Sig. (2-tailed)	.000		.023
	N	54	54	54
Impact	Pearson Correlation	.804**	.309*	1
	Sig. (2-tailed)	.000	.023	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CH1.2: Inaccurate Estimates Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	24666.812	2	12333.406	564.521	.000[b]
	Residual	1114.225	51	21.848		
	Total	25781.037	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CH1.3: Inaccurate Estimates linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-34.293	2.064		-16.614	.000
	Probability	.598	.031	.585	19.126	.000
	Impact	.603	.030	.624	20.378	.000

a. Dependent Variable: Risk

Table 5- CH1.4: Inaccurate Estimates regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	7.66	67.76	31.41	21.573	54
Residual	-16.553	5.228	.000	4.585	54
Std. Predicted Value	-1.101	1.685	.000	1.000	54
Std. Residual	-3.541	1.119	.000	.981	54

a. Dependent Variable: Risk

Table 5- CH1.6: Inaccurate Estimates Regression Residuals Statistics showing the Mean value of population Error.

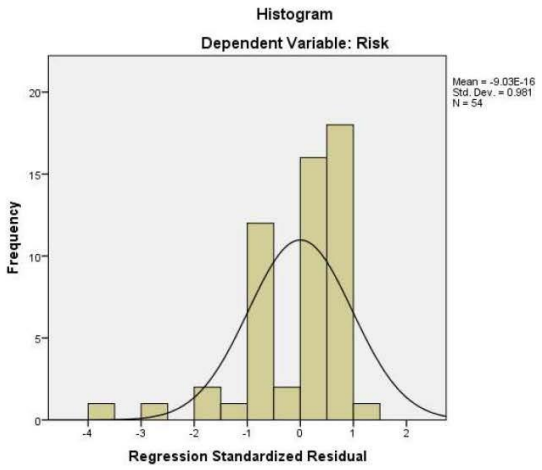


Figure 5- CH1.3: Normality of Inaccurate Estimates Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.978[a]	.957	.955	4.674	2.089

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CH1.5: Inaccurate Estimates regression Model Summary showing how much in percentage (%) the population is represented by the integrated

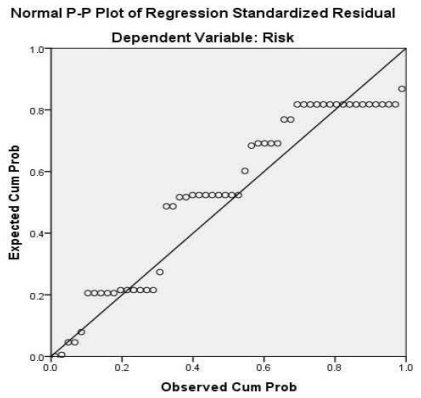


Figure 5- CH1.2: Homoscedasticity Inaccurate Estimates normal Error (i.e. Constant Variance).

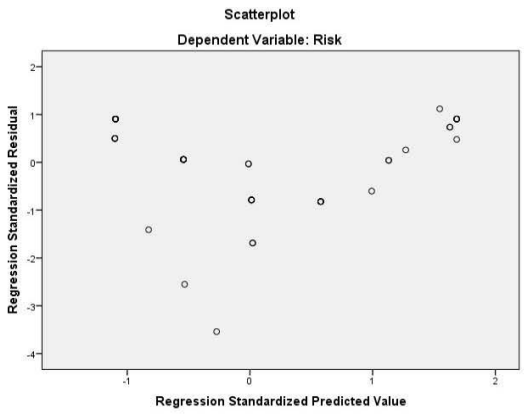


Figure 5- CH1.1: Inaccurate Estimates normal Predicted Probability of the residual.

2- **High Finance Cost**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.713, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.713 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.830, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.830 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CH2.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CH2.1} = -26.010 + 0.528\, X_{prob} + 0.521\, X_{imp} \quad \text{(Eq.5-CH2)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CH1 is equal to **26.3%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CH2.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	26.26	21.016	54
Probability	52.87	20.337	54
Impact	46.69	27.311	54

Table 5- CH2.1: High Finance Cost Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.713**	.830**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.713**	1	.298*
	Sig. (2-tailed)	.000		.029
	N	54	54	54
Impact	Pearson Correlation	.830**	.298*	1
	Sig. (2-tailed)	.000	.029	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CH2.2: High Finance Cost Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21694.611	2	10847.306	322.806	.000[b]
	Residual	1713.759	51	33.603		
	Total	23408.370	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CH2.3: High Finance Cost linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-26.010	2.349		-11.075	.000
	Probability	.528	.041	.511	12.877	.000
	Impact	.521	.031	.678	17.075	.000

a. Dependent Variable: Risk

Table 5- CH2.4: High Finance Cost regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-4.95	63.24	26.26	20.232	54
Residual	-14.953	8.758	.000	5.686	54
Std. Predicted Value	-1.543	1.828	.000	1.000	54
Std. Residual	-2.580	1.511	.000	.981	54

a. Dependent Variable: Risk

Table 5- CH2.6: High Finance Cost Regression Residuals Statistics showing the Mean value of population Error.

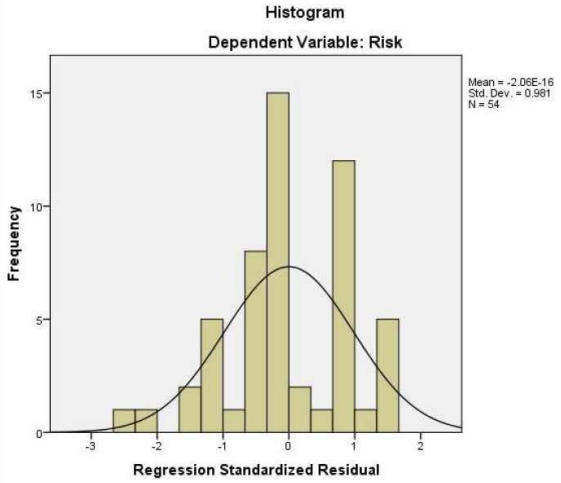


Figure 5- CH2.3: Normality of High Finance Cost Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.963[a]	.927	.924	5.797	2.149

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CH2.5: High Finance Cost regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

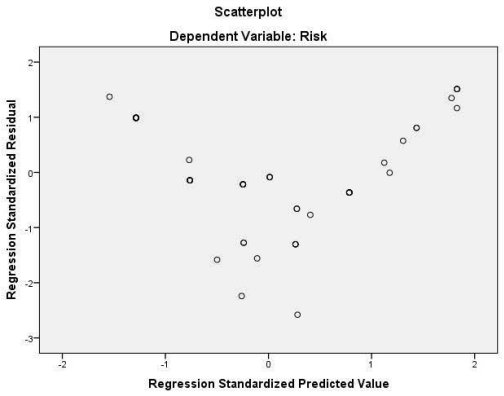


Figure 5- CH2.2: Homoscedasticity High Finance Cost normal Error (i.e. Constant Variance).

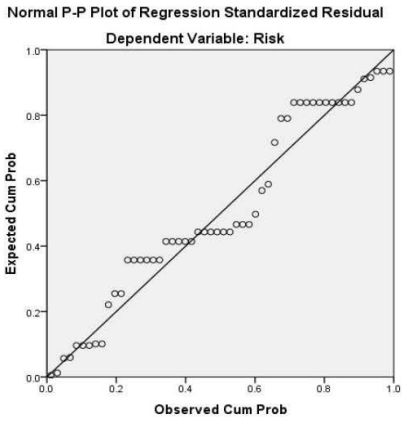


Figure 5- CH2.1: High Finance Cost normal Predicted Probability of the residual.

3- **High Bidding Costs**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.733, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.733 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.814, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.814 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CH3.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CH3.1} = -26.230 + 0.518 X_{prob} + 0.543 X_{imp} \quad \text{(Eq.5-CH3)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CH3 is equal to **26.9%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CH3.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 93.5% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	26.85	20.754	54
Probability	53.65	21.792	54
Impact	46.56	25.170	54

Table 5- CH3.1: High Bidding Cost Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.733**	.814**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.733**	1	.286*
	Sig. (2-tailed)	.000		.036
	N	54	54	54
Impact	Pearson Correlation	.814**	.286*	1
	Sig. (2-tailed)	.000	.036	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CH3.2: High Bidding Cost Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21342.661	2	10671.330	366.206	.000[b]
	Residual	1486.154	51	29.140		
	Total	22828.815	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CH3.3: High Bidding Cost linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-26.230	2.158		-12.155	.000
	Probability	.518	.036	.544	14.597	.000
	Impact	.543	.031	.658	17.655	.000

a. Dependent Variable: Risk

Table 5- CH3.4: High Bidding Cost regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-15.62	63.85	26.85	20.067	54
Residual	-14.382	16.618	.000	5.295	54
Std. Predicted Value	-2.116	1.844	.000	1.000	54
Std. Residual	-2.664	3.078	.000	.981	54

a. Dependent Variable: Risk

Table 5- CH3.6: High Bidding Cost Regression Residuals Statistics showing the Mean value of population Error.

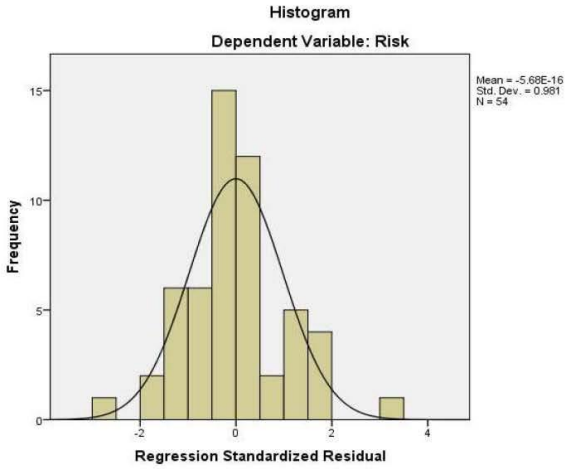


Figure 5- CH3.3: Normality of High Bidding Cost Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.967[a]	.935	.932	5.398	2.446

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CH3.5: High Bidding Cost regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

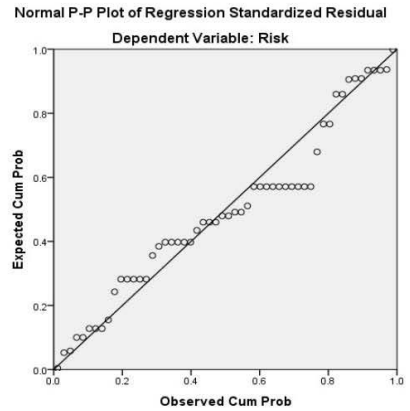


Figure 5- CH3.1: High Bidding Cost normal Predicted Probability of the residual.

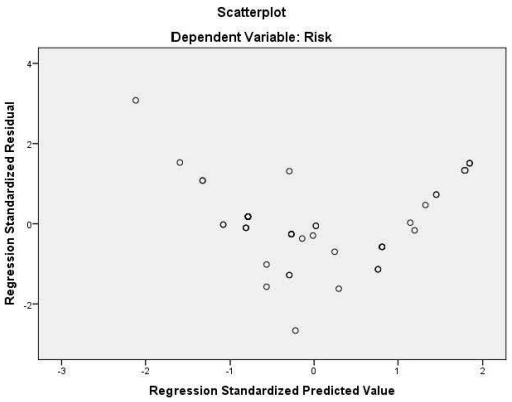


Figure 5- CH3.2: Homoscedasticity High Bidding Cost normal Error (i.e. Constant Variance).

4- Delay in Payment of Annuity:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.732, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.732 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.856, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.856 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CH4.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CH4.1} = -20.774 + 0.449 X_{prob} + 0.521 X_{imp} \quad \text{(Eq.5-CH4)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CH4 is equal to **28%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CH4.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 90.1% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	27.98	20.087	54
Probability	53.67	20.216	54
Impact	47.33	25.686	54

Table 5- CH4.1: Delay in Payment of Annuity Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.732**	.856**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.732**	1	.420**
	Sig. (2-tailed)	.000		.002
	N	54	54	54
Impact	Pearson Correlation	.856**	.420**	1
	Sig. (2-tailed)	.000	.002	
	N	54	54	54

** . Correlation is significant at the 0.01 level (2-tailed).

Table 5- CH4.2: Delay in Payment of Annuity Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19266.553	2	9633.276	231.916	.000[b]
	Residual	2118.429	51	41.538		
	Total	21384.981	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CH4.3: Delay in Payment of Annuity linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-20.774	2.607		-7.969	.000
	Probability	.449	.048	.452	9.307	.000
	Impact	.521	.038	.666	13.708	.000

a. Dependent Variable: Risk

Table 5- CH4.4: Delay in Payment of Annuity regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-11.07	61.31	27.98	19.066	54
Residual	-10.361	25.867	.000	6.322	54
Std. Predicted Value	-2.048	1.748	.000	1.000	54
Std. Residual	-1.608	4.014	.000	.981	54

a. Dependent Variable: Risk

Table 5- CH4.6: Delay in Payment of Annuity Regression Residuals Statistics showing the Mean value of population

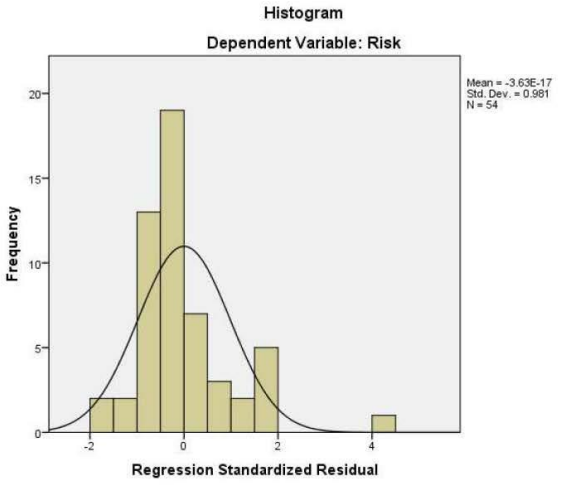


Figure 5- CH4.3: Normality of Delay in Payment of Annuity Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.949[a]	.901	.897	6.445	1.982

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CH4.5: Delay in Payment of Annuity regression Model Summary showing how much in percentage (%) the population is represented by the

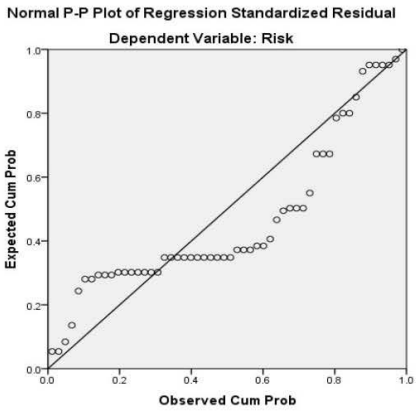


Figure 5- CH4.1: Delay in Payment of Annuity normal Predicted Probability of the residual.

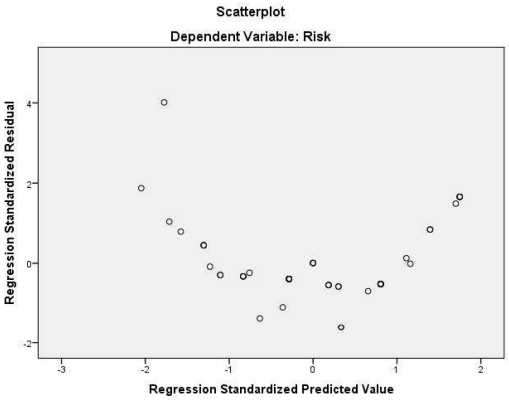


Figure 5- CH4.2: Homoscedasticity Delay in Payment of Annuity normal Error (i.e. Constant Variance).

5- Financial Attraction of Project to Investors:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.647, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.647 (0.5 to 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.863, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.963 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CH5.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CH5.1} = -27.694 + 0.550\, X_{prob} + 0.525\, X_{imp} \quad \text{(Eq.5-CH5)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CH5 is equal to **23.9%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CH5.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 96.5% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	23.89	17.372	54
Probability	48.33	15.178	54
Impact	47.63	25.071	54

Table 5- CH5.1: Financial Attraction of Project to Investors Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.647**	.863**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.647**	1	.220
	Sig. (2-tailed)	.000		.109
	N	54	54	54
Impact	Pearson Correlation	.863**	.220	1
	Sig. (2-tailed)	.000	.109	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CH5.2: Financial Attraction of Project to Investors Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15433.920	2	7716.960	701.025	.000[b]
	Residual	561.414	51	11.008		
	Total	15995.333	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CH5.3: Financial Attraction of Project to Investors linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-27.694	1.620		-17.098	.000
	Probability	.550	.031	.481	17.870	.000
	Impact	.525	.019	.757	28.160	.000

a. Dependent Variable: Risk

Table 5- CH5.4: Financial Attraction of Project to Investors regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.982[a]	.965	.964	3.318	1.608

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CH5.5: Financial Attraction of Project to Investors regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.70	63.80	23.89	17.065	54
Residual	-11.790	8.203	.000	3.255	54
Std. Predicted Value	-1.441	2.339	.000	1.000	54
Std. Residual	-3.553	2.472	.000	.981	54

a. Dependent Variable: Risk

Table 5- CH5.6: Financial Attraction of Project to Investors Regression Residuals Statistics showing the Mean value of population Error.

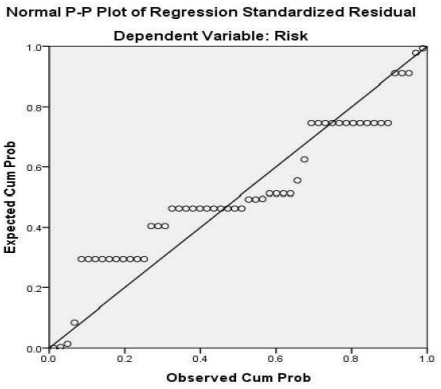


Figure 5- CH5.1: Financial Attraction of Project to Investors normal Predicted Probability of the residual.

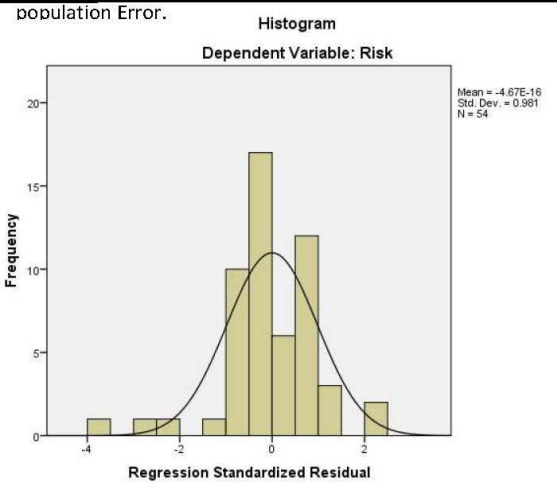


Figure 5- CH5.3: Normality of Financial Attraction of Project to Investors Error distribution (i.e. Bell Shaped).

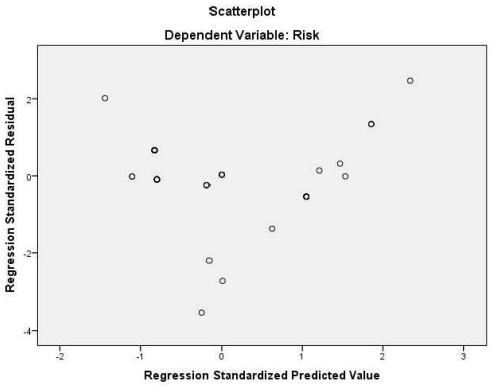


Figure 5- CH5.2: Homoscedasticity Financial Attraction of Project to Investors normal Error (i.e. Constant Variance).

6- Lack of Creditworthiness:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_l: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.661, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.661 (0.5 to 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.855, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.855 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CH6.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CH6.1} = -18.204 + 0.380\, X_{prob} + 0.532 X_{imp} \quad \text{(Eq.5-CH6)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CH6 is equal to **22.9%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CH6.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 88% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	22.87	17.394	54
Probability	52.98	18.840	54
Impact	39.37	23.243	54

Table 5- CH6.1: Lack of Creditworthiness Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.661**	.855**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.661**	1	.351**
	Sig. (2-tailed)	.000		.009
	N	54	54	54
Impact	Pearson Correlation	.855**	.351**	1
	Sig. (2-tailed)	.000	.009	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CH6.2: Lack of Creditworthiness Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14110.914	2	7055.457	186.906	.000[b]
	Residual	1925.179	51	37.749		
	Total	16036.093	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CH6.3: Lack of Creditworthiness linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-18.204	2.596		-7.013	.000
	Probability	.380	.048	.412	7.944	.000
	Impact	.532	.039	.711	13.715	.000

a. Dependent Variable: Risk

Table 5- CH6.4: Lack of Creditworthiness regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-4.14	58.55	22.87	16.317	54
Residual	-20.145	23.766	.000	6.027	54
Std. Predicted Value	-1.656	2.187	.000	1.000	54
Std. Residual	-3.279	3.868	.000	.981	54

a. Dependent Variable: Risk

Table 5- CH6.6: Lack of Creditworthiness Regression Residuals Statistics showing the Mean value of population Error.

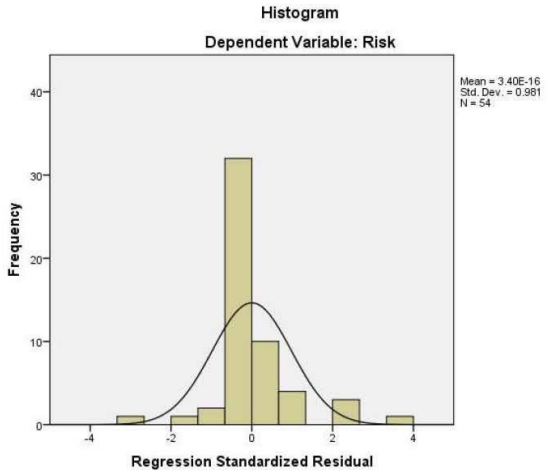


Figure 5- CH6.3: Normality of Lack of Creditworthiness Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.938[a]	.880	.875	6.144	2.289

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CH6.5: Lack of Creditworthiness regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

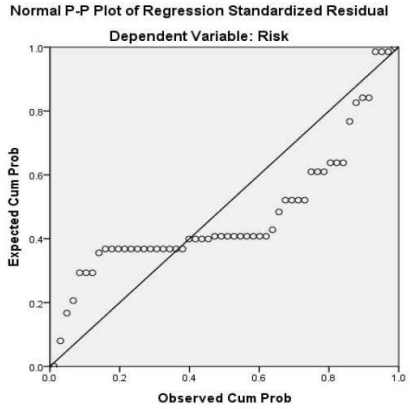


Figure 5- CH6.1: Lack of Creditworthiness normal Predicted Probability of the residual.

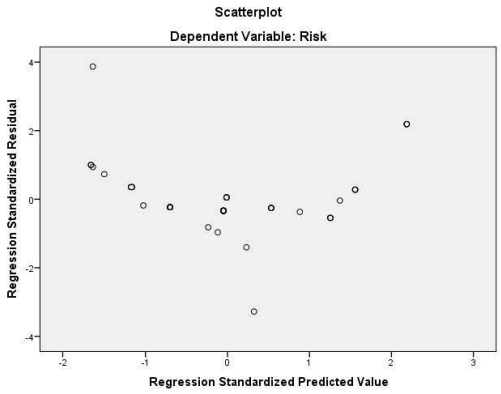


Figure 5- CH6.2: Homoscedasticity Lack of Creditworthiness normal Error (i.e. Constant Variance).

7- Delay in Financial Closure:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.558, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.558 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.745, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.745 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CH7.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CH7.1} = -30.516 + 0.567\ X_{prob} + 0.531\ X_{imp} \quad \text{(Eq.5-CH7)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CH7 is equal to **27.9%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CH7.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92.5% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	27.85	19.082	54
Probability	54.02	20.513	54
Impact	52.24	28.206	54

Table 5- CH7.1: Delay in Financial Closure Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.558**	.745**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.558**	1	-.066
	Sig. (2-tailed)	.000		.637
	N	54	54	54
Impact	Pearson Correlation	.745**	-.066	1
	Sig. (2-tailed)	.000	.637	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CH7.2: Delay in Financial Closure Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17841.865	2	8920.933	312.274	.000[b]
	Residual	1456.950	51	28.568		
	Total	19298.815	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CH7.3: Delay in Financial Closure linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-30.516	2.547		-11.982	.000
	Probability	.567	.036	.610	15.815	.000
	Impact	.531	.026	.785	20.347	.000

a. Dependent Variable: Risk

Table 5- CH7.4: Delay in Financial Closure regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-14.23	63.00	27.85	18.348	54
Residual	-7.844	16.229	.000	5.243	54
Std. Predicted Value	-2.294	1.915	.000	1.000	54
Std. Residual	-1.468	3.036	.000	.981	54

a. Dependent Variable: Risk

Table 5- CH7.6: Delay in Financial Closure Regression Residuals Statistics showing the Mean value of population Error.

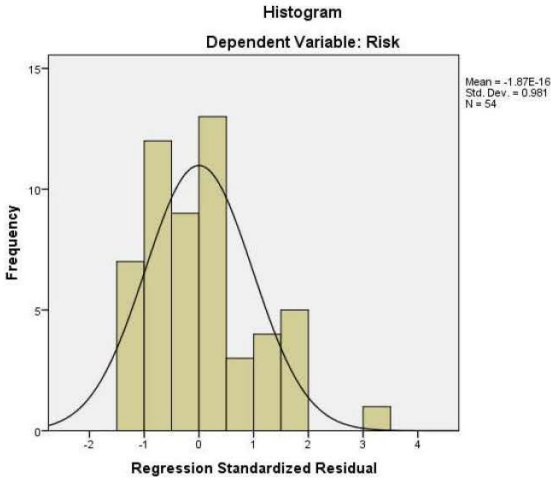


Figure 5- CH7.3: Normality of Delay in Financial Closure Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.962[a]	.925	.922	5.345	2.150

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CH7.5: Delay in Financial Closure regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

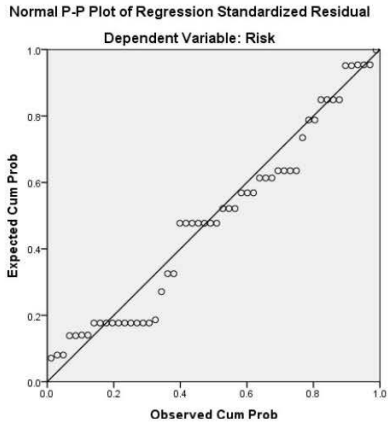


Figure 5- CH7.1: Delay in Financial Closure normal Predicted Probability of the residual.

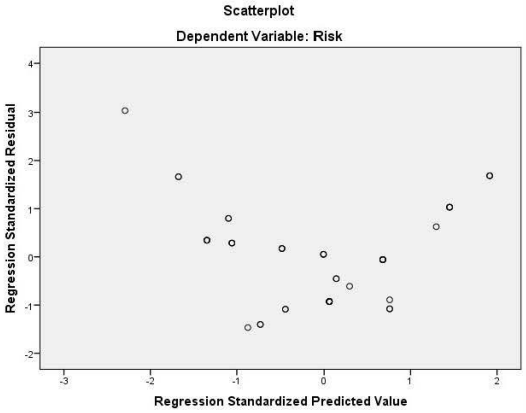


Figure 5- CH7.2: Homoscedasticity Delay in Financial Closure normal Error (i.e. Constant Variance).

8- **Inability to Service Debt**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.509, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.509 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.704, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.704 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CH8.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CH8.1} = -28.090 + 0.536\, X_{prob} + 0.504\, X_{imp} \quad \text{(Eq.5-CH8)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CH8 is equal to **26.4%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CH8.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 89.4% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	26.41	17.615	54
Probability	51.54	21.041	54
Impact	53.37	28.242	54

Table 5- CH8.1: Inability to Service Debt Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.509**	.704**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.509**	1	-.162
	Sig. (2-tailed)	.000		.242
	N	54	54	54
Impact	Pearson Correlation	.704**	-.162	1
	Sig. (2-tailed)	.000	.242	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CH8.2: Inability to Service Debt Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14705.281	2	7352.640	215.539	.000[b]
	Residual	1739.756	51	34.113		
	Total	16445.037	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CH8.3: Inability to Service Debt linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-28.090	2.820		-9.962	.000
	Probability	.536	.039	.640	13.867	.000
	Impact	.504	.029	.808	17.496	.000

a. Dependent Variable: Risk

Table 5- CH8.4: Inability to Service Debt regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-9.50	60.43	26.41	16.657	54
Residual	-16.173	11.570	.000	5.729	54
Std. Predicted Value	-2.155	2.043	.000	1.000	54
Std. Residual	-2.769	1.981	.000	.981	54

a. Dependent Variable: Risk

Table 5- CH8.6: Inability to Service Debt Regression Residuals Statistics showing the Mean value of population Error.

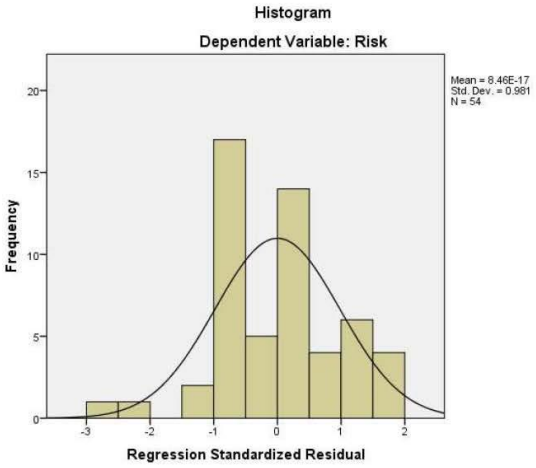


Figure 5- CH8.3: Normality of Inability to Service Debt Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.946[a]	.894	.890	5.841	1.738

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CH8.5: Inability to Service Debt regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

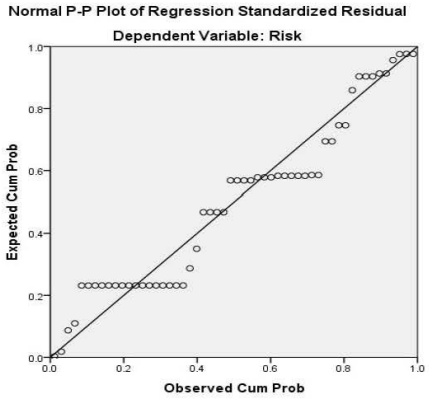


Figure 5- CH8.1: Inability to Service Debt normal Predicted Probability of the residual.

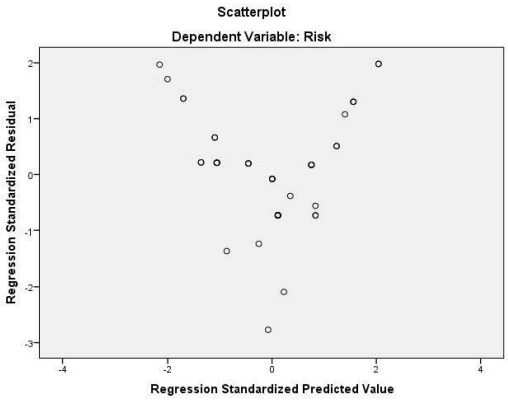


Figure 5- CH8.2: Homoscedasticity Inability to Service Debt normal Error (i.e. Constant Variance).

9- Lack of Government Guarantees:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.697, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.697 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.911, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.911 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CH9.1b} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CH9.1b} = -19.149 + 0.329 X_{prob} + 0.635 X_{imp} \quad \textbf{(Eq.5-CH9b)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CH9b is equal to **23.5%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CH9.5b, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	23.47	20.526	53
Probability	53.58	23.476	53
Impact	39.34	24.259	53

Table 5- CH9.1b: Lack of Government Guarantees Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.697**	.911**
	Sig. (2-tailed)		.000	.000
	N	53	53	53
Probability	Pearson Correlation	.697**	1	.428**
	Sig. (2-tailed)	.000		.001
	N	53	53	53
Impact	Pearson Correlation	.911**	.428**	1
	Sig. (2-tailed)	.000	.001	
	N	53	53	53

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CH9.2b: Lack of Government Guarantees Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20740.508	2	10370.254	443.666	.000[b]
	Residual	1168.699	50	23.374		
	Total	21909.208	52			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CH9.3b: Lack of Government Guarantees linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-19.149	1.736		-11.034	.000
	Probability	.329	.032	.377	10.420	.000
	Impact	.635	.031	.750	20.769	.000

a. Dependent Variable: Risk

Table 5- CH9.4b: Lack of Government Guarantees regression coefficients of Probability and Impact

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.973[a]	.947	.945	4.835	1.822

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CH9.5b: Lack of Government Guarantees regression Model Summary showing how much in percentage (%) the population is represented by the

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-9.51	61.28	23.47	19.971	53
Residual	-8.110	10.721	.000	4.741	53
Std. Predicted Value	-1.651	1.893	.000	1.000	53
Std. Residual	-1.678	2.218	.000	.981	53

a. Dependent Variable: Risk

Table 5- CH9.6b: Lack of Government Guarantees Regression Residuals Statistics showing the Mean value of population Error.

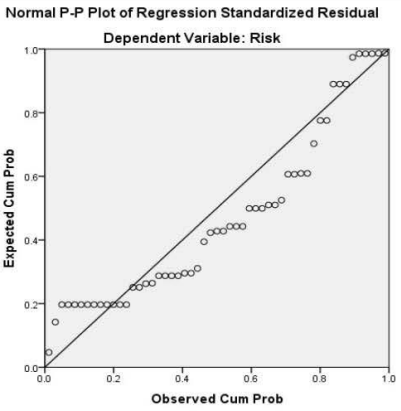


Figure 5- CH9.1b: Lack of Government Guarantees normal Predicted Probability of the residual.

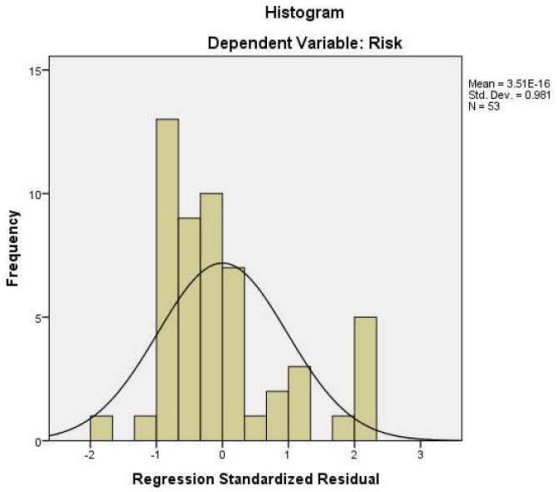


Figure 5- CH9.3b: Normality of Lack of Government Guarantees Error distribution (i.e. Bell Shaped).

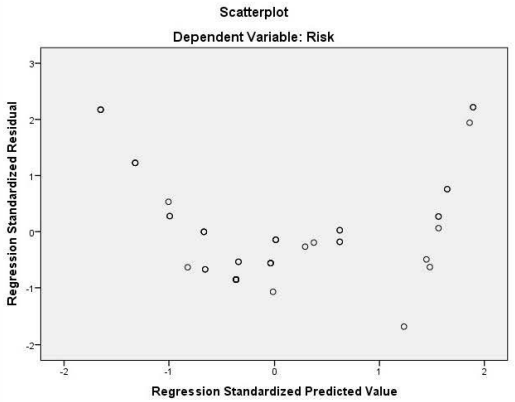


Figure 5- CH9.2b: Homoscedasticity Lack of Government Guarantees normal Error (i.e. Constant Variance).

10- **Financer Unwilling to Take High Risk**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.559, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.559 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.836, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.836 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CH10.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CH10.1} = -24.299 + 0.453\, X_{prob} + 0.566\, X_{imp} \quad \text{(Eq.5-CH10)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CH10 is equal to **28.1%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CH10.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	28.09	20.574	54
Probability	56.44	21.559	54
Impact	47.43	28.523	54

Table 5- CH10.1: Financer Unwilling to Take High Risk Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.559**	.836**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.559**	1	.109
	Sig. (2-tailed)	.000		.434
	N	54	54	54
Impact	Pearson Correlation	.836**	.109	1
	Sig. (2-tailed)	.000	.434	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CH10.2: Financer Unwilling to Take High Risk Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20678.304	2	10339.152	300.243	.000[b]
	Residual	1756.233	51	34.436		
	Total	22434.537	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CH10.3: Financer Unwilling to Take High Risk linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-24.299	2.518		-9.650	.000
	Probability	.453	.038	.474	12.032	.000
	Impact	.566	.028	.785	19.913	.000

a. Dependent Variable: Risk

Table 5- CH10.4: Financer Unwilling to Take High Risk regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.960[a]	.922	.919	5.868	2.350

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CH10.5: Financer Unwilling to Take High Risk regression Model Summary showing how much in percentage (%) the population is represented by the

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-14.11	61.72	28.09	19.752	54
Residual	-13.091	15.113	.000	5.756	54
Std. Predicted Value	-2.137	1.702	.000	1.000	54
Std. Residual	-2.231	2.575	.000	.981	54

a. Dependent Variable: Risk

Table 5- CH10.6: Financer Unwilling to Take High Risk Regression Residuals Statistics showing the Mean value of population Error.

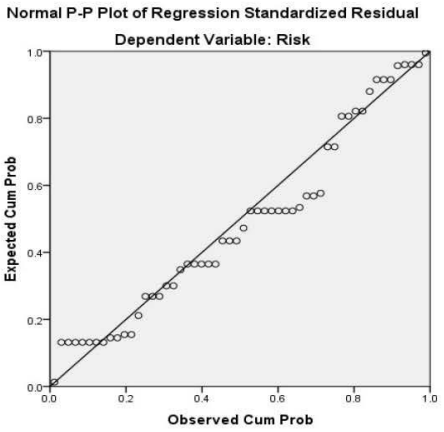


Figure 5- CH10.1: Financer Unwilling to Take High Risk normal Predicted Probability of the residual.

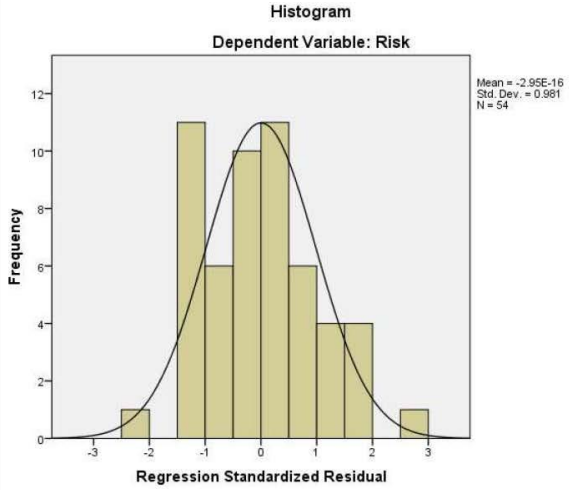


Figure 5- CH10.3: Normality of Financer Unwilling to Take High Risk Error distribution (i.e. Bell Shaped).

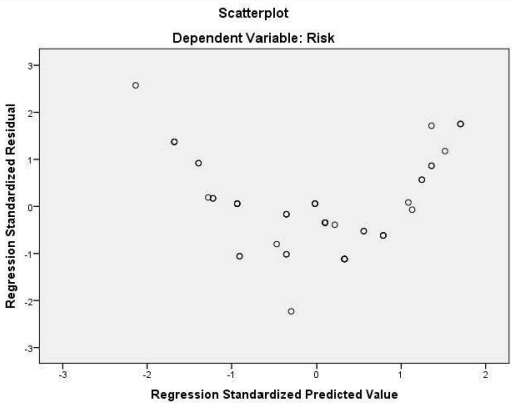


Figure 5- CH10.2: Homoscedasticity Financer Unwilling to Take High Risk normal Error (i.e. Constant Variance).

I- Building Functionality and Serviceability Cost Factors:

1- Construction Time Delay:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.563, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.563 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.927, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.927 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CI1.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CI1.1} = -31.763 + 0.483 X_{prob} + 0.685 X_{imp} \quad \text{(Eq.5-CI1)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CI1 is equal to **33.2%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CI1.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 96.4% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	33.24	23.063	54
Probability	65.94	16.083	54
Impact	48.39	28.113	54

Table 5- CI1.1: Construction Time Delay Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.563**	.927**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.563**	1	.271*
	Sig. (2-tailed)	.000		.047
	N	54	54	54
Impact	Pearson Correlation	.927**	.271*	1
	Sig. (2-tailed)	.000	.047	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CI1.2: Construction Time Delay Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	27172.084	2	13586.042	679.445	.000[b]
	Residual	1019.786	51	19.996		
	Total	28191.870	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CI1.3: Construction Time Delay linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-31.763	2.620		-12.124	.000
	Probability	.483	.040	.337	12.169	.000
	Impact	.685	.023	.835	30.186	.000

a. Dependent Variable: Risk

Table 5- CI1.4: Construction Time Delay regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.982[a]	.964	.962	4.472	2.047

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CI1.5: Construction Time Delay regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	5.47	66.52	33.24	22.642	54
Residual	-12.545	5.725	.000	4.386	54
Std. Predicted Value	-1.227	1.470	.000	1.000	54
Std. Residual	-2.805	1.280	.000	.981	54

a. Dependent Variable: Risk

Table 5- CI1.6: Variance Construction Time Delay Regression Residuals Statistics showing the Mean value of population Error.

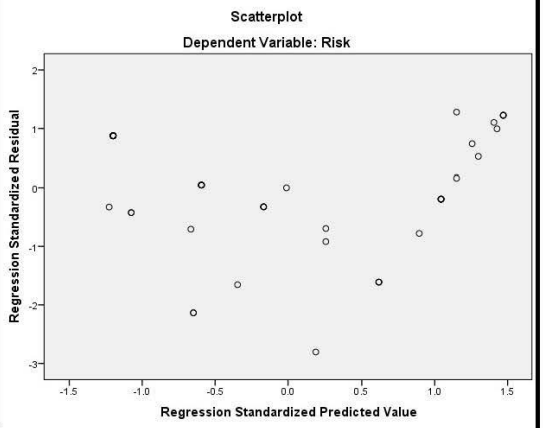


Figure 5- CI1.2: Homoscedasticity Construction Time Delay normal Error (i.e. Constant Variance).

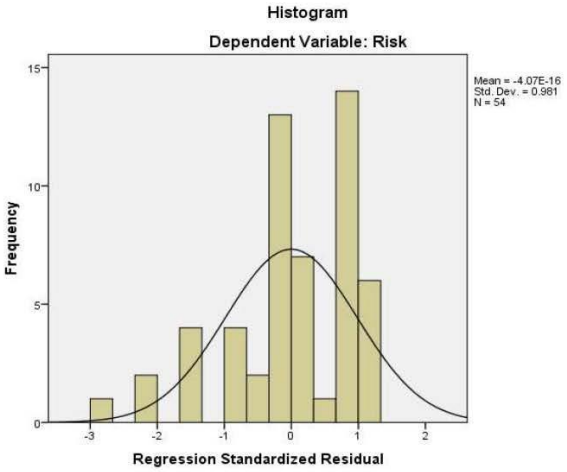


Figure 5- CI1.3: Normality of Construction Time Delay Error distribution (i.e. Bell Shaped).

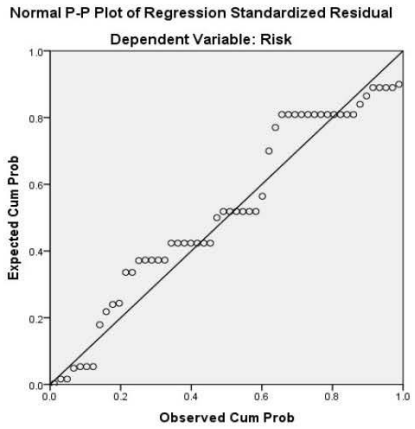


Figure 5- CI1.1: Construction Time Delay normal Predicted Probability of the residual.

2- **Material Availability**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.650, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.650 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.962, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.962 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CI2.1b} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CI2.1b} = -13.223 + 0.266\, X_{prob} + 0.561\, X_{imp} \quad \text{(Eq.5-CI2b)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CI2b is equal to **21.7%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CI2.5b, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 96.6% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	21.72	19.022	50
Probability	50.66	16.564	50
Impact	38.24	28.748	50

Table 5- CI2.1b: Material Availability Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.650**	.962**
	Sig. (2-tailed)		.000	.000
	N	50	50	50
Probability	Pearson Correlation	.650**	1	.493**
	Sig. (2-tailed)	.000		.000
	N	50	50	50
Impact	Pearson Correlation	.962**	.493**	1
	Sig. (2-tailed)	.000	.000	
	N	50	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CI2.2b: Material Availability Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17132.358	2	8566.179	673.575	.000[b]
	Residual	597.722	47	12.717		
	Total	17730.080	49			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CI2.3b: Material Availability linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-13.223	1.641		-8.058	.000
	Probability	.266	.035	.232	7.534	.000
	Impact	.561	.020	.848	27.542	.000

a. Dependent Variable: Risk

Table 5- CI2.4b: Material Availability regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.983[a]	.966	.965	3.566	1.868

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CI2.5b: Material Availability regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.38	51.63	21.72	18.699	50
Residual	-5.205	8.373	.000	3.493	50
Std. Predicted Value	-1.141	1.599	.000	1.000	50
Std. Residual	-1.460	2.348	.000	.979	50

a. Dependent Variable: Risk

Table 5- CI2.6b: Material Availability Risk Regression Residuals Statistics showing the Mean value of population Error.

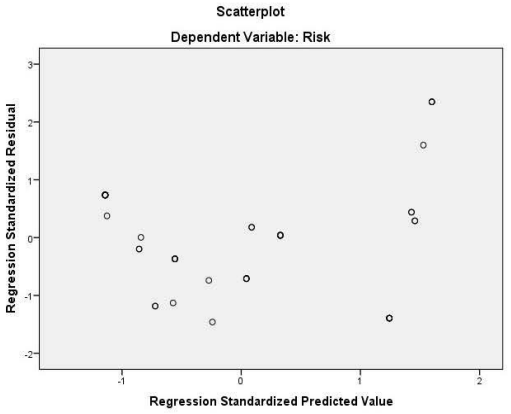


Figure 5- CI2.2b: Homoscedasticity Material Availability normal Error (i.e. Constant Variance).

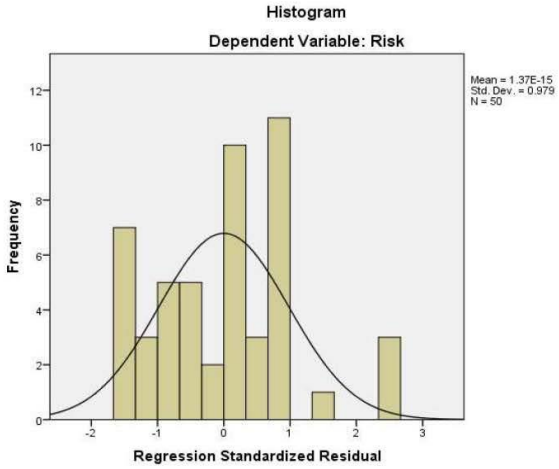


Figure 5- CI2.3b: Normality of Material Availability Error distribution (i.e. Bell Shaped).

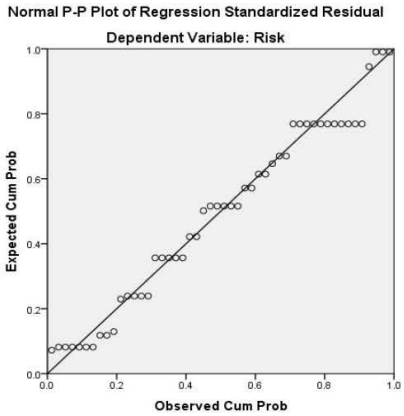


Figure 5- CI2.1b: Material Availability normal Predicted Probability of the residual.

3- **Labor Availability**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.701, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.701 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.908, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.908 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CI3.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CI3.1} = -26.526 + 0.538\, X_{prob} + 0.524\, X_{imp} \quad \text{(Eq.5-CI3)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CI3 is equal to **24.5%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CI3.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is auto correlated data.
- This Model is reflecting 95.9% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	24.48	21.043	54
Probability	53.81	15.709	54
Impact	42.11	29.990	54

Table 5- CI3.1: Labor Availability Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.701**	.908**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.701**	1	.401**
	Sig. (2-tailed)	.000		.003
	N	54	54	54
Impact	Pearson Correlation	.908**	.401**	1
	Sig. (2-tailed)	.000	.003	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CI3.2: Labor Availability Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22506.218	2	11253.109	595.796	.000[b]
	Residual	963.263	51	18.888		
	Total	23469.481	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CI3.3: Labor Availability linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-26.526	2.129		-12.459	.000
	Probability	.538	.041	.401	12.967	.000
	Impact	.524	.022	.747	24.119	.000

a. Dependent Variable: Risk

Table 5- CI3.4: Labor Availability regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-5.15	63.79	24.48	20.607	54
Residual	-9.361	8.205	.000	4.263	54
Std. Predicted Value	-1.438	1.908	.000	1.000	54
Std. Residual	-2.154	1.888	.000	.981	54

a. Dependent Variable: Risk

Table 5- CI3.6: Labor Availability Risk Regression Residuals Statistics showing the Mean value of population Error.

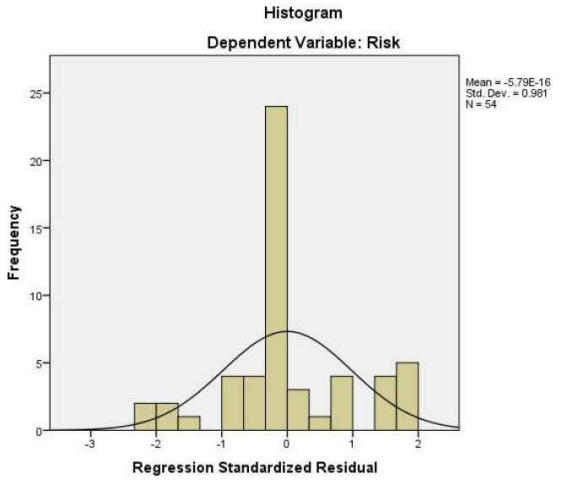


Figure 5- CI3.3: Normality of Labor Availability Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.979[a]	.959	.957	4.346	1.729

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CI3.5: Labor Availability regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

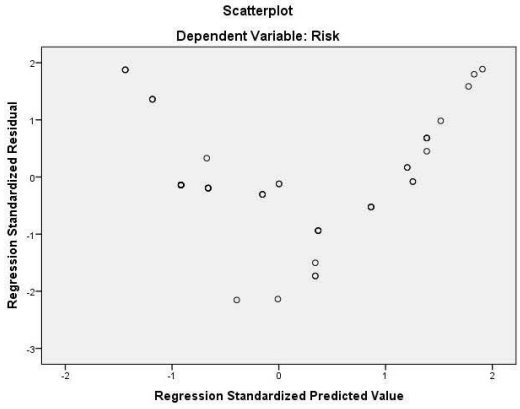


Figure 5- CI3.2: Homoscedasticity Labor Availability normal Error (i.e. Constant Variance).

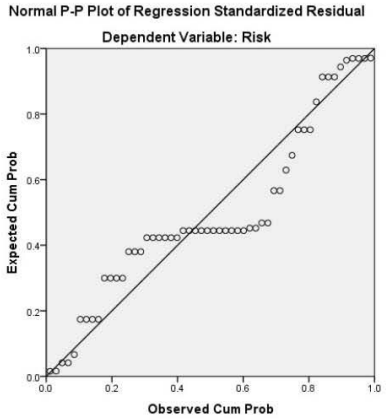


Figure 5- CI3.1: Labor Availability normal Predicted Probability of the residual.

4- **Poor Quality of Workmanship**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.805, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.805 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.935, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.935 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CI4.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CI4.1} = -20.011 + 0.433\, X_{prob} + 0.542 X_{imp} \quad \text{(Eq.5-CI4)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CI4 is equal to **27.7%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CC1.5b, the Durbin-Watson is between 1.5 and 2.5; hence, there is auto correlated data.
- This Model is reflecting 95.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	27.72	22.443	54
Probability	54.57	18.979	54
Impact	44.54	29.369	54

Table 5- CI4.1: Poor Quality of Workmanship Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.805**	.935**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.805**	1	.619**
	Sig. (2-tailed)	.000		.000
	N	54	54	54
Impact	Pearson Correlation	.935**	.619**	1
	Sig. (2-tailed)	.000	.000	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CI4.2: Poor Quality of Workmanship Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25550.497	2	12775.248	569.358	.000[b]
	Residual	1144.337	51	22.438		
	Total	26694.833	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CI4.2: Poor Quality of Workmanship linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-20.011	1.991		-10.051	.000
	Probability	.433	.044	.366	9.913	.000
	Impact	.542	.028	.709	19.200	.000

a. Dependent Variable: Risk

Table 5- CI4.4: Poor Quality of Workmanship regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.978[a]	.957	.955	4.737	1.675

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CI4.5: Poor Quality of Workmanship regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-1.61	62.26	27.72	21.956	54
Residual	-8.272	9.744	.000	4.647	54
Std. Predicted Value	-1.336	1.573	.000	1.000	54
Std. Residual	-1.746	2.057	.000	.981	54

a. Dependent Variable: Risk

Table 5- CI4.6: Poor Quality of Workmanship Risk Regression Residuals Statistics showing the Mean value of population Error.

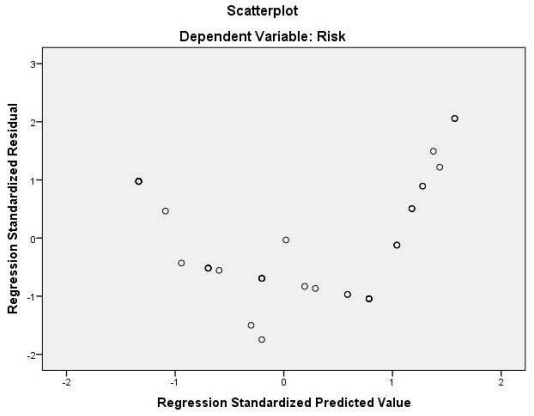


Figure 5- CI4.2: Homoscedasticity Poor Quality of Workmanship normal Error (i.e. Constant Variance).

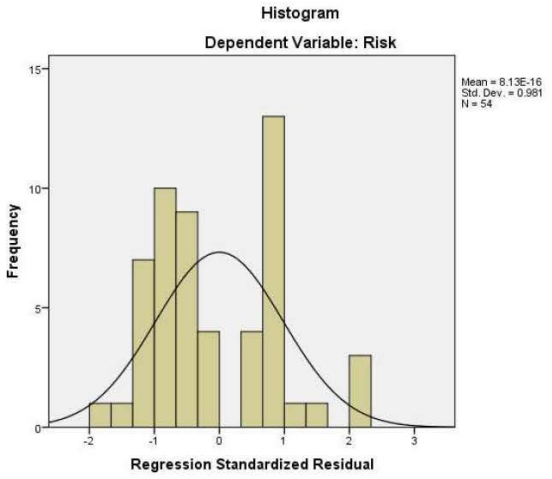


Figure 5- CI4.3: Normality of Poor Quality of Workmanship Error distribution (i.e. Bell Shaped).

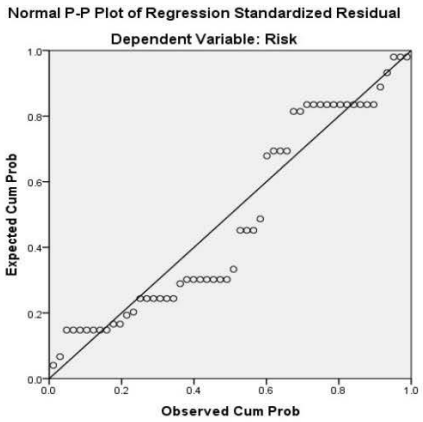


Figure 5- CI4.1: Poor Quality of Workmanship normal Predicted Probability of the residual.

5- **Default of Sub-Contractors or Suppliers**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.690, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.690 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.923, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.923 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CI5.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CI5.1} = -27.842 + 0.493 X_{prob} + 0.605 X_{imp} \quad \text{(Eq.5-CI5)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CI5 is equal to **27.3%.** This result shall s due to Durbin-Watson Value.

- Finally, from Table 5-CC1.5b, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 96.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	27.26	22.192	54
Probability	60.19	16.425	54
Impact	42.07	28.241	54

Table 5- CI5.1: Default of Sub-Contractors or Suppliers Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.690**	.923**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.690**	1	.422**
	Sig. (2-tailed)	.000		.001
	N	54	54	54
Impact	Pearson Correlation	.923**	.422**	1
	Sig. (2-tailed)	.000	.001	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CI5.2: Default of Sub-Contractors or Suppliers Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25108.578	2	12554.289	644.268	.000[b]
	Residual	993.792	51	19.486		
	Total	26102.370	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CI5.3: Default of Sub-Contractors or Suppliers linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-27.842	2.302		-12.095	.000
	Probability	.493	.041	.365	12.104	.000
	Impact	.605	.024	.769	25.525	.000

a. Dependent Variable: Risk

Table 5- CI5.4: Default of Sub-Contractors or Suppliers regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.981[a]	.962	.960	4.414	1.820

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CI5.5: Default of Sub-Contractors or Suppliers regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-7.01	64.88	27.26	21.766	54
Residual	-11.308	10.009	.000	4.330	54
Std. Predicted Value	-1.574	1.729	.000	1.000	54
Std. Residual	-2.562	2.267	.000	.981	54

a. Dependent Variable: Risk

Table 5- CI5.6: Default of Sub-Contractors or Suppliers Risk Regression Residuals Statistics showing the Mean value of population Error.

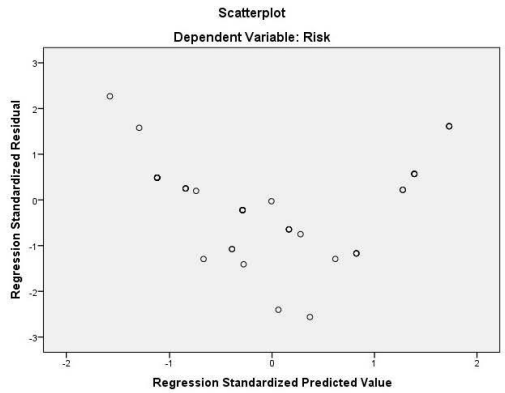


Figure 5- CI5.2: Homoscedasticity Default of Sub-Contractors or Suppliers normal Error (i.e. Constant Variance).

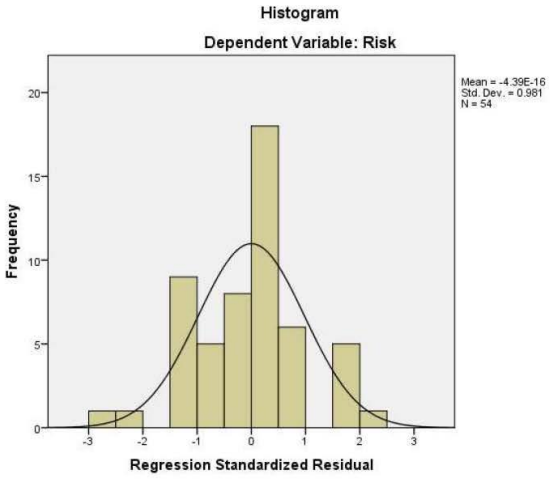


Figure 5- CI5.3: Normality of Default of Sub-Contractors or Suppliers Error distribution (i.e. Bell Shaped).

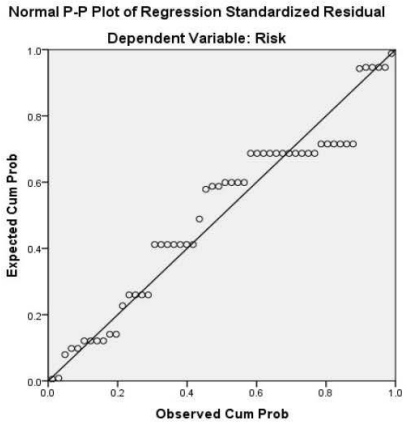


Figure 5- CI5.1: Default of Sub-Contractors or Suppliers normal Predicted Probability of the residual.

6- **Design & Construction Complexity**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.702, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.702 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.912, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.912 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CI6.1c} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CI6.1c} = -32.106 + 0.570\, X_{prob} + 0.584\, X_{imp} \quad \text{(Eq.5-CI6c)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CI6c is equal to **28.9%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CI6.5c, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 97.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	28.86	20.276	51
Probability	60.18	14.438	51
Impact	45.65	26.156	51

Table 5- CI6.1c: Design & Construction Complexity Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.702**	.912**
	Sig. (2-tailed)		.000	.000
	N	51	51	51
Probability	Pearson Correlation	.702**	1	.392**
	Sig. (2-tailed)	.000		.004
	N	51	51	51
Impact	Pearson Correlation	.912**	.392**	1
	Sig. (2-tailed)	.000	.004	
	N	51	51	51

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CI6.2c: Design & Construction Complexity Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19978.437	2	9989.218	830.126	.000[b]
	Residual	577.602	48	12.033		
	Total	20556.039	50			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CI6.3c: Design & Construction Complexity linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-32.106	2.102		-15.271	.000
	Probability	.570	.037	.406	15.442	.000
	Impact	.584	.020	.753	28.624	.000

a. Dependent Variable: Risk

Table 5- CI6.4c: Design & Construction Complexity regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.25	65.93	28.86	19.989	51
Residual	-7.578	6.074	.000	3.399	51
Std. Predicted Value	-1.331	1.854	.000	1.000	51
Std. Residual	-2.185	1.751	.000	.980	51

a. Dependent Variable: Risk

Table 5- CI6.6c: Design & Construction Complexity Risk Regression Residuals Statistics showing the Mean value of population Error.

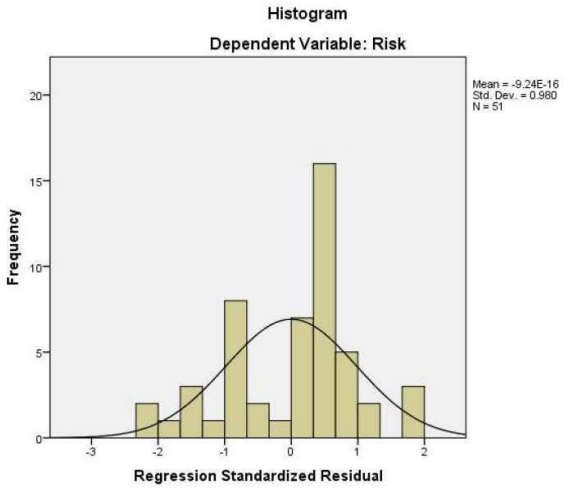


Figure 5- CI6.3c: Normality of Design & Construction Complexity Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.986[a]	.972	.971	3.469	1.577

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CI6.5c: Design & Construction Complexity regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

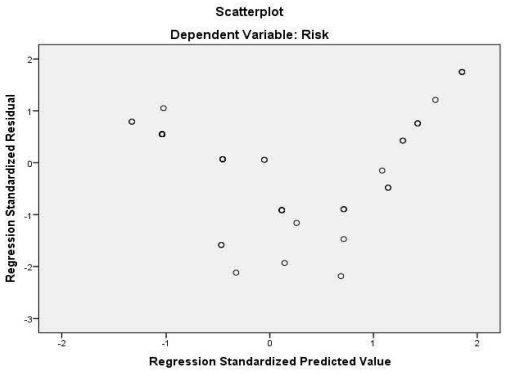


Figure 5- CI6.2c: Homoscedasticity Design & Construction Complexity normal Error (i.e. Constant Variance).

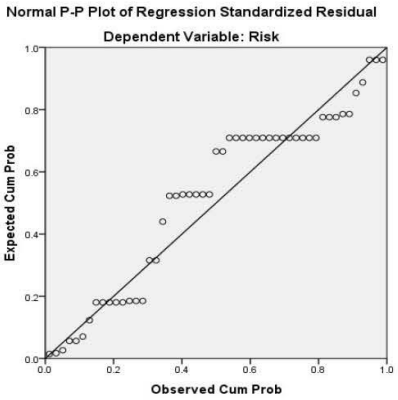


Figure 5- CI6.1c: Design & Construction Complexity normal Predicted Probability of the residual.

7- **Design Deficiency**:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_0: ρ = 0, (i.e. No Correlation between variables),
H_1: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.831, P-value= 0.000 (P-value < α), So H_0 is ***Rejected***.
- r= 0.831 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.803, P-value= 0.000 (P-value < α), So H_0 is ***Rejected***.
- r= 0.803 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CI7.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CI7.1} = -36.247 + 0.674\, X_{prob} + 0.556\, X_{imp} \quad \text{(Eq.5-CI7)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CI7 is equal to **34.4%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CI7.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 97.4% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	34.37	21.935	54
Probability	58.65	20.088	54
Impact	55.85	22.607	54

Table 5- CI7.1: Design Deficiency Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.831**	.803**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.831**	1	.372**
	Sig. (2-tailed)	.000		.006
	N	54	54	54
Impact	Pearson Correlation	.803**	.372**	1
	Sig. (2-tailed)	.000	.006	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CI7.2: Design Deficiency Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	24830.512	2	12415.256	944.928	.000[b]
	Residual	670.081	51	13.139		
	Total	25500.593	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CI7.3: Design Deficiency linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-36.247	1.705		-21.258	.000
	Probability	.674	.027	.617	25.246	.000
	Impact	.556	.024	.573	23.447	.000

a. Dependent Variable: Risk

Table 5- CI7.4: Design Deficiency regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.987[a]	.974	.973	3.625	1.505

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CI7.5: Design Deficiency regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3.03	68.94	34.37	21.645	54
Residual	-10.688	5.765	.000	3.556	54
Std. Predicted Value	-1.448	1.597	.000	1.000	54
Std. Residual	-2.949	1.590	.000	.981	54

a. Dependent Variable: Risk

Table 5- CI7.6: Design Deficiency Risk Regression Residuals Statistics showing the Mean value of population Error.

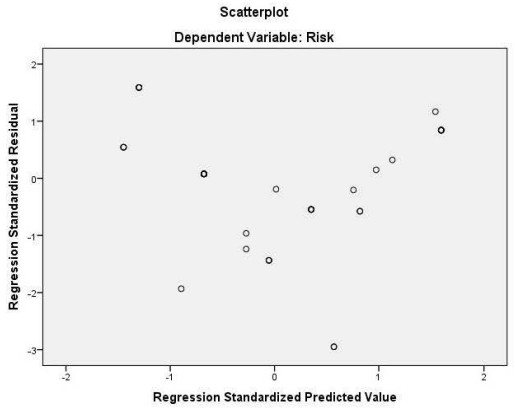


Figure 5- CI7.2: Homoscedasticity Design Deficiency normal Error (i.e. Constant Variance).

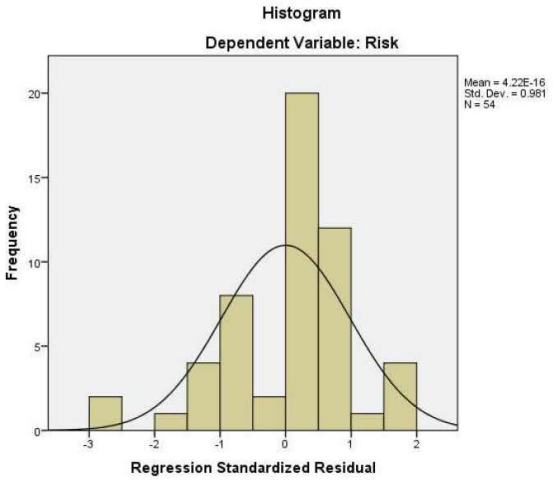


Figure 5- CI7.3: Normality of Design Deficiency Error distribution (i.e. Bell Shaped).

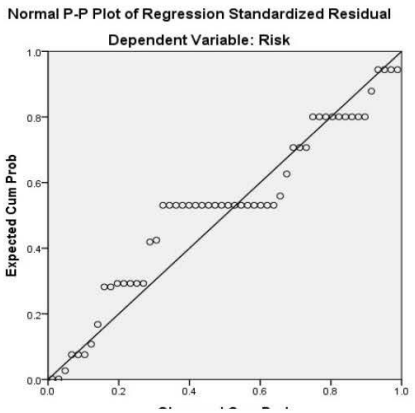


Figure 5- CI7.1: Design Deficiency normal Predicted Probability of the residual.

8- **Late Design Change**:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.760, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.760 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.907, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.907 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CI8.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CI8.1} = -27.519 + 0.474 X_{prob} + 0.624 X_{imp} \quad \text{(Eq.5-CI8)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CI8 is equal to **32.2%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CI8.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	33.24	20.054	54
Probability	59.89	17.724	54
Impact	51.80	22.594	54

Table 5- CI8.1: Late Design Change Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.760**	.907**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.760**	1	.484**
	Sig. (2-tailed)	.000		.000
	N	54	54	54
Impact	Pearson Correlation	.907**	.484**	1
	Sig. (2-tailed)	.000	.000	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CI8.2: Late Design Change Data Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20389.069	2	10194.534	562.198	.000[b]
	Residual	924.801	51	18.133		
	Total	21313.870	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CI8.3: Late Design Change Data linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-27.519	2.106		-13.068	.000
	Probability	.474	.038	.419	12.578	.000
	Impact	.624	.030	.704	21.100	.000

a. Dependent Variable: Risk

Table 5- CI8.4: Late Design Change regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-10.16	65.14	33.24	19.614	54
Residual	-11.670	14.467	.000	4.177	54
Std. Predicted Value	-2.213	1.626	.000	1.000	54
Std. Residual	-2.740	3.397	.000	.981	54

a. Dependent Variable: Risk

Table 5- CI8.6: Late Design Change Regression Residuals Statistics showing the Mean value of population Error.

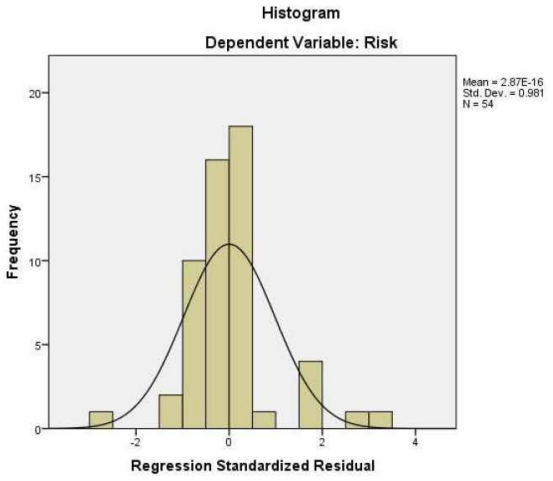


Figure 5- CI8.3: Normality of Late Design Change Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.978[a]	.957	.955	4.258	1.856

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CI8.5: Late Design Change regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

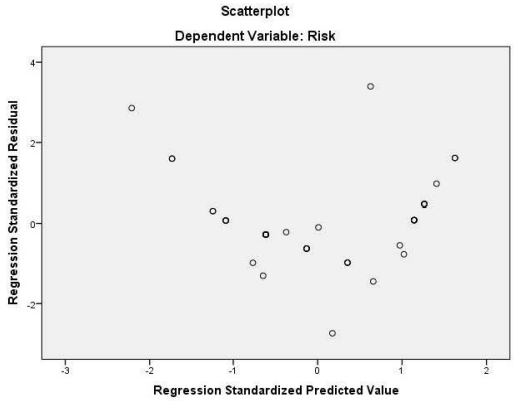


Figure 5- CI8.2: Homoscedasticity Late Design Change normal Error (i.e. Constant Variance).

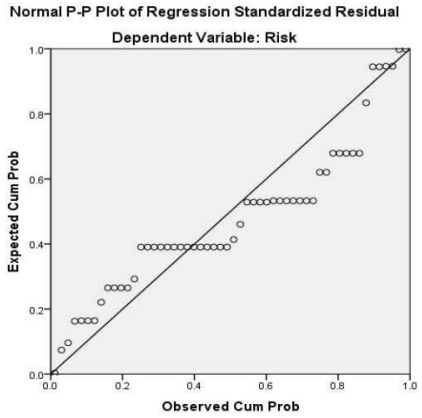


Figure 5- CI8.1: Late Design Change normal Predicted Probability of the residual.

9- Construction Technology Risk:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.434, P-value= 0.001 (P-value < α), So H_O is ***Rejected***.
- r= 0.434 (0.3 to 0.5), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.877, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.877 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CI9.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CI9.1} = -23.389 + 0.408\, X_{prob} + 0.573\, X_{imp} \quad \text{(Eq.5-CI9)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CI9 is equal to **24.1%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CI9.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.5% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	24.09	17.485	54
Probability	59.20	17.959	54
Impact	40.69	26.529	54

Table 5- CI9.1: Construction Technology Risk Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.434**	.877**
	Sig. (2-tailed)		.001	.000
	N	54	54	54
Probability	Pearson Correlation	.434**	1	.017
	Sig. (2-tailed)	.001		.901
	N	54	54	54
Impact	Pearson Correlation	.877**	.017	1
	Sig. (2-tailed)	.000	.901	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CI9.2: Construction Technology Risk Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15304.449	2	7652.225	434.549	.000[b]
	Residual	898.088	51	17.610		
	Total	16202.537	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CI9.3: Construction Technology Risk regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-23.389	2.159		-10.833	.000
	Probability	.408	.032	.419	12.715	.000
	Impact	.573	.022	.870	26.373	.000

a. Dependent Variable: Risk

Table 5- CI9.4: Construction Technology regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-5.41	59.19	24.09	16.993	54
Residual	-10.705	12.806	.000	4.116	54
Std. Predicted Value	-1.736	2.066	.000	1.000	54
Std. Residual	-2.551	3.052	.000	.981	54

a. Dependent Variable: Risk

Table 5- CI9.6: Construction Technology Regression Residuals Statistics showing the Mean value of population Error.

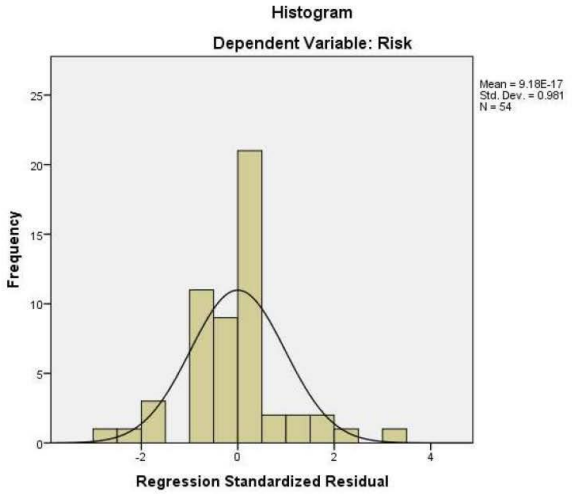


Figure 5- CI9.3: Normality of Construction Technology Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.972[a]	.945	.942	4.196	2.061

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CI9.5: Construction Technology regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

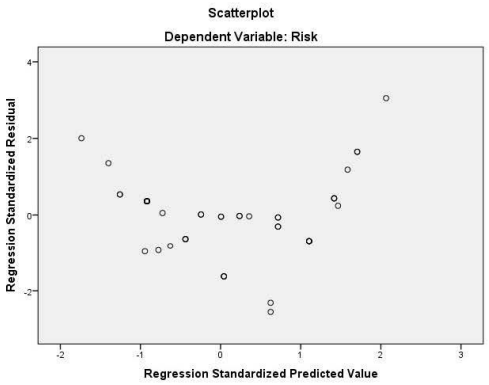


Figure 5- CI9.2: Homoscedasticity Construction Technology normal Error (i.e. Constant Variance).

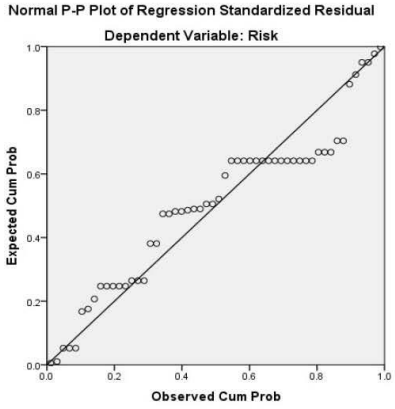


Figure 5- CI9.1: Construction Technology normal Predicted Probability of the residual.

10- **Contractual Risk**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.588, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.588 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.899, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.899 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CI10.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CI10.1} = -21.148 + 0.410\, X_{prob} + 0.539\, X_{imp} \quad \text{(Eq.5-CI10)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CI10 is equal to **24.6%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CI10.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is auto correlated data.
- This Model is reflecting 95.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	24.61	16.973	54
Probability	55.46	16.416	54
Impact	42.65	25.339	54

Table 5- CI10.1: Contractual Risk Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.588**	.899**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.588**	1	.237
	Sig. (2-tailed)	.000		.084
	N	54	54	54
Impact	Pearson Correlation	.899**	.237	1
	Sig. (2-tailed)	.000	.084	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CI10.2: Contractual Risk Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14614.947	2	7307.474	569.948	.000[b]
	Residual	653.886	51	12.821		
	Total	15268.833	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CI10.3: Contractual Risk linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-21.148	1.788		-11.827	.000
	Probability	.410	.031	.397	13.309	.000
	Impact	.539	.020	.805	26.982	.000

a. Dependent Variable: Risk

Table 5- CI10.4: Contractual Risk regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-11.65	58.93	24.61	16.606	54
Residual	-10.297	13.074	.000	3.512	54
Std. Predicted Value	-2.184	2.066	.000	1.000	54
Std. Residual	-2.876	3.651	.000	.981	54

a. Dependent Variable: Risk

Table 5- CI10.6: Contractual Risk Regression Residuals Statistics showing the Mean value of population Error.

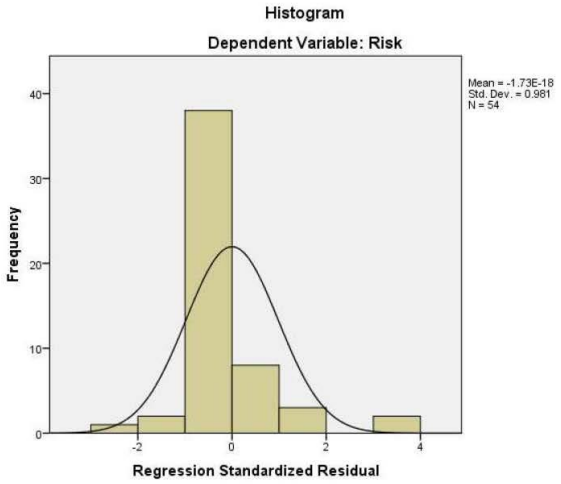


Figure 5- CI10.3: Normality of Contractual Risk Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.978[a]	.957	.955	3.581	2.283

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CI10.5: Contractual Risk regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

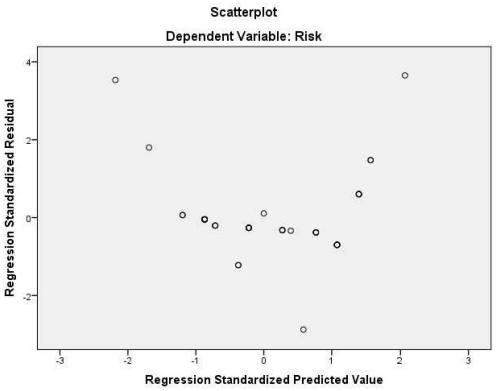


Figure 5- CI10.2: Homoscedasticity Contractual Risk normal Error (i.e. Constant Variance).

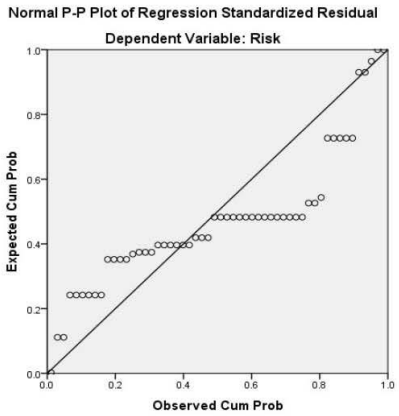


Figure 5- CI10.1: Contractual Risk normal Predicted Probability of the residual.

11- **Contractor Failure**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.535, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.535 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.748, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.748 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CI11.1d} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CI11.1d} = -50.875 + 0.760\, X_{prob} + 0.669\, X_{imp} \quad \text{(Eq.5-CI11d)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CI11d is equal to **36.3%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CI11.5d, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 98.8% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	36.29	20.888	48
Probability	62.21	18.202	48
Impact	59.69	26.466	48

Table 5- CI11.1d: Contractor Failure Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.535**	.748**
	Sig. (2-tailed)		.000	.000
	N	48	48	48
Probability	Pearson Correlation	.535**	1	-.150
	Sig. (2-tailed)	.000		.309
	N	48	48	48
Impact	Pearson Correlation	.748**	-.150	1
	Sig. (2-tailed)	.000	.309	
	N	48	48	48

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CI11.2d: Contractor Failure Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20252.344	2	10126.172	1797.029	.000[b]
	Residual	253.573	45	5.635		
	Total	20505.917	47			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CI11.3d: Contractor Failure linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-50.875	1.568		-32.453	.000
	Probability	.760	.019	.662	39.485	.000
	Impact	.669	.013	.847	50.524	.000

a. Dependent Variable: Risk

Table 5- CI11.4d: Contractor Failure regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	8.99	70.99	36.29	20.758	48
Residual	-2.209	6.146	.000	2.323	48
Std. Predicted Value	-1.315	1.671	.000	1.000	48
Std. Residual	-.931	2.589	.000	.978	48

a. Dependent Variable: Risk

Table 5- CI11.6d: Contractor Failure Regression Residuals Statistics showing the Mean value of population Error.

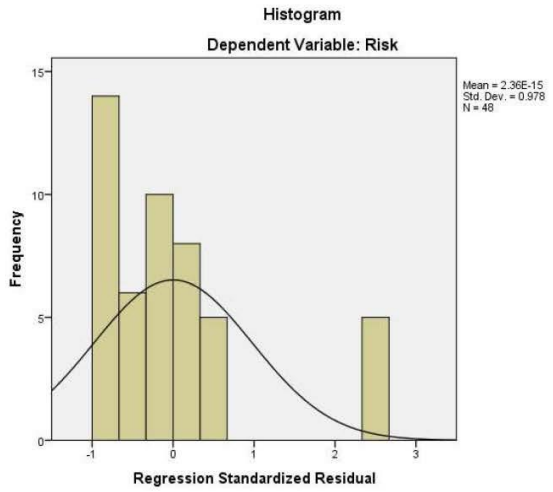


Figure 5- CI11.3d: Normality of Contractor Failure Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.994[a]	.988	.987	2.374	1.559

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CI11.5d: Contractor Failure regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

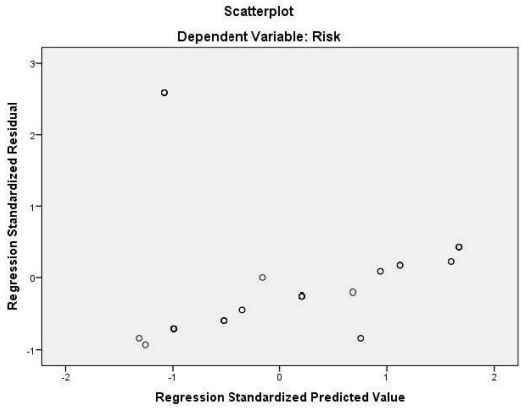


Figure 5- CI11.2d: Homoscedasticity Contractor Failure normal Error (i.e. Constant Variance).

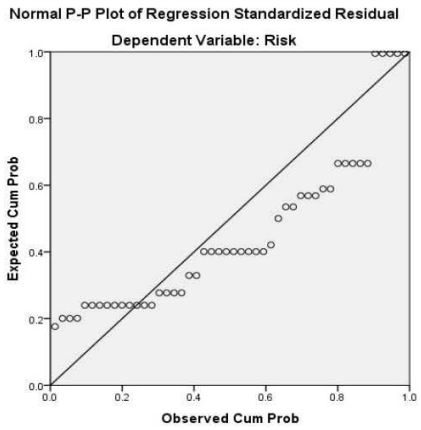


Figure 5- CI11.1d: Contractor Failure normal Predicted Probability of the residual.

12- **Quality Risk**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.642, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.642 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.867, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.867 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CI12.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CI12.1} = -32.094 + 0.589 X_{prob} + 0.553 X_{imp} \quad \text{(Eq.5-CI12)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CI12 is equal to **25.2%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CI12.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 96% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	25.17	18.248	54
Probability	57.37	14.533	54
Impact	42.48	25.094	54

Table 5- CI12.1: Quality Risk Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.642**	.867**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.642**	1	.228
	Sig. (2-tailed)	.000		.098
	N	54	54	54
Impact	Pearson Correlation	.867**	.228	1
	Sig. (2-tailed)	.000	.098	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CI12.2: Quality Risk Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16940.830	2	8470.415	611.305	.000[b]
	Residual	706.670	51	13.856		
	Total	17647.500	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CI12.3: Quality Risk linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-32.094	2.122		-15.122	.000
	Probability	.589	.036	.469	16.297	.000
	Impact	.553	.021	.760	26.413	.000

a. Dependent Variable: Risk

Table 5- CI12.4: Quality Risk regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-3.38	65.12	25.17	17.878	54
Residual	-10.011	9.375	.000	3.651	54
Std. Predicted Value	-1.596	2.235	.000	1.000	54
Std. Residual	-2.689	2.519	.000	.981	54

a. Dependent Variable: Risk

Table 5- CI12.6: Quality Risk Regression Residuals Statistics showing the Mean value of population Error.

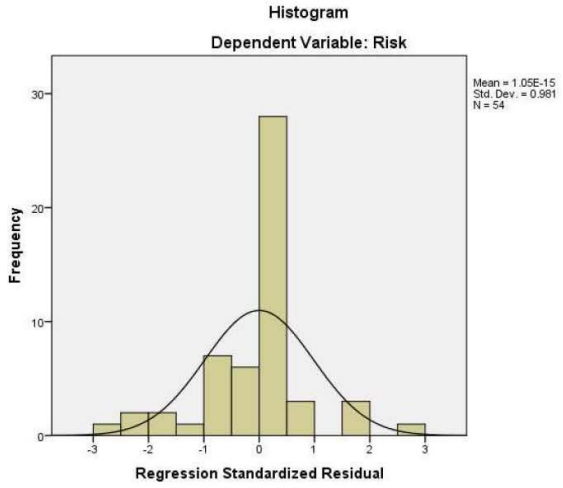


Figure 5- CI12.3: Normality of Quality Risk Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.980[a]	.960	.958	3.722	2.061

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CI12.5: Quality Risk regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

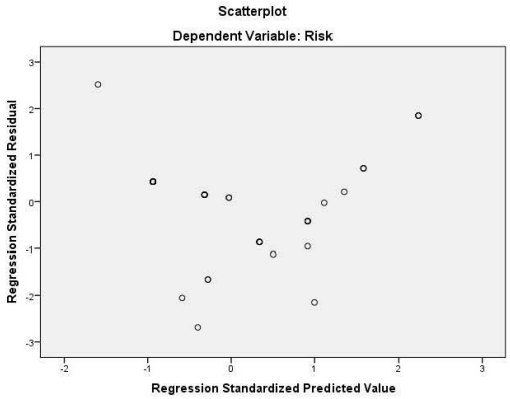


Figure 5- CI12.2: Homoscedasticity Quality Risk normal Error (i.e. Constant Variance).

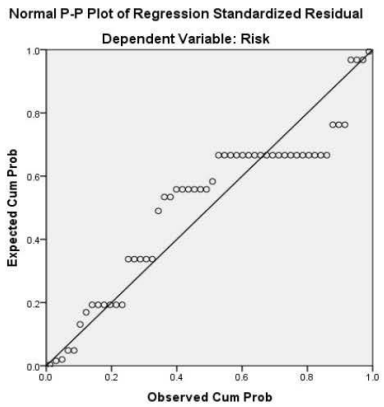


Figure 5- CI12.1: Quality Risk normal Predicted Probability of the residual.

J- Construction Stakeholders Relationship Cost Factors:

1- Different Working Method Between Partners:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_l: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.582, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.582 (0.5 to 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.916, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.916 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CJ1.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CJ1.1} = -15.742 + 0.319\, X_{prob} + 0.542\, X_{imp} \quad \text{(Eq.5-CJ1)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CJ1 is equal to **22.7%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CJ1.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is auto correlated data.
- This Model is reflecting 94.3% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	22.67	16.968	54
Probability	56.67	17.876	54
Impact	37.52	25.523	54

Table 5- CJ1.1: Different Working Method Between Partners Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.582**	.916**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.582**	1	.302*
	Sig. (2-tailed)	.000		.026
	N	54	54	54
Impact	Pearson Correlation	.916**	.302*	1
	Sig. (2-tailed)	.000	.026	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CJ1.2: Different Working Method Between Partners Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14383.336	2	7191.668	418.376	.000[b]
	Residual	876.664	51	17.189		
	Total	15260.000	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CJ1.3: Different Working Method Between Partners linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-15.742	1.916		-8.216	.000
	Probability	.319	.033	.336	9.548	.000
	Impact	.542	.023	.815	23.145	.000

a. Dependent Variable: Risk

Table 5- CJ1.4: Different Working Method Between Partners regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-7.13	56.32	22.67	16.474	54
Residual	-12.172	15.682	.000	4.067	54
Std. Predicted Value	-1.809	2.043	.000	1.000	54
Std. Residual	-2.936	3.782	.000	.981	54

a. Dependent Variable: Risk

Table 5- CJ1.6: Different Working Method Between Partners Regression Residuals Statistics showing the Mean value of population Error.

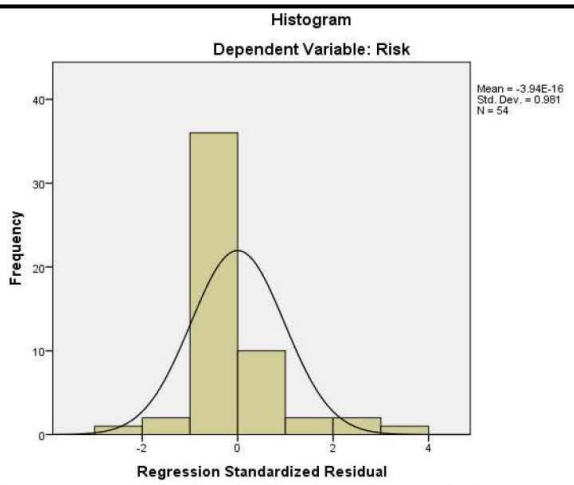


Figure 5- CJ1.3: Normality of Different Working Method Between Partners Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.971[a]	.943	.940	4.146	1.969

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CJ1.5: Different Working Method Between Partners regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

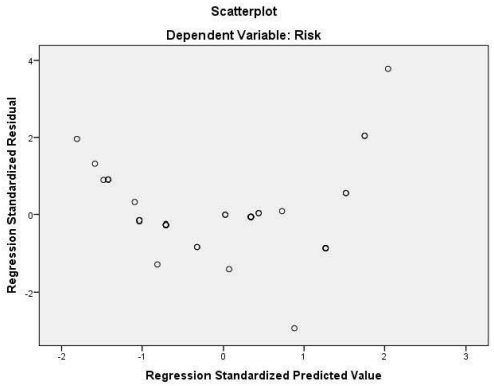


Figure 5- CJ1.2: Homoscedasticity Different Working Method Between Partners normal Error (i.e. Constant Variance).

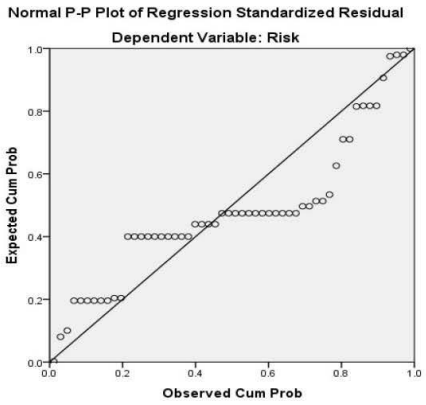


Figure 5- CJ1.1: Different Working Method Between Partners normal Predicted Probability of the residual.

2- **Inadequate Experience in Residential Projects**:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.501, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.501 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.790, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.790 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CJ2.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CJ2.1} = -26.927 + 0.523 X_{prob} + 0.517 X_{imp} \quad \text{(Eq.5-CJ2)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CJ2 is equal to **25.9%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CJ2.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 89.4% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	25.85	18.700	54
Probability	53.81	18.602	54
Impact	47.61	28.984	54

Table 5- CJ2.1: Inadequate Experience in Residential Projects Data Descriptive Statistics of Risk, Probability

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.501**	.790**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.501**	1	-.024
	Sig. (2-tailed)	.000		.864
	N	54	54	54
Impact	Pearson Correlation	.790**	-.024	1
	Sig. (2-tailed)	.000	.864	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CJ2.2: Inadequate Experience in Residential Projects Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16566.766	2	8283.383	214.874	.000[b]
	Residual	1966.049	51	38.550		
	Total	18532.815	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CJ2.3: Inadequate Experience in Residential Projects linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-26.927	2.989		-9.009	.000
	Probability	.523	.046	.520	11.404	.000
	Impact	.517	.029	.802	17.580	.000

a. Dependent Variable: Risk

Table 5- CJ2.4: Inadequate Experience in Residential Projects regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-6.06	61.53	25.85	17.680	54
Residual	-16.315	20.081	.000	6.091	54
Std. Predicted Value	-1.805	2.018	.000	1.000	54
Std. Residual	-2.628	3.234	.000	.981	54

a. Dependent Variable: Risk

Table 5- CJ2.6: Inadequate Experience in Residential Projects Regression Residuals Statistics showing the Mean value of population Error.

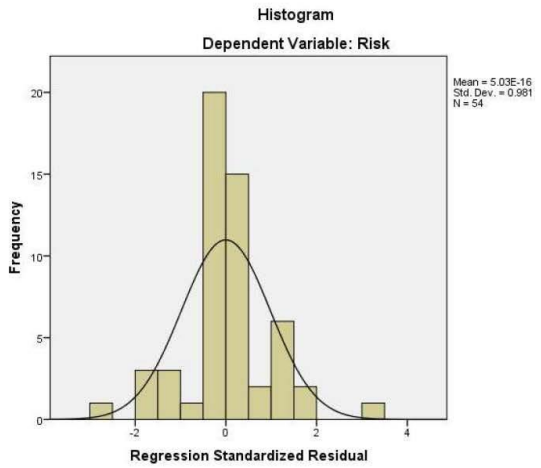


Figure 5- CJ2.3: Normality of Inadequate Experience in Residential Projects Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.945[a]	.894	.890	6.209	1.694

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CJ2.5: Inadequate Experience in Residential Projects regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

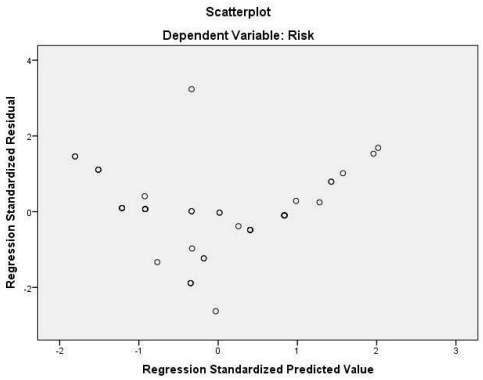


Figure 5- CJ2.2: Homoscedasticity Inadequate Experience in Residential Projects normal Error (i.e. Constant Variance)

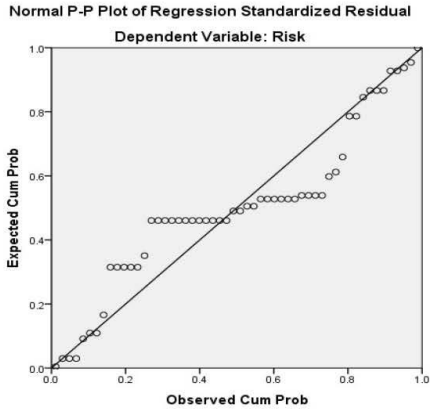


Figure 5- CJ2.1: Inadequate Experience in Residential Projects normal Predicted Probability of the residual.

3- Lack of Commitment From Public/Private Sector:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.569, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.569 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.818, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.818 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CJ3.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CJ3.1} = -19.470 + 0.395\, X_{prob} + 0.508\, X_{imp} \quad \text{(Eq.5-CJ3)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CJ3 is equal to **24.8%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CJ3.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 93.3% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	24.80	16.725	54
Probability	57.89	21.813	54
Impact	42.11	25.777	54

Table 5- CJ3.1: Lack of Commitment From Public/Private Sector Data Descriptive Statistics of Risk, Probability and

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.569**	.818**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.569**	1	.068
	Sig. (2-tailed)	.000		.624
	N	54	54	54
Impact	Pearson Correlation	.818**	.068	1
	Sig. (2-tailed)	.000	.624	
	N	54	54	54

** Correlation is significant at the 0.01 level (2-tailed).

Table 5- CJ3.2: Lack of Commitment From Public/Private Sector Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13834.954	2	6917.477	356.425	.000[b]
	Residual	989.805	51	19.408		
	Total	14824.759	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CJ3.3: Lack of Commitment From Public/Private Sector linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-19.470	1.927		-10.102	.000
	Probability	.395	.028	.516	14.218	.000
	Impact	.508	.024	.783	21.576	.000

a. Dependent Variable: Risk

Table 5- CJ3.4: Lack of Commitment From Public/Private Sector regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-10.44	56.73	24.80	16.157	54
Residual	-9.006	15.272	.000	4.322	54
Std. Predicted Value	-2.181	1.976	.000	1.000	54
Std. Residual	-2.044	3.467	.000	.981	54

a. Dependent Variable: Risk

Table 5- CJ3.6: Lack of Commitment From Public/Private Sector Regression Residuals Statistics showing the Mean value of population Error.

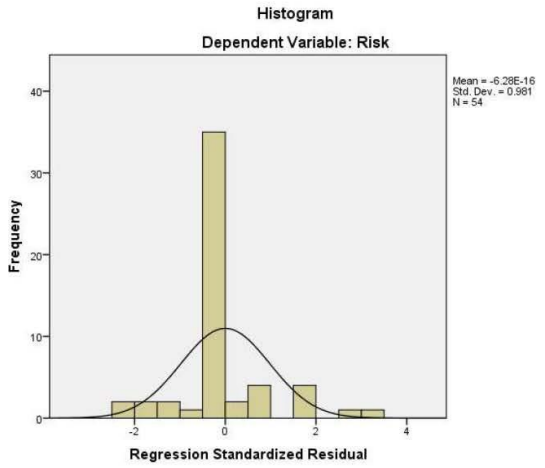


Figure 5- CJ3.3: Normality of Lack of Commitment From Public/Private SectoError distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.966[a]	.933	.931	4.405	1.953

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CJ3.5: Lack of Commitment From Public/Private Sector regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

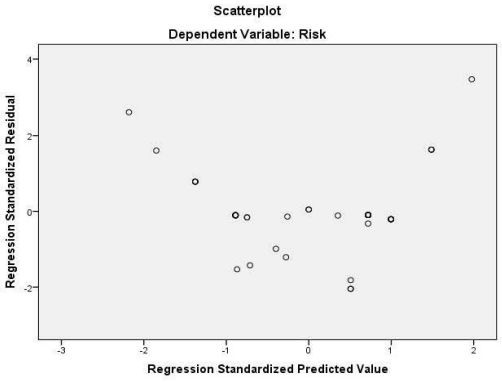


Figure 5- CJ3.2: Homoscedasticity Lack of Commitment From Public/Private Sector normal Error (i.e. Constant Variance).

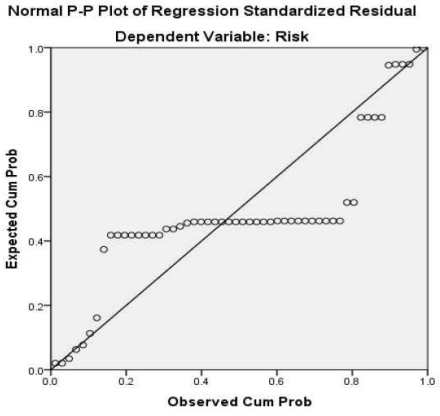


Figure 5- CJ3.1: Lack of Commitment From Public/Private Sector normal Predicted Probability of the residual.

4- **Organization and Coordination Risk**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.536, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.536 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.778, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.778 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CJ4.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CJ4.1} = -27.211 + 0.547 X_{prob} + 0.490 X_{imp} \quad \text{(Eq.5-CJ4)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CJ4 is equal to **17.8%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CJ4.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 91.5% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	17.83	15.720	54
Probability	50.65	15.959	54
Impact	35.37	25.437	54

Table 5- CJ4.1: Organization and Coordination Risk Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.536**	.778**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.536**	1	-.025
	Sig. (2-tailed)	.000		.860
	N	54	54	54
Impact	Pearson Correlation	.778**	-.025	1
	Sig. (2-tailed)	.000	.860	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CJ4.2: Organization and Coordination Risk Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11981.154	2	5990.577	273.678	.000[b]
	Residual	1116.346	51	21.889		
	Total	13097.500	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CJ4.2: Organization and Coordination Risk linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-27.211	2.336		-11.649	.000
	Probability	.547	.040	.556	13.592	.000
	Impact	.490	.025	.792	19.370	.000

a. Dependent Variable: Risk

Table 5- CJ4.4: Organization and Coordination Risk regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-5.89	61.23	17.83	15.035	54
Residual	-9.426	10.774	.000	4.589	54
Std. Predicted Value	-1.578	2.886	.000	1.000	54
Std. Residual	-2.015	2.303	.000	.981	54

a. Dependent Variable: Risk

Table 5- CJ4.6: Organization and Coordination Risk Regression Residuals Statistics showing the Mean value of population Error.

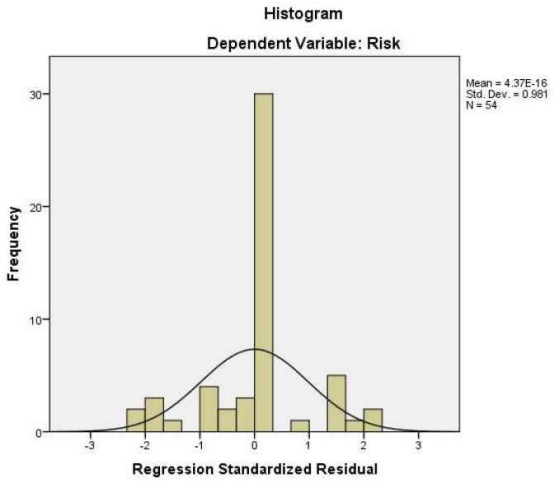


Figure 5- CJ4.3: Normality of Organization and Coordination Risk Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.956[a]	.915	.911	4.679	2.318

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CJ4.5: Organization and Coordination Risk regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

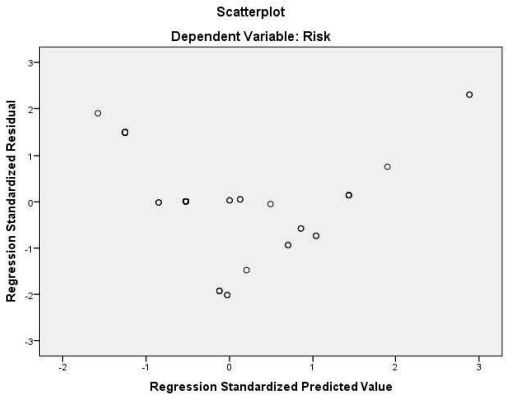


Figure 5- CJ4.2: Homoscedasticity Organization and Coordination Risk normal Error (i.e. Constant Variance).

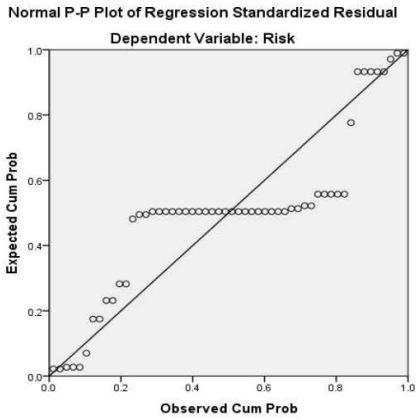


Figure 5- CJ4.1: Organization and Coordination Risk normal Predicted Probability of the residual.

5- **Inadequate Distribution of Responsibility & Risk**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.622, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.622 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.889, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.889 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CJ5.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CJ5.1} = -21.988 + 0.371\, X_{prob} + 0.621\, X_{imp} \quad \text{(Eq.5-CJ5)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CJ5 is equal to **20.6%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CJ5.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	20.61	17.066	54
Probability	53.00	19.191	54
Impact	36.93	21.416	54

Table 5- CJ5.1: Inadequate Distribution of Responsibility & Risk Data Descriptive Statistics of Risk, Probability and

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.622**	.889**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.622**	1	.263
	Sig. (2-tailed)	.000		.055
	N	54	54	54
Impact	Pearson Correlation	.889**	.263	1
	Sig. (2-tailed)	.000	.055	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CJ5.2: Inadequate Distribution of Responsibility & Risk Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14696.484	2	7348.242	506.194	.000[b]
	Residual	740.349	51	14.517		
	Total	15436.833	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CJ5.3: Inadequate Distribution of Responsibility & Risk linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-21.988	1.628		-13.504	.000
	Probability	.371	.028	.417	13.134	.000
	Impact	.621	.025	.779	24.515	.000

a. Dependent Variable: Risk

Table 5- CJ5.4: Inadequate Distribution of Responsibility & Risk regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-4.64	61.09	20.61	16.652	54
Residual	-8.627	10.911	.000	3.737	54
Std. Predicted Value	-1.517	2.431	.000	1.000	54
Std. Residual	-2.264	2.864	.000	.981	54

a. Dependent Variable: Risk

Table 5- CJ5.6: Inadequate Distribution of Responsibility & Risk Regression Residuals Statistics showing the Mean value of population Error.

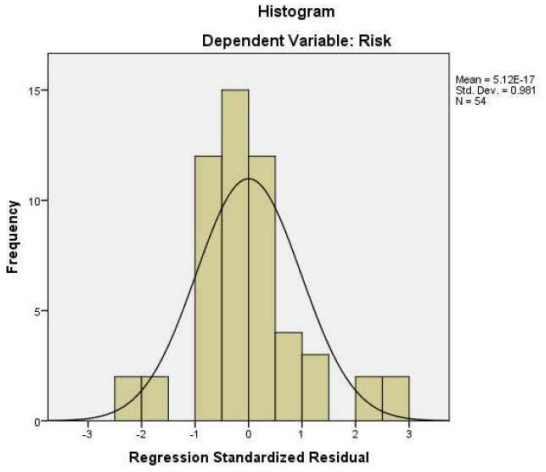


Figure 5- CJ5.3: Normality of Inadequate Distribution of Responsibility & Risk Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.976[a]	.952	.950	3.810	2.306

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CJ5.5: Inadequate Distribution of Responsibility & Risk regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

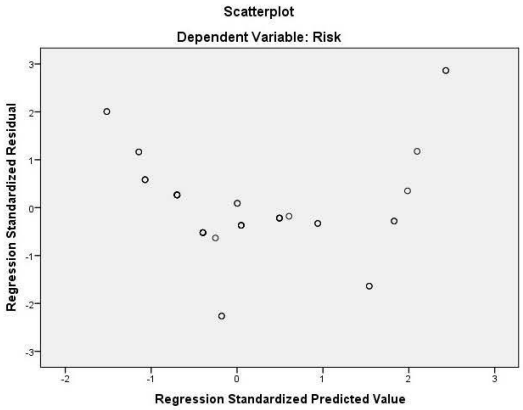


Figure 5- CJ5.2: Homoscedasticity Inadequate Distribution of Responsibility & Risk normal Error (i.e. Constant Variance).

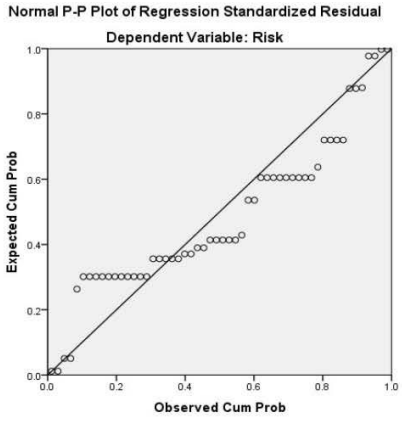


Figure 5- CJ5.1: Inadequate Distribution of Responsibility & Risk normal Predicted Probability of the residual.

6- Inadequate Negotiation Period Prior to Initiation:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.584, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.584 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.769, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.769 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CJ6.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CJ6.1} = -20.968 + 0.457 X_{prob} + 0.453 X_{imp} \quad \text{(Eq.5-CJ6)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CJ6 is equal to **20.3%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CJ6.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 91.1% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	20.26	13.902	54
Probability	50.78	17.194	54
Impact	39.72	23.157	54

Table 5- CJ6.1: Inadequate Negotiation Period Prior to Initiation Data Descriptive Statistics of Risk, Probability

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.584**	.769**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.584**	1	.024
	Sig. (2-tailed)	.000		.862
	N	54	54	54
Impact	Pearson Correlation	.769**	.024	1
	Sig. (2-tailed)	.000	.862	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CJ6.2: Inadequate Negotiation Period Prior to Initiation Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9327.388	2	4663.694	259.948	.000[b]
	Residual	914.983	51	17.941		
	Total	10242.370	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CJ6.3: Inadequate Negotiation Period Prior to Initiation linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-20.968	2.049		-10.232	.000
	Probability	.457	.034	.566	13.514	.000
	Impact	.453	.025	.755	18.032	.000

a. Dependent Variable: Risk

Table 5- CJ6.4: Inadequate Negotiation Period Prior to Initiation regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-4.98	56.45	20.26	13.266	54
Residual	-11.861	15.547	.000	4.155	54
Std. Predicted Value	-1.903	2.728	.000	1.000	54
Std. Residual	-2.800	3.671	.000	.981	54

a. Dependent Variable: Risk

Table 5- CJ6.6: Inadequate Negotiation Period Prior to Initiation Regression Residuals Statistics showing the Mean value of population Error.

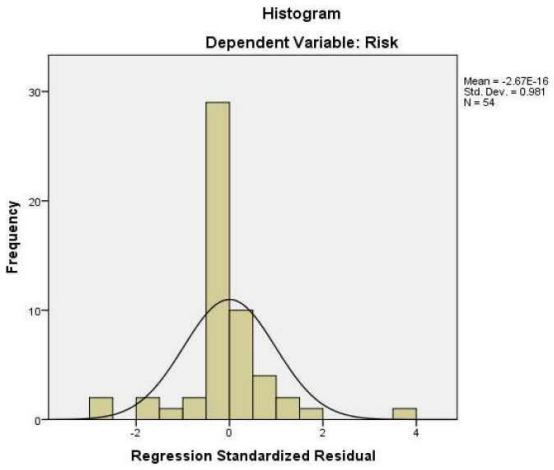


Figure 5- CJ6.3: Normality of Inadequate Negotiation Period Prior to Initiation Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.954[a]	.911	.907	4.236	2.389

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CJ6.5: Inadequate Negotiation Period Prior to Initiation regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

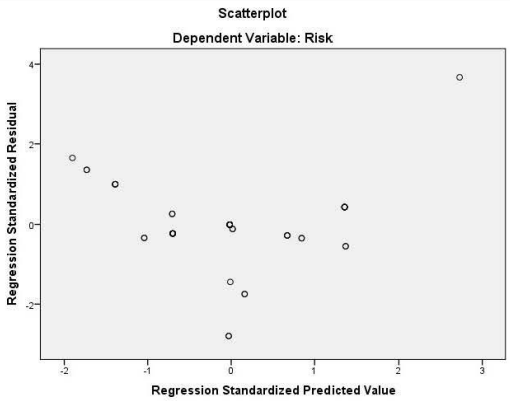


Figure 5- CJ6.2: Homoscedasticity Inadequate Negotiation Period Prior to Initiation normal Error (i.e. Constant Variance).

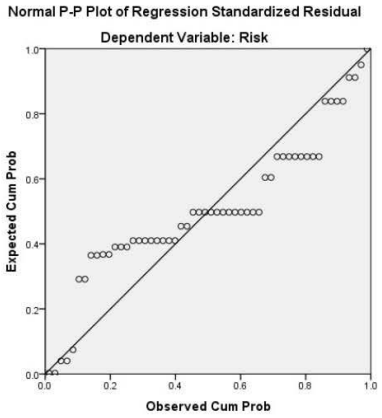


Figure 5- CJ6.1: Inadequate Negotiation Period Prior to Initiation normal Predicted Probability of the residual.

7- Conflict Between Project's Participants:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.675, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.675 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.785, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.785 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CJ7.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CJ7.1} = -24.109 + 0.497 X_{prob} + 0.512 X_{imp} \quad \text{(Eq.5-CJ7)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CJ7 is equal to **23.2%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CJ7.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.4% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	23.19	17.059	54
Probability	50.93	19.834	54
Impact	42.89	23.499	54

Table 5- CJ7.1: Conflict Between Project's Participants Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.675**	.785**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.675**	1	.137
	Sig. (2-tailed)	.000		.324
	N	54	54	54
Impact	Pearson Correlation	.785**	.137	1
	Sig. (2-tailed)	.000	.324	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CJ7.2: Conflict Between Project's Participants Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14557.063	2	7278.532	428.107	.000[b]
	Residual	867.085	51	17.002		
	Total	15424.148	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CJ7.3: Conflict Between Project's Participants linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-24.109	1.772		-13.606	.000
	Probability	.497	.029	.578	17.253	.000
	Impact	.512	.024	.705	21.049	.000

a. Dependent Variable: Risk

Table 5- CJ7.4: Conflict Between Project's Participants regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.971[a]	.944	.942	4.123	2.241

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CJ7.5: Conflict Between Project's Participants regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-4.07	61.63	23.19	16.573	54
Residual	-7.784	10.374	.000	4.045	54
Std. Predicted Value	-1.644	2.319	.000	1.000	54
Std. Residual	-1.888	2.516	.000	.981	54

a. Dependent Variable: Risk

Table 5- CJ7.6: Conflict Between Project's Participants Regression Residuals Statistics showing the Mean value of population Error.

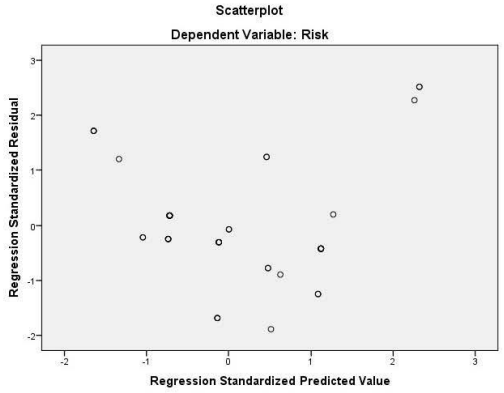


Figure 5- CJ7.2: Homoscedasticity Conflict Between Project's Participants normal Error (i.e. Constant Variance).

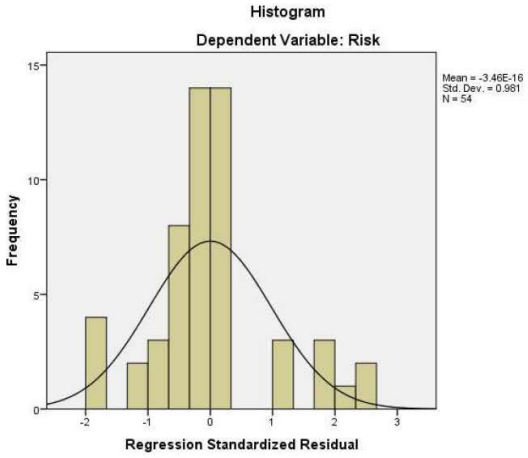


Figure 5- CJ7.3: Normality of Conflict Between Project's Participants Error distribution (i.e. Bell Shaped).

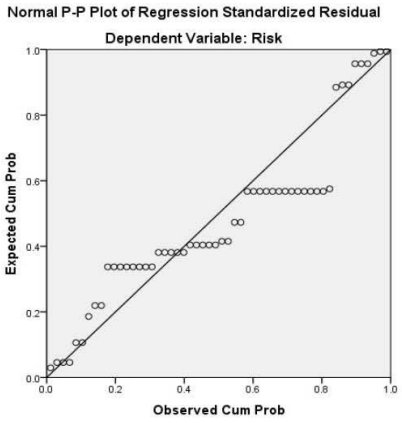


Figure 5- CJ7.1: Conflict Between Project's Participants normal Predicted Probability of the residual.

8- **Workers Strike**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.738, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.738 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.870, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.870 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CJ8.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CJ8.1} = -16.370 + 0.390\, X_{prob} + 0.484\, X_{imp} \quad \text{(Eq.5-CJ8)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CJ8 is equal to **19.2%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CJ8.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 91.3% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	19.20	18.867	54
Probability	45.24	21.300	54
Impact	37.02	26.337	54

Table 5- CJ8.1: Workers Strike Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.738**	.870**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.738**	1	.440**
	Sig. (2-tailed)	.000		.001
	N	54	54	54
Impact	Pearson Correlation	.870**	.440**	1
	Sig. (2-tailed)	.000	.001	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CJ8.2: Workers Strike Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17224.018	2	8612.009	267.366	.000[b]
	Residual	1642.741	51	32.211		
	Total	18866.759	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CJ8.3: Workers Strike linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-16.370	1.872		-8.744	.000
	Probability	.390	.041	.440	9.569	.000
	Impact	.484	.033	.676	14.692	.000

a. Dependent Variable: Risk

Table 5- CJ8.4: Workers Strike regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-7.63	57.48	19.20	18.027	54
Residual	-10.419	14.522	.000	5.567	54
Std. Predicted Value	-1.488	2.123	.000	1.000	54
Std. Residual	-1.836	2.559	.000	.981	54

a. Dependent Variable: Risk

Table 5- CJ8.6: Workers Strike Regression Residuals Statistics showing the Mean value of population Error.

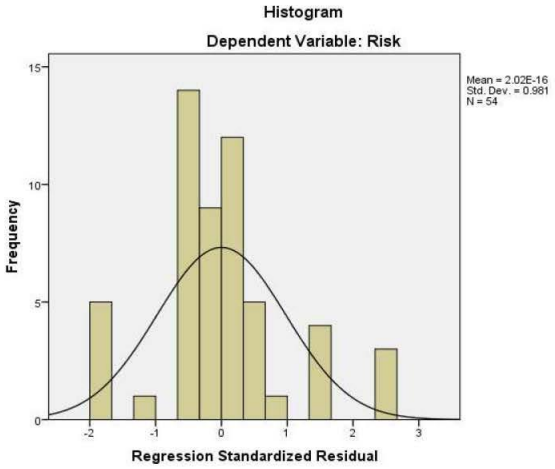


Figure 5- CJ8.3: Normality of Workers Strike Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.955[a]	.913	.910	5.675	2.016

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CJ8.5: Workers Strike regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

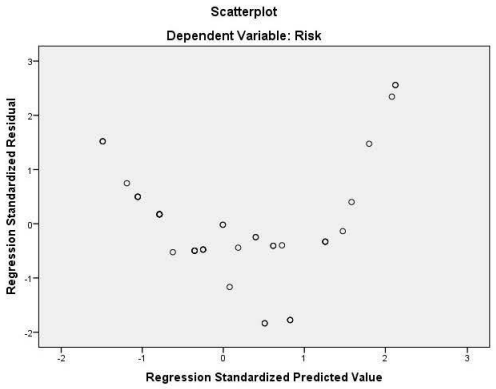


Figure 5- CJ8.2: Homoscedasticity Workers Strike normal Error (i.e. Constant Variance).

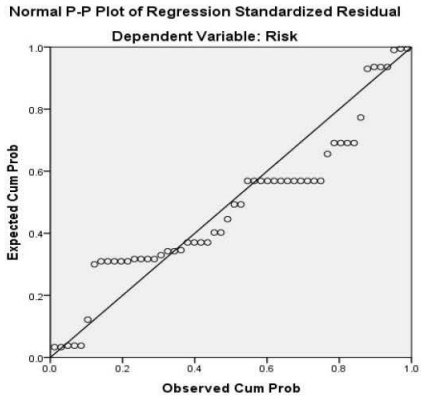


Figure 5- CJ8.1: Workers Strike normal Predicted Probability of the residual.

9- Cultural Differences Between Main Stakeholders:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.689, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.689 (0.5 to 0.7), indicate that a positive Moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.835, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.835 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CJ9.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CJ9.1} = -14.387 + 0.373\, X_{prob} + 0.415\, X_{imp} \quad \text{(Eq.5-CJ9)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CJ9 is equal to **15.1%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CJ9.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 90.6% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	15.06	14.330	54
Probability	42.80	18.414	54
Impact	32.48	23.762	54

Table 5- CJ9.1: Cultural Differences Between Main Stakeholders Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.689**	.835**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.689**	1	.306*
	Sig. (2-tailed)	.000		.025
	N	54	54	54
Impact	Pearson Correlation	.835**	.306*	1
	Sig. (2-tailed)	.000	.025	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CJ9.2: Cultural Differences Between Main Stakeholders Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9854.542	2	4927.271	244.377	.000[b]
	Residual	1028.291	51	20.163		
	Total	10882.833	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CJ9.3: Cultural Differences Between Main Stakeholders linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-14.387	1.615		-8.907	.000
	Probability	.373	.035	.479	10.594	.000
	Impact	.415	.027	.689	15.238	.000

a. Dependent Variable: Risk

Table 5- CJ9.4: Cultural Differences Between Main Stakeholders regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.952[a]	.906	.902	4.490	1.716

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CJ9.5: Cultural Differences Between Main Stakeholders regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-6.51	52.39	15.06	13.636	54
Residual	-10.864	19.613	.000	4.405	54
Std. Predicted Value	-1.581	2.738	.000	1.000	54
Std. Residual	-2.419	4.368	.000	.981	54

a. Dependent Variable: Risk

Table 5- CJ9.6: Cultural Differences Between Main Stakeholders Regression Residuals Statistics showing the Mean value of population Error.

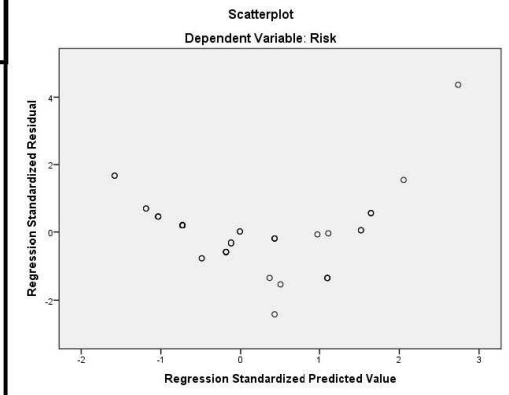


Figure 5- CJ9.2: Homoscedasticity Cultural Differences Between Main Stakeholders normal Error (i.e. Constant Variance).

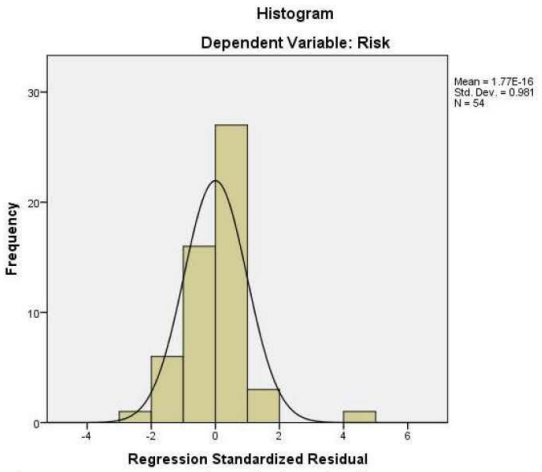


Figure 5- CJ9.3: Normality of Cultural Differences Between Main Stakeholders Error distribution (i.e. Bell Shaped).

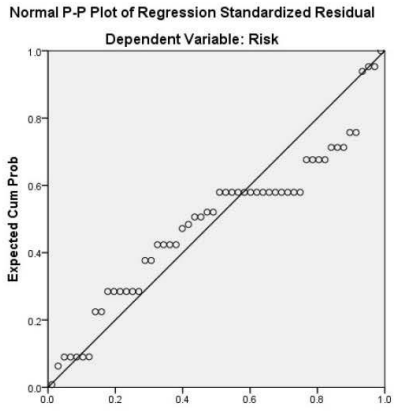


Figure 5- CJ9.1: Cultural Differences Between Main Stakeholders normal Predicted Probability of the residual.

K. Construction Knowledge Cost Factors:

1- **Expertise**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_0: ρ = 0, (i.e. No Correlation between variables),
H_1: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.550, P-value= 0.000 (P-value < α), So H_0 is ***Rejected***.
- r= 0.550 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.827, P-value= 0.000 (P-value < α), So H_0 is ***Rejected***.
- r= 0.827 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CK1.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CK1.1} = -28.386 + 0.475\, X_{prob} + 0.604\, X_{imp} \quad \text{(Eq.5-CK1)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CK1 is equal to **26.3%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CK1.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 93.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	26.26	18.559	54
Probability	54.31	19.506	54
Impact	47.74	24.448	54

Table 5- CK1.1: Expertise Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.550**	.827**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.550**	1	.063
	Sig. (2-tailed)	.000		.652
	N	54	54	54
Impact	Pearson Correlation	.827**	.063	1
	Sig. (2-tailed)	.000	.652	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CK1.1: Expertise Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17017.247	2	8508.624	350.765	.000[b]
	Residual	1237.123	51	24.257		
	Total	18254.370	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CK1.1: Expertise linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-28.386	2.335		-12.159	.000
	Probability	.475	.035	.500	13.680	.000
	Impact	.604	.028	.795	21.776	.000

a. Dependent Variable: Risk

Table 5- CK1.4: Expertise regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-11.11	62.70	26.26	17.919	54
Residual	-11.437	13.105	.000	4.831	54
Std. Predicted Value	-2.085	2.034	.000	1.000	54
Std. Residual	-2.322	2.661	.000	.981	54

a. Dependent Variable: Risk

Table 5- CK1.6: Expertise Regression Residuals Statistics showing the Mean value of population Error.

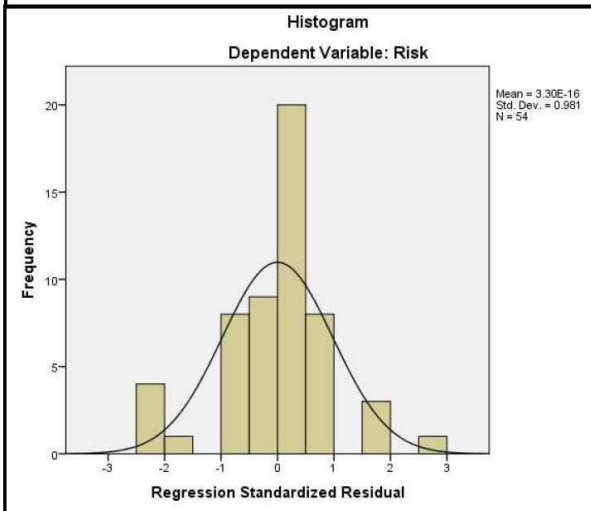


Figure 5- CK1.3: Normality of Expertise Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.966[a]	.932	.930	4.925	1.954

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CK1.5: Expertise regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

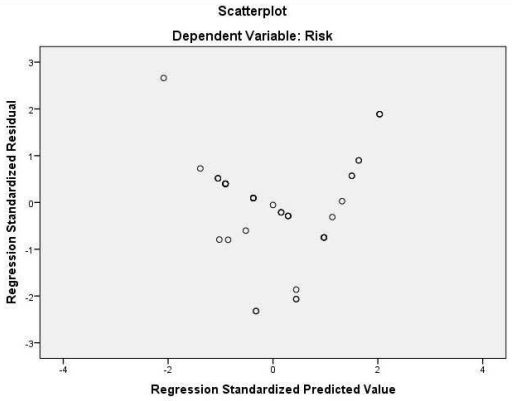


Figure 5- CK1.2: Homoscedasticity Expertise normal Error (i.e. Constant Variance).

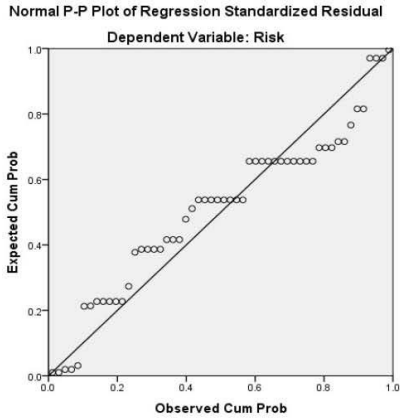


Figure 5- CK1.1: Expertise normal Predicted Probability of the residual.

2- **Familiarities**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_l: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.534, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.534 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.871, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.871 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CK2.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CK2.1} = -24.478 + 0.479\, X_{prob} + 0.524\, X_{imp} \quad \text{(Eq.5-CK2)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CK2 is equal to **21.2%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CK2.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	21.17	15.358	54
Probability	48.65	14.006	54
Impact	42.65	24.021	54

Table 5- CK2.1: Familiarities Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.534**	.871**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.534**	1	.118
	Sig. (2-tailed)	.000		.394
	N	54	54	54
Impact	Pearson Correlation	.871**	.118	1
	Sig. (2-tailed)	.000	.394	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CK2.2: Familiarities Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11841.212	2	5920.606	457.302	.000[b]
	Residual	660.288	51	12.947		
	Total	12501.500	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CK2.3: Familiarities linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-24.478	1.910		-12.816	.000
	Probability	.479	.036	.437	13.474	.000
	Impact	.524	.021	.820	25.290	.000

a. Dependent Variable: Risk

Table 5- CK2.4: Familiarities regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-7.49	60.54	21.17	14.947	54
Residual	-7.811	11.458	.000	3.530	54
Std. Predicted Value	-1.917	2.634	.000	1.000	54
Std. Residual	-2.171	3.184	.000	.981	54

a. Dependent Variable: Risk

Table 5- CK2.6: Familiarities Regression Residuals Statistics showing the Mean value of population Error.

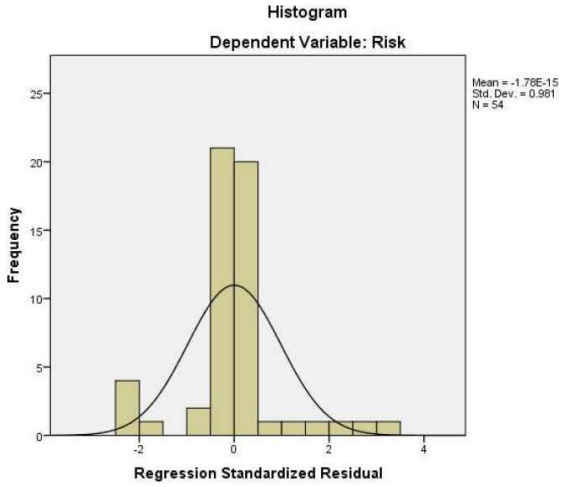


Figure 5- CK2.3: Normality of Familiarities Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.973[a]	.947	.945	3.598	1.989

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CK2.5: Familiarities regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

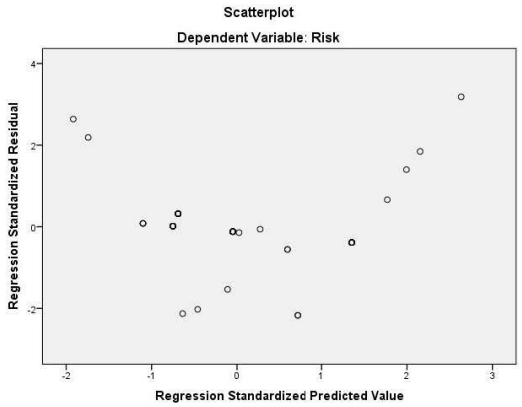


Figure 5- CK2.2: Homoscedasticity Familiarities normal Error (i.e. Constant Variance).

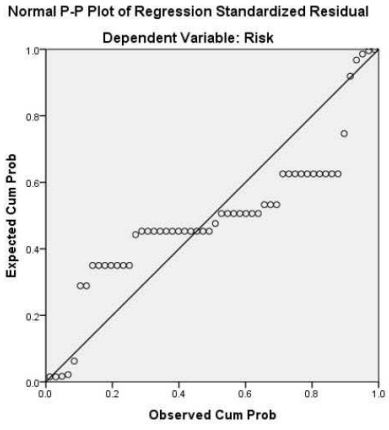


Figure 5- CK2.1: Familiarities normal Predicted Probability of the residual.

3- **Number of Bidders**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.378, P-value= 0.005 (P-value < α), So H_O is ***Rejected***.
- r= 0.378 (0.3 to 0.5), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.966, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.966 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CK3.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CK3.1} = -13.106 + 0.224\, X_{prob} + 0.598\, X_{imp} \quad \text{(Eq.5-CK3)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CK3 is equal to **20%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CK3.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 97.4% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	20.02	15.540	54
Probability	57.02	14.449	54
Impact	34.06	24.088	54

Table 5- CK3.1: Number of Bidders Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.378**	.966**
	Sig. (2-tailed)		.005	.000
	N	54	54	54
Probability	Pearson Correlation	.378**	1	.184
	Sig. (2-tailed)	.005		.183
	N	54	54	54
Impact	Pearson Correlation	.966**	.184	1
	Sig. (2-tailed)	.000	.183	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CK3.2: Number of Bidders Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12466.868	2	6233.434	957.218	.000[b]
	Residual	332.114	51	6.512		
	Total	12798.981	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CK3.3: Number of Bidders linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-13.106	1.447		-9.056	.000
	Probability	.224	.025	.208	9.061	.000
	Impact	.598	.015	.927	40.411	.000

a. Dependent Variable: Risk

Table 5- CK3.4: Number of Bidders regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-3.41	50.41	20.02	15.337	54
Residual	-5.935	5.593	.000	2.503	54
Std. Predicted Value	-1.527	1.981	.000	1.000	54
Std. Residual	-2.326	2.192	.000	.981	54

a. Dependent Variable: Risk

Table 5- CK3.6: Number of Bidders Regression Residuals Statistics showing the Mean value of population Error.

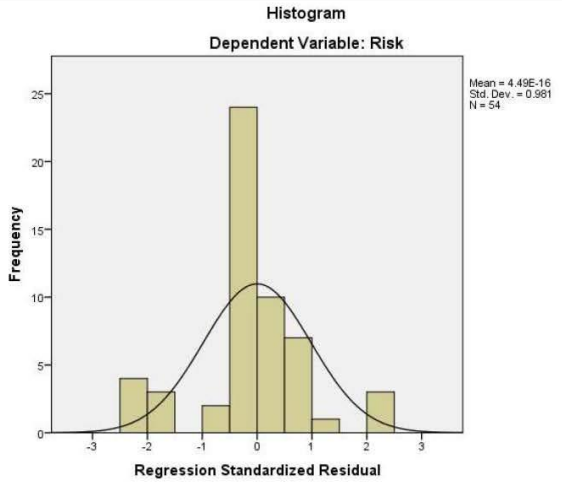


Figure 5- CK3.3: Normality of Number of Bidders Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.987[a]	.974	.973	2.552	1.582

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CK3.5: Number of Bidders regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

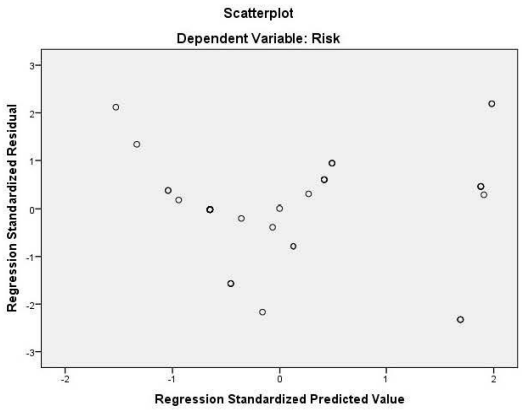


Figure 5- CK3.2: Homoscedasticity Number of Bidders normal Error (i.e. Constant Variance).

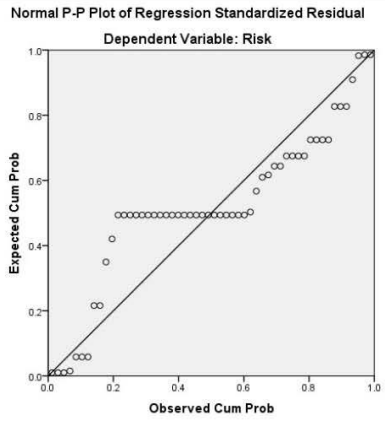


Figure 5- CK3.1: Number of Bidders normal Predicted Probability of the residual.

4- **Market Conditions**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.728, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.728 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.922, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.922 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CK4.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CK4.1} = -20.929 + 0.386\, X_{prob} + 0.606\, X_{imp} \quad \text{(Eq.5-CK4)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CK4 is equal to **25.7%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CK4.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	25.70	20.870	54
Probability	57.28	20.161	54
Impact	40.46	25.629	54

Table 5- CK4.1: Market Conditions Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.728**	.922**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.728**	1	.477**
	Sig. (2-tailed)	.000		.000
	N	54	54	54
Impact	Pearson Correlation	.922**	.477**	1
	Sig. (2-tailed)	.000	.000	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CK4.2: Market Conditions Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22098.867	2	11049.433	571.295	.000[b]
	Residual	986.392	51	19.341		
	Total	23085.259	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CK4.3: Market Conditions linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-20.929	1.824		-11.474	.000
	Probability	.386	.034	.373	11.330	.000
	Impact	.606	.027	.744	22.591	.000

a. Dependent Variable: Risk

Table 5- CK4.4: Market Conditions regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-3.29	62.29	25.70	20.420	54
Residual	-6.844	9.708	.000	4.314	54
Std. Predicted Value	-1.420	1.792	.000	1.000	54
Std. Residual	-1.556	2.207	.000	.981	54

a. Dependent Variable: Risk

Table 5- CK4.6: Market Conditions Regression Residuals Statistics showing the Mean value of population Error.

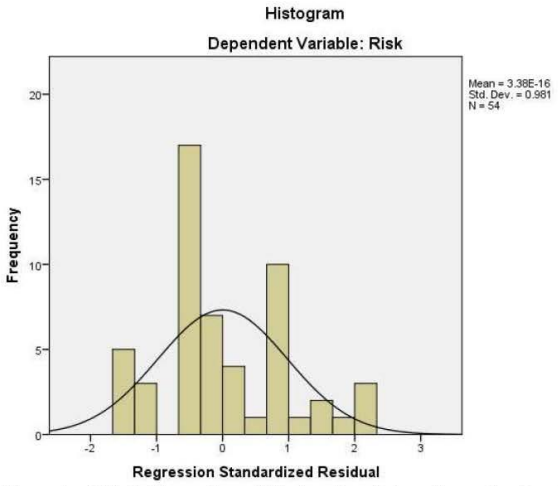


Figure 5- CK4.3: Normality of Market Conditions Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.978[a]	.957	.956	4.398	1.982

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CK4.5: Market Conditions regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

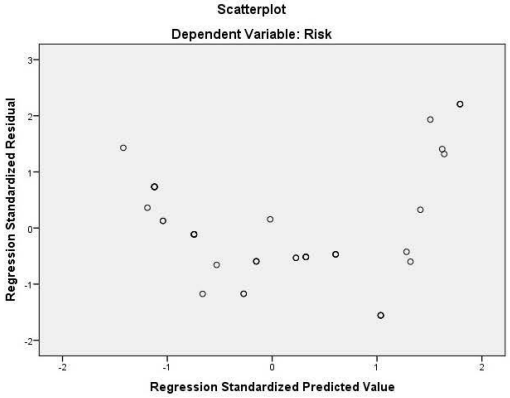


Figure 5- CK4.2: Homoscedasticity Market Conditions normal Error (i.e. Constant Variance).

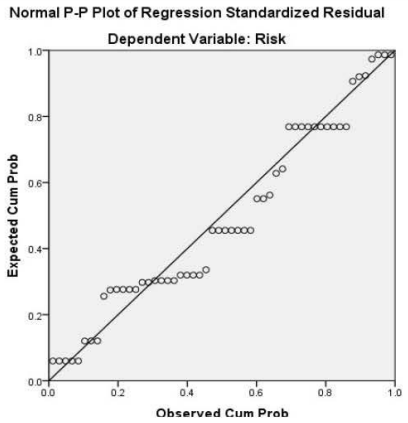


Figure 5- CK4.1: Market Conditions normal Predicted Probability of the residual.

5- **Size of the Project**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_l: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.735, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.735 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.884, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.884 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CK5.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CK5.1} = -18.089 + 0.387 X_{prob} + 0534 X_{imp} \quad \text{(Eq.5-CK5)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CK5 is equal to **25.7%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CK5.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	25.69	21.231	54
Probability	55.11	22.873	54
Impact	41.98	27.547	54

Table 5- CK5.1: Size of the Project Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.735**	.884**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.735**	1	.458**
	Sig. (2-tailed)	.000		.000
	N	54	54	54
Impact	Pearson Correlation	.884**	.458**	1
	Sig. (2-tailed)	.000	.000	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CK5.2: Size of the Project Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21967.551	2	10983.776	291.438	.000[b]
	Residual	1922.097	51	37.688		
	Total	23889.648	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CK5.3: Size of the Project linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-18.089	2.233		-8.102	.000
	Probability	.387	.041	.417	9.340	.000
	Impact	.534	.034	.693	15.507	.000

a. Dependent Variable: Risk

Table 5- CK5.4: Size of the Project regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-11.54	59.51	25.69	20.359	54
Residual	-12.262	12.544	.000	6.022	54
Std. Predicted Value	-1.829	1.661	.000	1.000	54
Std. Residual	-1.997	2.043	.000	.981	54

a. Dependent Variable: Risk

Table 5- CK5.6: Size of the Project Regression Residuals Statistics showing the Mean value of population Error.

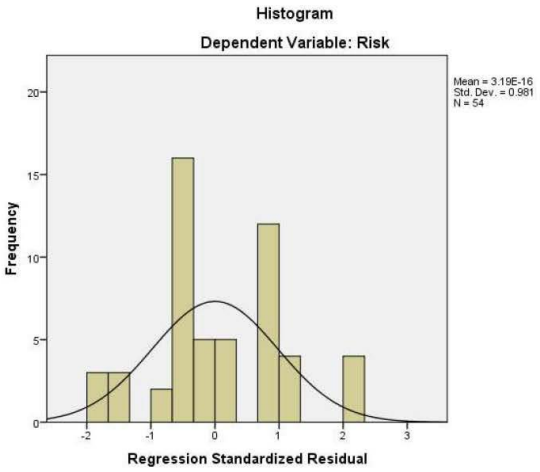


Figure 5- CK5.3: Normality of Size of the Project Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.959[a]	.920	.916	6.139	1.806

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CK5.5: Size of the Project regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

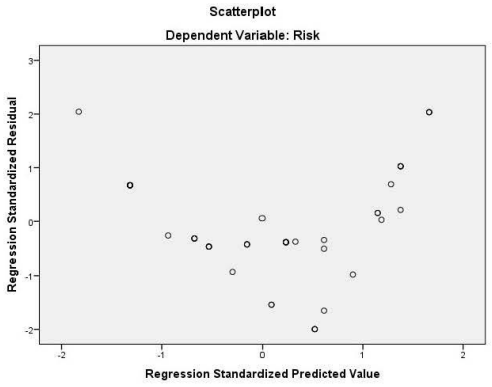


Figure 5- CK5.2: Homoscedasticity Size of the Project normal Error (i.e. Constant Variance).

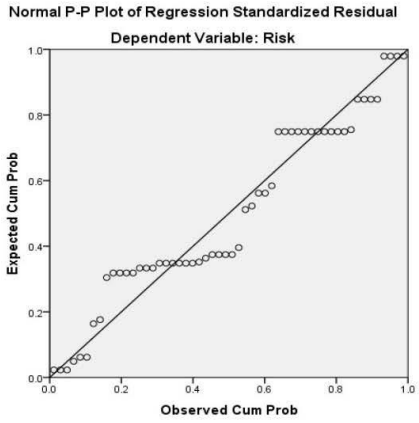


Figure 5- CK5.1: Size of the Project normal Predicted Probability of the residual.

6- **Type of Building**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.656, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.656 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.931, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.931 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CK6.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CK6.1} = -20.515 + 0.393\, X_{prob} + 0.566\, X_{imp} \quad \text{(Eq.5-CK6)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CK6 is equal to **23.2%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CK6.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 96% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	23.19	19.125	54
Probability	56.44	16.351	54
Impact	38.02	26.870	54

Table 5- CK6.1: Type of Building Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.656**	.931**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.656**	1	.402**
	Sig. (2-tailed)	.000		.003
	N	54	54	54
Impact	Pearson Correlation	.931**	.402**	1
	Sig. (2-tailed)	.000	.003	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CK6.2: Type of Building Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18619.425	2	9309.712	619.253	.000[b]
	Residual	766.723	51	15.034		
	Total	19386.148	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CK6.3: Type of Building linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-20.515	1.913		-10.725	.000
	Probability	.393	.036	.336	11.042	.000
	Impact	.566	.022	.796	26.161	.000

a. Dependent Variable: Risk

Table 5- CK6.4: Type of Building regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.980[a]	.960	.959	3.877	1.833

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CK6.5: Type of Building regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-5.90	60.14	23.19	18.743	54
Residual	-5.271	11.862	.000	3.803	54
Std. Predicted Value	-1.552	1.972	.000	1.000	54
Std. Residual	-1.359	3.059	.000	.981	54

a. Dependent Variable: Risk

Table 5- CK6.6: Type of Building Regression Residuals Statistics showing the Mean value of population Error.

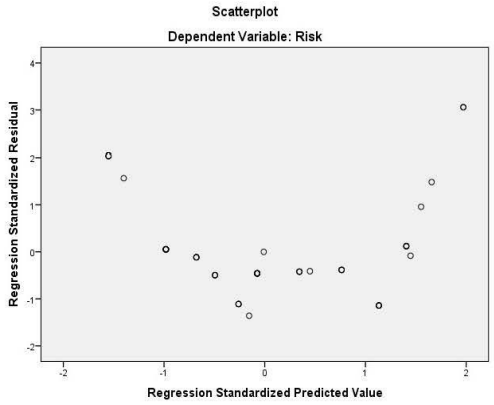


Figure 5- CK6.2: Homoscedasticity Type of Building normal Error (i.e. Constant Variance).

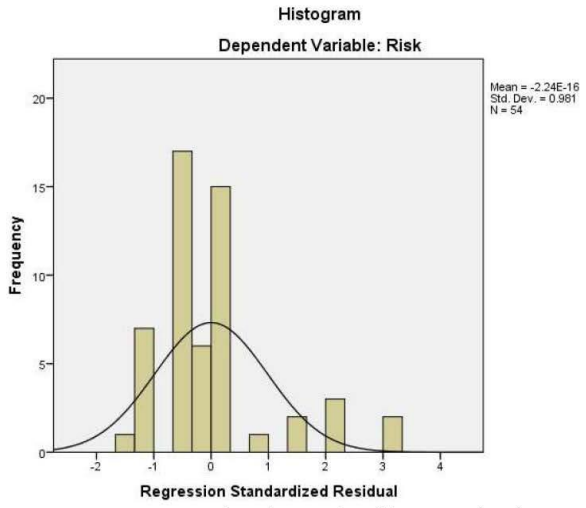


Figure 5- CK6.3: Normality of Type of Building Error distribution (i.e. Bell Shaped).

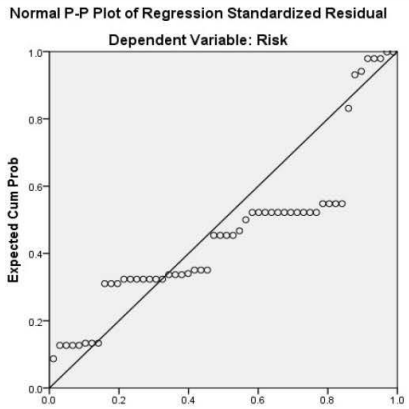


Figure 5- CK6.1: Type of Building normal Predicted Probability of the residual.

7- **Extent of Database**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.633, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.633 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.839, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.839 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CK7.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CK7.1} = -13.046 + 0.333\, X_{prob} + 0.456\, X_{imp} \quad \text{(Eq.5-CK7)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CK7 is equal to **17.1%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CK7.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 85.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	17.11	15.633	54
Probability	52.20	19.093	54
Impact	28.04	24.322	54

Table 5- CK7.1: Extent of Database Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.633**	.839**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.633**	1	.319*
	Sig. (2-tailed)	.000		.019
	N	54	54	54
Impact	Pearson Correlation	.839**	.319*	1
	Sig. (2-tailed)	.000	.019	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- CK7.2: Extent of Database Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11040.992	2	5520.496	147.225	.000[b]
	Residual	1912.342	51	37.497		
	Total	12953.333	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CK7.3: Extent of Database linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-13.046	2.459		-5.306	.000
	Probability	.333	.046	.406	7.159	.000
	Impact	.456	.036	.710	12.499	.000

a. Dependent Variable: Risk

Table 5- CK7.4: Extent of Database regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-5.16	48.39	17.11	14.433	54
Residual	-19.713	17.275	.000	6.007	54
Std. Predicted Value	-1.543	2.167	.000	1.000	54
Std. Residual	-3.219	2.821	.000	.981	54

a. Dependent Variable: Risk

Table 5- CK7.6: Extent of Database Regression Residuals Statistics showing the Mean value of population Error.

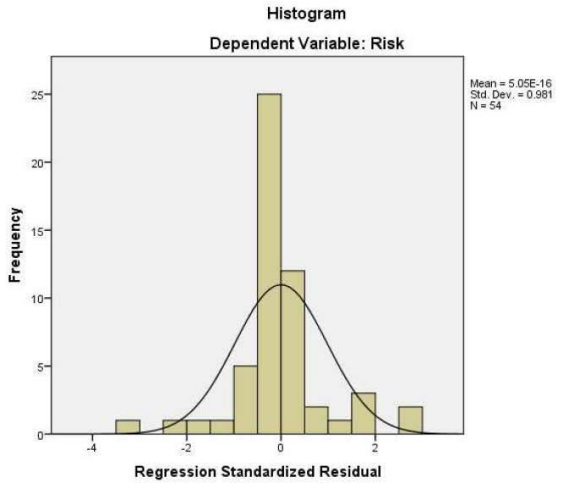


Figure 5- CK7.3: Normality of Extent of Database Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.923[a]	.852	.847	6.123	1.535

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CK7.5: Extent of Database regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

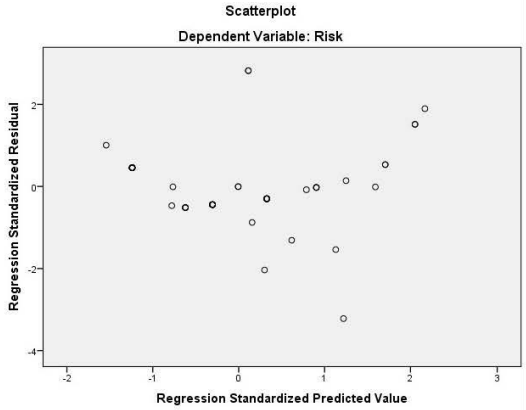


Figure 5- CK7.2: Homoscedasticity Extent of Database normal Error (i.e. Constant Variance).

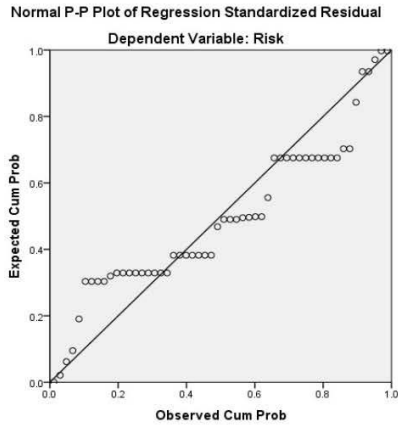


Figure 5- CK7.1: Extent of Database normal Predicted Probability of the residual.

8- **Homogeneity of Samples**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.585, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.585 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.958, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.958 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CK8.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CK8.1} = -9.893 + 0.212\, X_{prob} + 0.534\, X_{imp} \quad \text{(Eq.5-CK8)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CK8 is equal to **14.9%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CK8.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 96.6% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	14.89	15.298	54
Probability	48.69	17.406	54
Impact	27.07	24.657	54

Table 5- CK8.1: Homogeneity of Samples Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.585**	.958**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.585**	1	.400**
	Sig. (2-tailed)	.000		.003
	N	54	54	54
Impact	Pearson Correlation	.958**	.400**	1
	Sig. (2-tailed)	.000	.003	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CK8.2: Homogeneity of Samples Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11978.049	2	5989.024	718.202	.000[b]
	Residual	425.285	51	8.339		
	Total	12403.333	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CK8.3: Homogeneity of Samples linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-9.893	1.177		-8.405	.000
	Probability	.212	.025	.241	8.523	.000
	Impact	.534	.018	.861	30.440	.000

a. Dependent Variable: Risk

Table 5- CK8.4: Homogeneity of Samples regression coefficients of Probability and Impact Variables.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.983[a]	.966	.964	2.888	1.982

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CK8.5: Homogeneity of Samples regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-2.43	48.74	14.89	15.033	54
Residual	-5.444	11.258	.000	2.833	54
Std. Predicted Value	-1.152	2.252	.000	1.000	54
Std. Residual	-1.885	3.899	.000	.981	54

a. Dependent Variable: Risk

Table 5- CK8.6: Homogeneity of Samples Regression Residuals Statistics showing the Mean value of population Error.

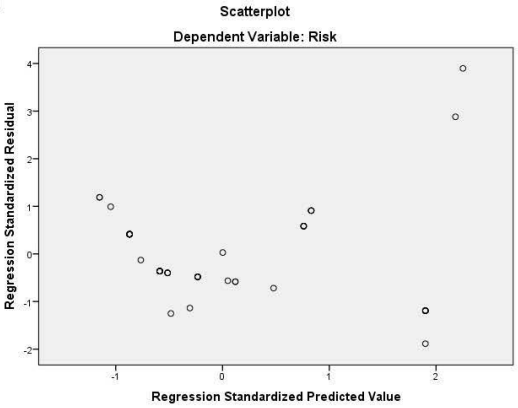


Figure 5- CK8.2: Homoscedasticity Homogeneity of Samples normal Error (i.e. Constant Variance).

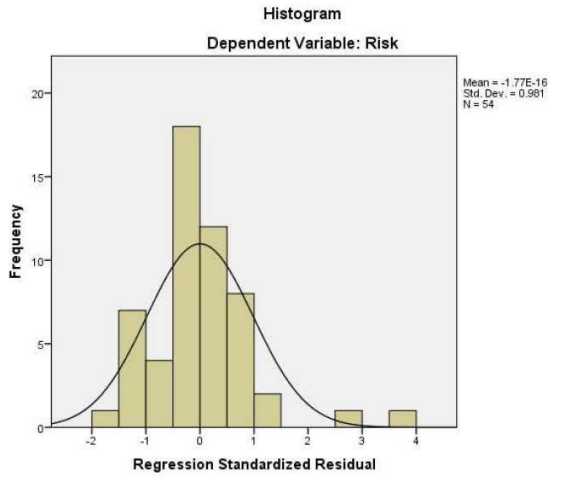


Figure 5- CK8.3: Normality of Homogeneity of Samples Error distribution (i.e. Bell Shaped).

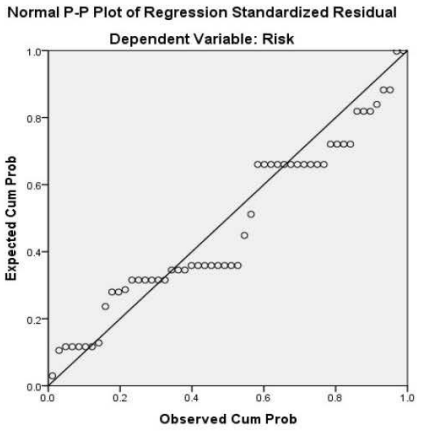


Figure 5- CK8.1: Homogeneity of Samples normal Predicted Probability of the residual.

9- **Details of Information**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_0: ρ = 0, (i.e. No Correlation between variables),
H_1: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.662, P-value= 0.000 (P-value < α), So H_0 is ***Rejected***.
- r= 0.662 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.932, P-value= 0.000 (P-value < α), So H_0 is ***Rejected***.
- r= 0.932 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{CK9.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{CK9.1} = -20.361 + 0.374\, X_{prob} + 0.594\, X_{imp} \quad \text{(Eq.5-CK9)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-CK9 is equal to **21.7%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-CK9.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 96.3% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	21.74	19.511	54
Probability	55.33	17.568	54
Impact	36.04	26.087	54

Table 5- CK9.1: Details of Information Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.662**	.932**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.662**	1	.409**
	Sig. (2-tailed)	.000		.002
	N	54	54	54
Impact	Pearson Correlation	.932**	.409**	1
	Sig. (2-tailed)	.000	.002	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- CK9.2: Details of Information Correlation significance analysis of Risk, Probability and Impact

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19422.305	2	9711.152	656.798	.000[b]
	Residual	754.065	51	14.786		
	Total	20176.370	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- CK9.3: Details of Information linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-20.361	1.745		-11.670	.000
	Probability	.374	.033	.337	11.357	.000
	Impact	.594	.022	.794	26.756	.000

a. Dependent Variable: Risk

Table 5- CK9.4: Details of Information regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-10.68	60.82	21.74	19.143	54
Residual	-5.847	11.682	.000	3.772	54
Std. Predicted Value	-1.694	2.041	.000	1.000	54
Std. Residual	-1.521	3.038	.000	.981	54

a. Dependent Variable: Risk

Table 5- CK9.6: Details of Information Regression Residuals Statistics showing the Mean value of population Error.

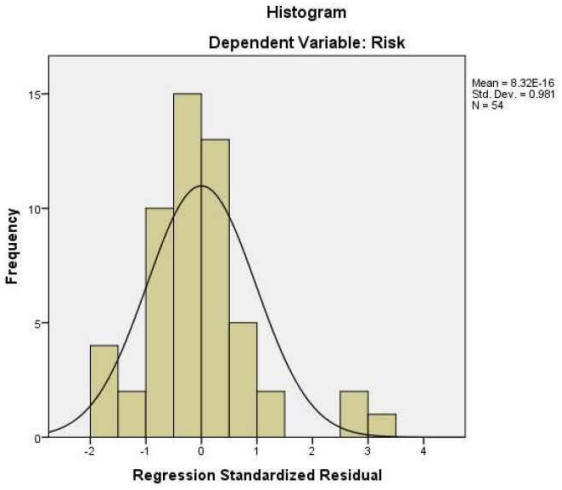


Figure 5- CK9.3: Normality of Details of Information Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.981[a]	.963	.961	3.845	1.956

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- CK9.5: Details of Information regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

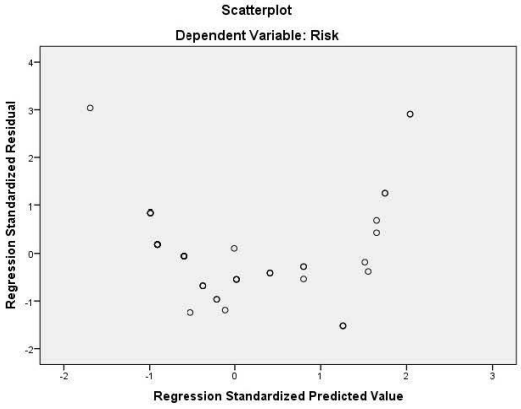


Figure 5- CK9.2: Homoscedasticity Details of Information normal Error (i.e. Constant Variance).

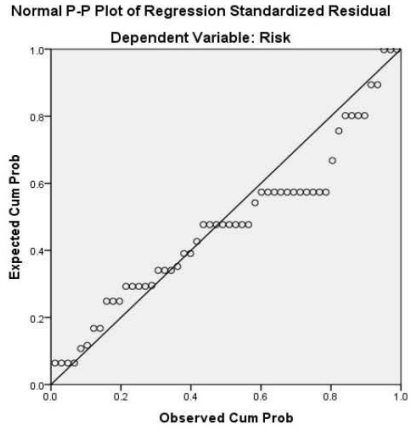


Figure 5- CK9.1: Details of Information normal Predicted Probability of the residual.

- **OPEX**:

OPEX Activities' Factors:

1- Energy Costs:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.673, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.673 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.829, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.829 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O1.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O1.1} = -29.619 + 0.554 X_{prob} + 0.554 X_{imp} \quad \text{(Eq.5-O1)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O1 is equal to **27.2%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O1.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92.4% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	27.19	21.098	54
Probability	57.54	19.089	54
Impact	45.00	26.935	54

Table 5- O1.1: Energy Costs Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.673**	.829**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.673**	1	.243
	Sig. (2-tailed)	.000		.076
	N	54	54	54
Impact	Pearson Correlation	.829**	.243	1
	Sig. (2-tailed)	.000	.076	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- O1.2: Energy Costs Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21793.153	2	10896.577	308.909	.000[b]
	Residual	1798.995	51	35.274		
	Total	23592.148	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O1.3: Energy Costs linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-29.619	2.706		-10.946	.000
	Probability	.554	.044	.501	12.574	.000
	Impact	.554	.031	.707	17.741	.000

a. Dependent Variable: Risk

Table 5- O1.4: Energy Costs regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-18.54	64.56	27.19	20.278	54
Residual	-16.781	19.539	.000	5.826	54
Std. Predicted Value	-2.255	1.843	.000	1.000	54
Std. Residual	-2.825	3.290	.000	.981	54

a. Dependent Variable: Risk

Table 5- O1.6: Energy Costs Regression Residuals Statistics showing the Mean value of population Error.

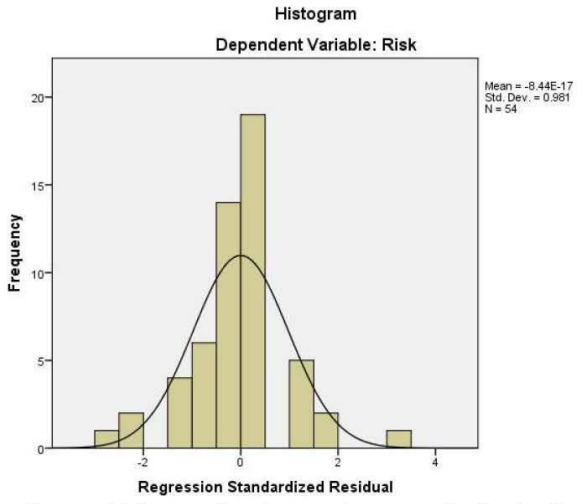


Figure 5- O1.3: Normality of Energy Costs Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.961[a]	.924	.921	5.939	2.047

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O1.5: Energy Costs regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

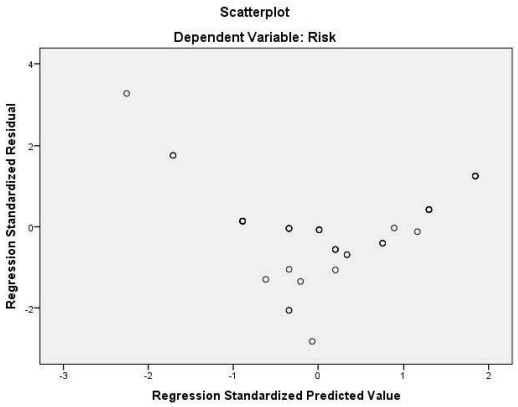


Figure 5- O1.2: Homoscedasticity Energy Costs normal Error (i.e. Constant Variance).

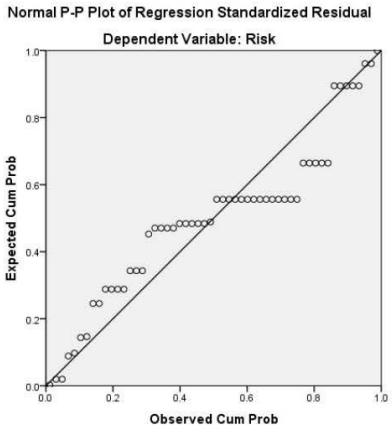


Figure 5- O1.1: Energy Costs normal Predicted Probability of the residual.

2- Service Life of Building Components:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.585, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.585 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.943, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.943 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O2.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O2.1} = -19.639 + 0.355 X_{prob} + 0.593 X_{imp} \quad \text{(Eq.5-O2)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O2 is equal to **23%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O2.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92.4% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	23.00	18.703	54
Probability	57.74	15.034	54
Impact	37.31	26.549	54

Table 5- O2.1: Service Life of Building Components Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.585**	.943**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.585**	1	.356**
	Sig. (2-tailed)	.000		.008
	N	54	54	54
Impact	Pearson Correlation	.943**	.356**	1
	Sig. (2-tailed)	.000	.008	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- O2.2: Service Life of Building Components Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17812.072	2	8906.036	623.973	.000[b]
	Residual	727.928	51	14.273		
	Total	18540.000	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O2.3: Service Life of Building Components linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-19.639	2.059		-9.541	.000
	Probability	.355	.037	.286	9.621	.000
	Impact	.593	.021	.842	28.348	.000

a. Dependent Variable: Risk

Table 5- O2.4: Service Life of Building Components regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-3.05	59.77	23.00	18.332	54
Residual	-6.197	12.231	.000	3.706	54
Std. Predicted Value	-1.421	2.006	.000	1.000	54
Std. Residual	-1.640	3.237	.000	.981	54

a. Dependent Variable: Risk

Table 5- O2.6: Service Life of Building Components Regression Residuals Statistics showing the Mean value of population Error.

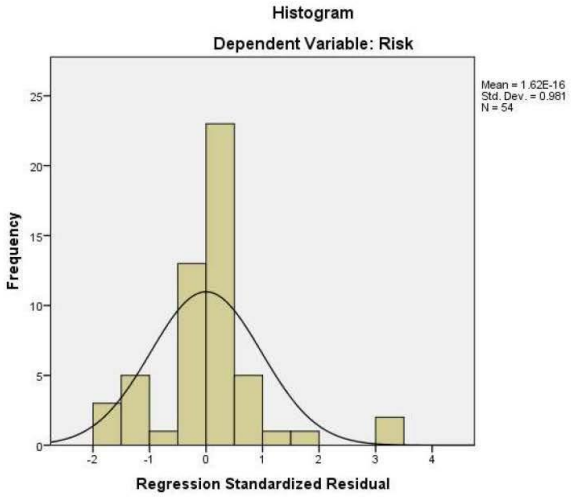


Figure 5- O2.3: Normality of Service Life of Building Components Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.980[a]	.961	.959	3.778	1.663

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O2.5: Service Life of Building Components regression Model Summary showing how much in percentage (%) the population is represented by the

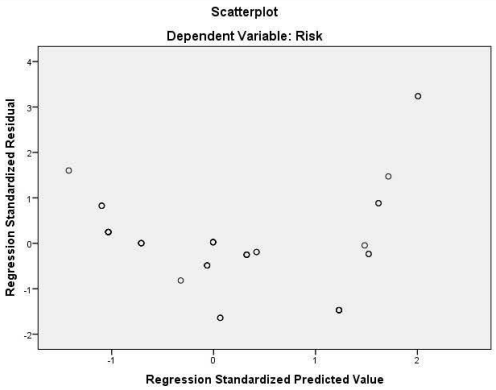


Figure 5- O2.2: Homoscedasticity Service Life of Building Components normal Error (i.e. Constant Variance).

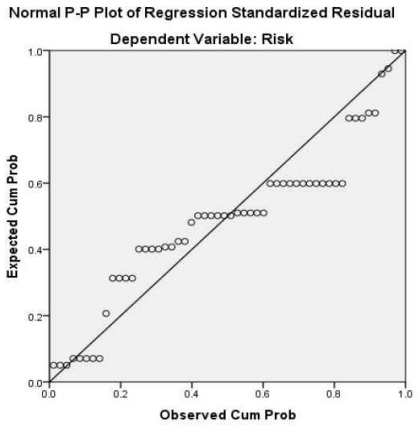


Figure 5- O2.1: Service Life of Building Components normal Predicted Probability of the residual.

3- **Building Components' Eco-Costs**:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.605, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.605 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.886, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.886 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O3.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O3.1} = -14.620 + 0.312\, X_{prob} + 0.499\, X_{imp} \quad \text{(Eq.5-O3)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O3 is equal to **17.3%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O3.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 88.5% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	17.31	15.076	54
Probability	50.65	16.329	54
Impact	32.31	23.212	54

Table 5- O3.1: Building Components' Eco-Costs Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.605**	.886**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.605**	1	.347*
	Sig. (2-tailed)	.000		.010
	N	54	54	54
Impact	Pearson Correlation	.886**	.347*	1
	Sig. (2-tailed)	.000	.010	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- O3.2: Building Components' Eco-Costs Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10659.473	2	5329.737	196.091	.000[b]
	Residual	1386.175	51	27.180		
	Total	12045.648	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O3.3: Building Components' Eco-Costs linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-14.620	2.344		-6.237	.000
	Probability	.312	.047	.338	6.675	.000
	Impact	.499	.033	.768	15.164	.000

a. Dependent Variable: Risk

Table 5- O3.4: Building Components' Eco-Costs regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.26	48.71	17.31	14.182	54
Residual	-20.415	11.292	.000	5.114	54
Std. Predicted Value	-1.240	2.214	.000	1.000	54
Std. Residual	-3.916	2.166	.000	.981	54

a. Dependent Variable: Risk

Table 5- O3.6: Building Components' Eco-Costs Regression Residuals Statistics showing the Mean value of population Error.

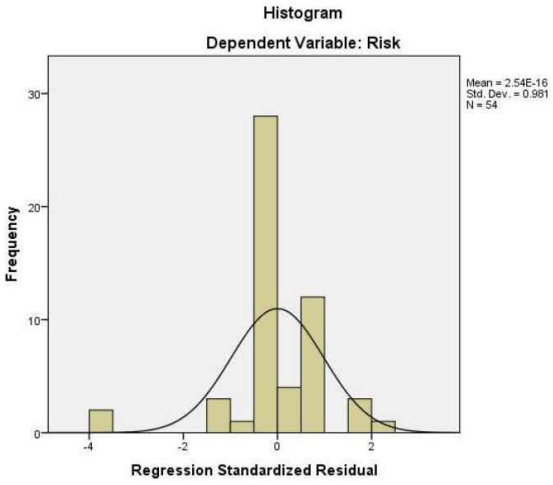


Figure 5- O3.3: Normality of Building Components' Eco-Costs Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.941[a]	.885	.880	5.213	1.858

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O3.5: Building Components' Eco-Costs regression Model Summary showing how much in percentage (%) the population is represented by the

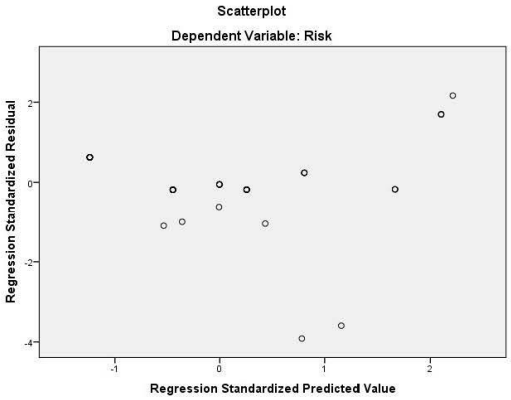


Figure 5- O3.2: Homoscedasticity Building Components' Eco-Costs normal Error (i.e. Constant Variance).

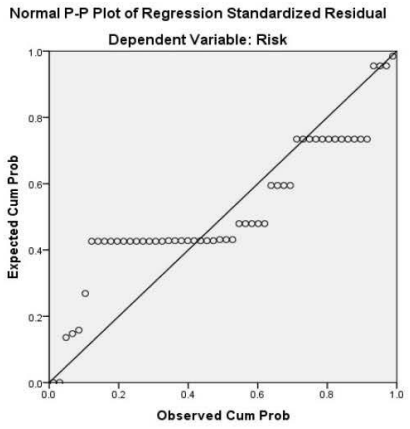


Figure 5- O3.1: Building Components' Eco-Costs normal Predicted Probability of the residual.

4- **Asset Operation Eco-Costs**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.604, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.604 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.918, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.918 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O4.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O4.1} = -13.456 + 0.272\, X_{prob} + 0.544\, X_{imp} \quad \text{(Eq.5-O4)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O4 is equal to **18.4%.** This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O4.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 93.9% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	18.35	14.947	54
Probability	52.37	18.178	54
Impact	32.28	22.132	54

Table 5- O4.1: Asset Operation Eco-Costs Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.604**	.918**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.604**	1	.339*
	Sig. (2-tailed)	.000		.012
	N	54	54	54
Impact	Pearson Correlation	.918**	.339*	1
	Sig. (2-tailed)	.000	.012	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- O4.2: Asset Operation Eco-Costs Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11116.044	2	5558.022	391.372	.000[b]
	Residual	724.271	51	14.201		
	Total	11840.315	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O4.3: Asset Operation Eco-Costs linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-13.456	1.599		-8.414	.000
	Probability	.272	.030	.331	8.990	.000
	Impact	.544	.025	.805	21.881	.000

a. Dependent Variable: Risk

Table 5- O4.4: Asset Operation Eco-Costs regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.15	50.47	18.35	14.482	54
Residual	-14.222	9.533	.000	3.697	54
Std. Predicted Value	-1.257	2.218	.000	1.000	54
Std. Residual	-3.774	2.530	.000	.981	54

a. Dependent Variable: Risk

Table 5- O4.6: Asset Operation Eco-Costs Regression Residuals Statistics showing the Mean value of population Error.

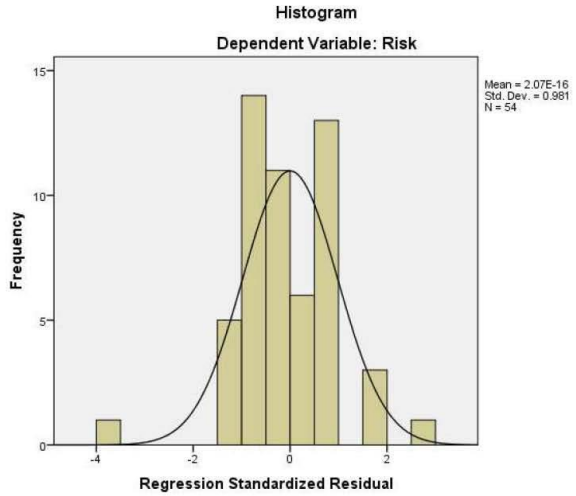


Figure 5- O4.3: Normality of Asset Operation Eco-Costs Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.969[a]	.939	.936	3.768	1.975

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O4.5: Asset Operation Eco-Costs regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

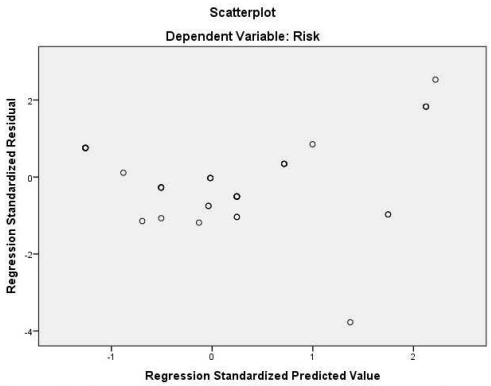


Figure 5- O4.2: Homoscedasticity Asset Operation Eco-Costs normal Error (i.e. Constant Variance).

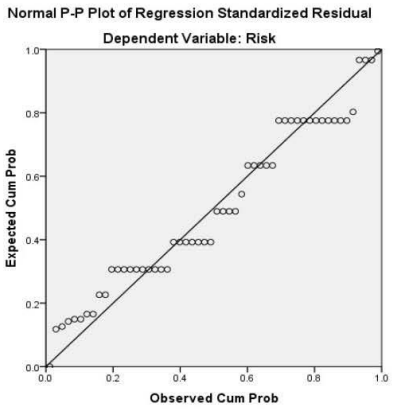


Figure 5- O4.1: Asset Operation Eco-Costs normal Predicted Probability of the residual.

5- **Disposal Eco-Costs**:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.653, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.653 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.950, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.950 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O5.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O5.1} = -11.825 + 0.247 X_{prob} + 0.549 X_{imp} \quad \text{(Eq.5-O5)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O5 is equal to **16.1%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O5.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.8% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	16.09	15.966	54
Probability	47.37	17.136	54
Impact	29.54	24.014	54

Table 5- O5.1: Disposal Eco-Costs Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.653**	.950**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.653**	1	.469**
	Sig. (2-tailed)	.000		.000
	N	54	54	54
Impact	Pearson Correlation	.950**	.469**	1
	Sig. (2-tailed)	.000	.000	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- O5.2: Disposal Eco-Costs Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12942.820	2	6471.410	581.349	.000[b]
	Residual	567.717	51	11.132		
	Total	13510.537	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O5.3: Disposal Eco-Costs linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-11.825	1.346		-8.784	.000
	Probability	.247	.030	.265	8.152	.000
	Impact	.549	.022	.826	25.412	.000

a. Dependent Variable: Risk

Table 5- O5.4: Disposal Eco-Costs regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-3.86	50.63	16.09	15.627	54
Residual	-8.612	9.371	.000	3.273	54
Std. Predicted Value	-1.277	2.210	.000	1.000	54
Std. Residual	-2.581	2.809	.000	.981	54

a. Dependent Variable: Risk

Table 5- O5.6: Disposal Eco-Costs Regression Residuals Statistics showing the Mean value of population Error.

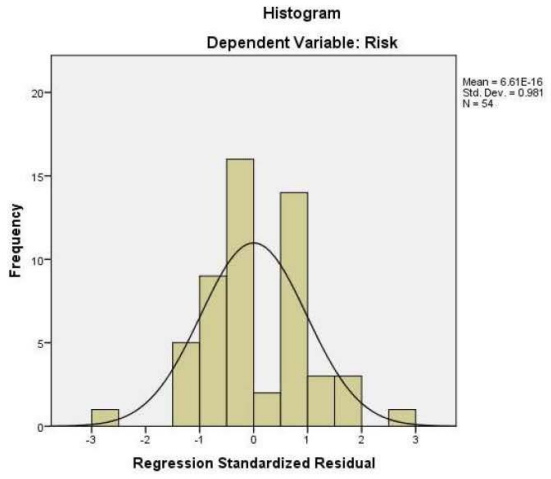


Figure 5- O5.3: Normality of Disposal Eco-Costs Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.979[a]	.958	.956	3.336	1.768

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O5.5: Disposal Eco-Costs regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

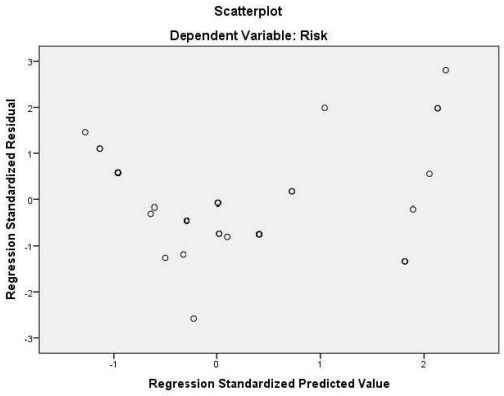


Figure 5- O5.2: Homoscedasticity Disposal Eco-Costs normal Error (i.e. Constant Variance).

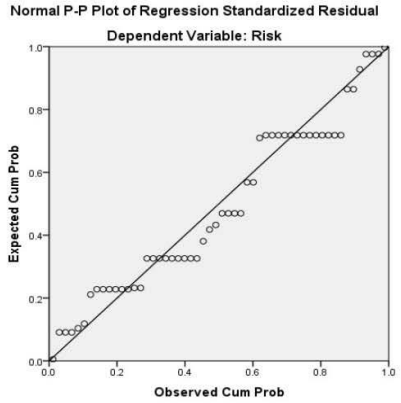


Figure 5- O5.1: Disposal Eco-Costs normal Predicted Probability of the residual.

6- Components' Deterioration Rate:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.747, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.747 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.921, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.921 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O6.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O6.1} = -15.652 + 0.329 X_{prob} + 0.553 X_{imp} \quad \text{(Eq.5-O6)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O6 is equal to **17.5%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O6.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94 % of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	17.54	17.103	54
Probability	48.74	18.636	54
Impact	31.00	22.571	54

Table 5- O6.1: Components' Deterioration Rate Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.747**	.921**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.747**	1	.532**
	Sig. (2-tailed)	.000		.000
	N	54	54	54
Impact	Pearson Correlation	.921**	.532**	1
	Sig. (2-tailed)	.000	.000	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- O6.2: Components' Deterioration Rate Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14569.644	2	7284.822	397.872	.000[b]
	Residual	933.782	51	18.309		
	Total	15503.426	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O6.3: Components' Deterioration Rate linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-15.652	1.644		-9.522	.000
	Probability	.329	.037	.359	8.839	.000
	Impact	.553	.031	.730	17.976	.000

a. Dependent Variable: Risk

Table 5- O6.4: Components' Deterioration Rate regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-6.83	58.22	17.54	16.580	54
Residual	-13.458	13.785	.000	4.197	54
Std. Predicted Value	-1.470	2.453	.000	1.000	54
Std. Residual	-3.145	3.222	.000	.981	54

a. Dependent Variable: Risk

Table 5- O6.6: Components' Deterioration Rate Regression Residuals Statistics showing the Mean value of population Error.

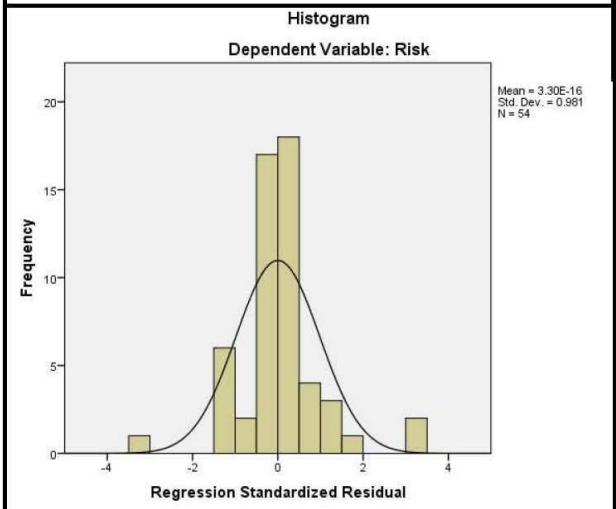


Figure 5- O6.3: Normality of Components' Deterioration Rate Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.969[a]	.940	.937	4.279	2.305

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O6.5: Components' Deterioration Rate regression Model Summary showing how much in percentage (%) the population is represented by the

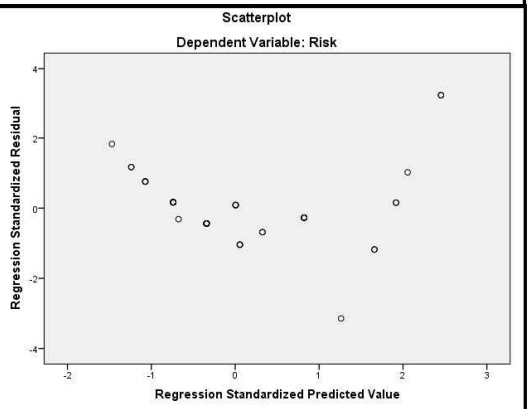


Figure 5- O6.2: Homoscedasticity Components' Deterioration Rate normal Error (i.e. Constant Variance).

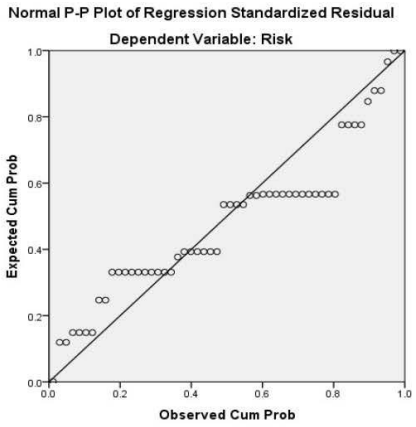


Figure 5- O6.1: Components' Deterioration Rate normal Predicted Probability of the residual.

7- **Fabric Maintenance**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.402, P-value= 0.003 (P-value < α), So H_O is ***Rejected***.
- r= 0.402 (0.3 to 0.5), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.919, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.919 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O7.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O7.1} = -14.582 + 0.277\, X_{prob} + 0.535\, X_{imp} \quad \text{(Eq.5-O7)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O7 is equal to **16 %**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O7.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 92.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	16.02	13.216	54
Probability	53.81	17.281	54
Impact	29.37	21.558	54

Table 5- O7.1: Fabric Maintenance Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.402**	.890**
	Sig. (2-tailed)		.003	.000
	N	54	54	54
Probability	Pearson Correlation	.402**	1	.046
	Sig. (2-tailed)	.003		.740
	N	54	54	54
Impact	Pearson Correlation	.890**	.046	1
	Sig. (2-tailed)	.000	.740	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- O7.2: Fabric Maintenance Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8536.240	2	4268.120	302.014	.000[b]
	Residual	720.742	51	14.132		
	Total	9256.981	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O7.3: Fabric Maintenance linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-14.582	1.801		-8.096	.000
	Probability	.277	.030	.362	9.245	.000
	Impact	.535	.024	.873	22.320	.000

a. Dependent Variable: Risk

Table 5- O7.4: Fabric Maintenance regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.93	53.12	16.02	12.691	54
Residual	-12.529	18.879	.000	3.688	54
Std. Predicted Value	-1.336	2.924	.000	1.000	54
Std. Residual	-3.333	5.022	.000	.981	54

a. Dependent Variable: Risk

Table 5- O7.6: Fabric Maintenance Regression Residuals Statistics showing the Mean value of population Error.

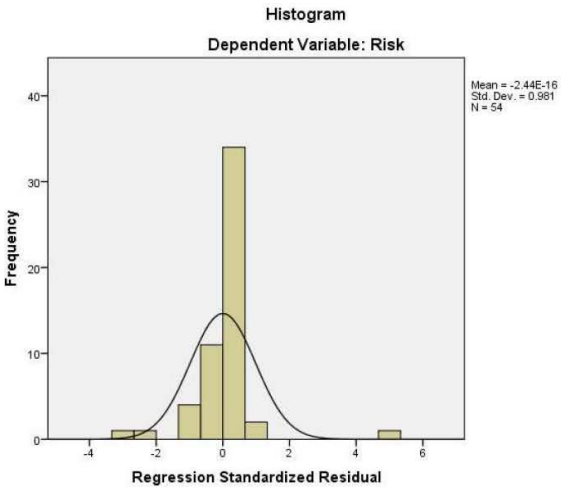


Figure 5- O7.3: Normality of Fabric Maintenance Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.960[a]	.922	.919	3.759	2.388

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O7.5: Fabric Maintenance regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

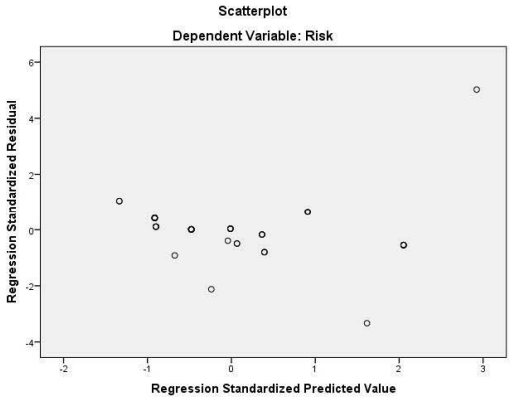


Figure 5- O7.2: Homoscedasticity Fabric Maintenance normal Error (i.e. Constant Variance).

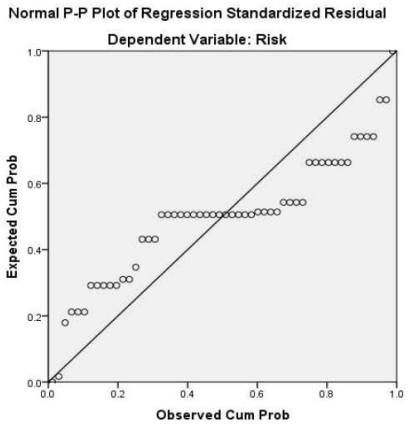


Figure 5- O7.1: Fabric Maintenance normal Predicted Probability of the residual.

8- **Services**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_0: ρ = 0, (i.e. No Correlation between variables),
H_1: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.461, P-value= 0.000 (P-value < α), So H_0 is ***Rejected***.
- r= 0.461 (0.3 to 0.5), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.930, P-value= 0.000 (P-value < α), So H_0 is ***Rejected***.
- r= 0.930 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O8.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O8.1} = -14.609 + 0.252\, X_{prob} + 0.596\, X_{imp} \quad \text{(Eq.5-O8)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O8 is equal to **21.9%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O8.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 93.4% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	21.93	15.286	54
Probability	59.78	16.213	54
Impact	36.02	22.339	54

Table 5- O8.1: Services Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.461**	.930**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.461**	1	.223
	Sig. (2-tailed)	.000		.106
	N	54	54	54
Impact	Pearson Correlation	.930**	.223	1
	Sig. (2-tailed)	.000	.106	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- O8.2: Services Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11562.360	2	5781.180	358.973	.000[b]
	Residual	821.343	51	16.105		
	Total	12383.704	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O8.3: Services linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-14.609	2.152		-6.790	.000
	Probability	.252	.035	.267	7.229	.000
	Impact	.596	.025	.871	23.545	.000

a. Dependent Variable: Risk

Table 5- O8.4: Services regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-1.09	51.97	21.93	14.770	54
Residual	-19.096	8.026	.000	3.937	54
Std. Predicted Value	-1.558	2.034	.000	1.000	54
Std. Residual	-4.758	2.000	.000	.981	54

a. Dependent Variable: Risk

Table 5- O8.6: Services Regression Residuals Statistics showing the Mean value of population Error.

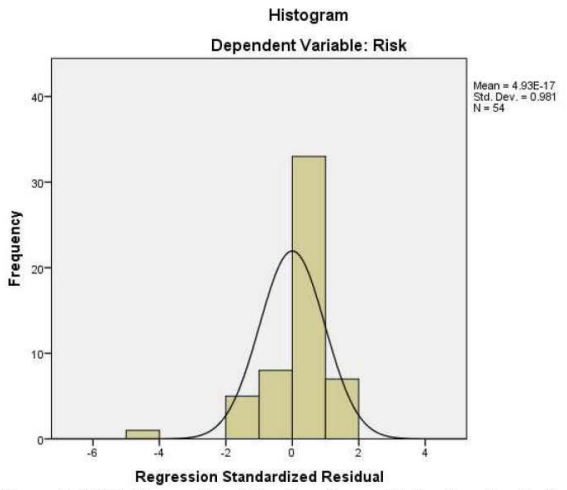


Figure 5- O8.3: Normality of Services Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.966[a]	.934	.931	4.013	1.639

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O8.5: Services regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

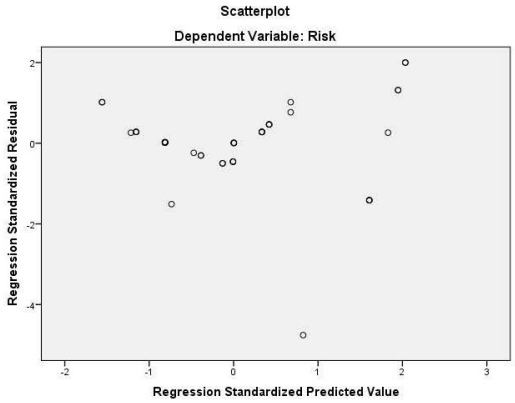


Figure 5- O8.2: Homoscedasticity Services normal Error (i.e. Constant Variance).

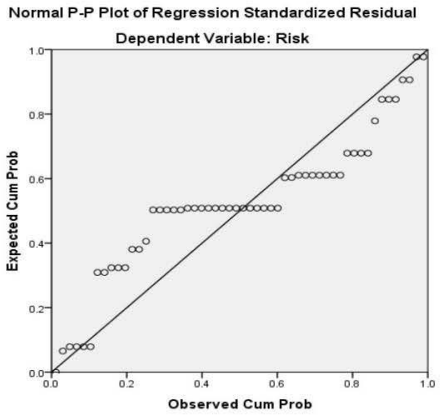


Figure 5- O8.1: Services normal Predicted Probability of the residual.

9- **Equipment's Maintenance**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.494, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.494 (0.3 to 0.5), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.935, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.935 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O9.1b} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O9.1b} = -16.289 + 0.305 X_{prob} + 0.558 X_{imp} \quad \text{(Eq.5-O9b)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O9b is equal to **21.9%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O9.5b, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 97.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	21.88	13.414	51
Probability	57.71	14.346	51
Impact	36.90	20.989	51

Table 5- O9.1b: Equipment's Maintenance Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.494**	.935**
	Sig. (2-tailed)		.000	.000
	N	51	51	51
Probability	Pearson Correlation	.494**	1	.192
	Sig. (2-tailed)	.000		.177
	N	51	51	51
Impact	Pearson Correlation	.935**	.192	1
	Sig. (2-tailed)	.000	.177	
	N	51	51	51

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- O9.2b: Equipment's Maintenance Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8788.182	2	4394.091	1008.627	.000[b]
	Residual	209.112	48	4.357		
	Total	8997.294	50			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O9.3b: Equipment's Maintenance linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-16.289	1.258		-12.947	.000
	Probability	.305	.021	.326	14.544	.000
	Impact	.558	.014	.872	38.906	.000

a. Dependent Variable: Risk

Table 5- O9.4b: Equipment's Maintenance regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-1.57	49.66	21.88	13.258	51
Residual	-4.306	6.339	.000	2.045	51
Std. Predicted Value	-1.769	2.095	.000	1.000	51
Std. Residual	-2.063	3.037	.000	.980	51

a. Dependent Variable: Risk

Table 5- O9.6b: Equipment's Maintenance Regression Residuals Statistics showing the Mean value of population Error.

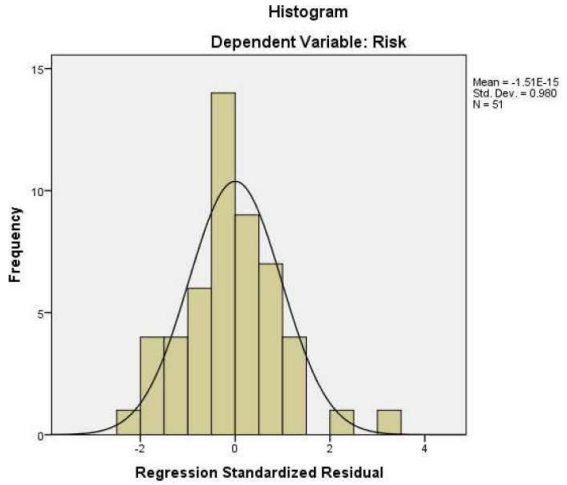


Figure 5- O9.3b: Normality of Equipment's Maintenance Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.988[a]	.977	.976	2.087	1.914

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O9.5b: Equipment's Maintenance regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

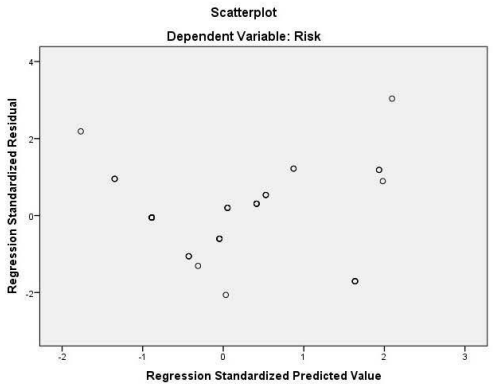


Figure 5- O9.2b: Homoscedasticity Equipment's Maintenance normal Error (i.e. Constant Variance).

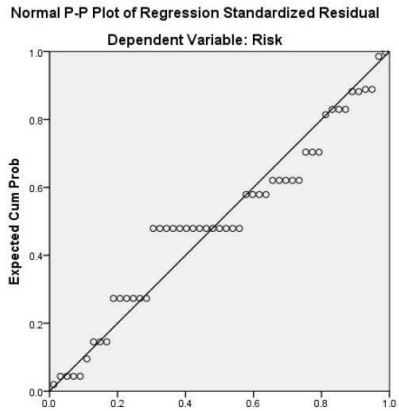


Figure 5- O9.1b: Equipment's Maintenance normal Predicted Probability of the residual.

10- **Overheads**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.308, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.308 (0.3 to 0.5), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.918, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.918 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O10.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O10.1} = -21.626 + 0.349 X_{prob} + 0.615 X_{imp} \quad \text{(Eq.5-O10)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O10 is equal to **20.6%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O10.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 95.4% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	20.56	17.649	54
Probability	60.35	16.778	54
Impact	34.28	26.582	54

Table 5- O10.1: Overheads Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.308*	.918**
	Sig. (2-tailed)		.023	.000
	N	54	54	54
Probability	Pearson Correlation	.308*	1	-.026
	Sig. (2-tailed)	.023		.854
	N	54	54	54
Impact	Pearson Correlation	.918**	-.026	1
	Sig. (2-tailed)	.000	.854	
	N	54	54	54

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- O10.2: Overheads Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15746.378	2	7873.189	526.286	.000[b]
	Residual	762.955	51	14.960		
	Total	16509.333	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O10.3: Overheads linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-21.626	2.114		-10.231	.000
	Probability	.349	.032	.332	11.030	.000
	Impact	.615	.020	.927	30.784	.000

a. Dependent Variable: Risk

Table 5- O10.4: Overheads regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-4.99	59.05	20.56	17.237	54
Residual	-14.092	12.946	.000	3.794	54
Std. Predicted Value	-1.482	2.234	.000	1.000	54
Std. Residual	-3.643	3.347	.000	.981	54

a. Dependent Variable: Risk

Table 5- O10.6: Equipment's Maintenance Regression Residuals Statistics showing the Mean value of population Error.

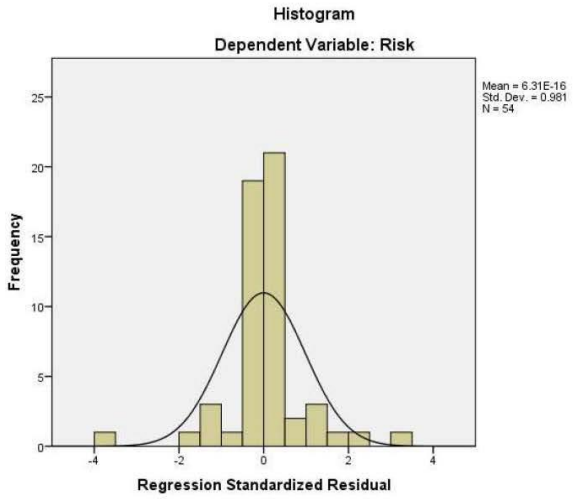


Figure 5- O10.3: Normality of Overheads Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.977[a]	.954	.952	3.868	1.778

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O10.5: Overheads regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

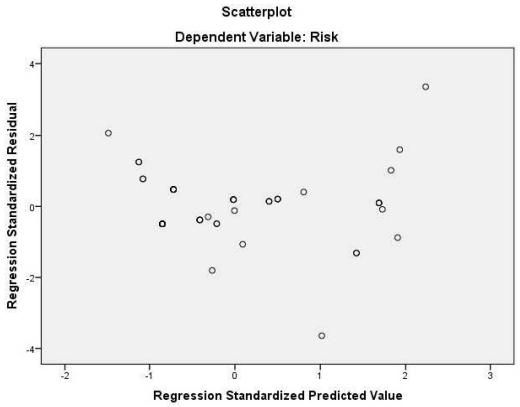


Figure 5- O10.2: Homoscedasticity Overheads normal Error (i.e. Constant Variance).

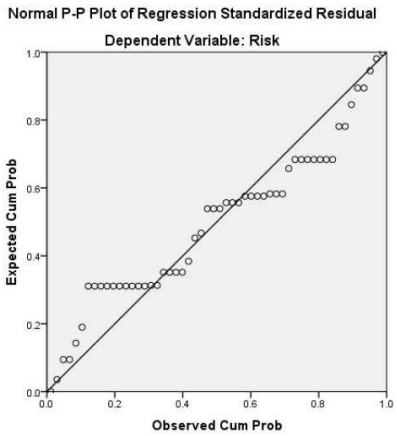


Figure 5- O10.1: Overheads normal Predicted Probability of the residual.

11- **Utilities**:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.209, P-value= 0.129 (P-value > α), So H_i is ***Rejected***.
- r= 0.209 (<0.3), indicate that a no linear relationship exist between Risk and Probability variables.
- Therefore, there is no evidence prove that between Risk and Probability Correlation Exists but it may be proved in the regression analysis.

Risk vs. Impact:

- r= 0.933, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.933 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O11.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O11.1} = -16.552 + 0.294 X_{prob} + 0.554 X_{imp} \quad \text{(Eq.5-O11)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O11 is equal to **22.8%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O11.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 96.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	22.81	14.523	54
Probability	57.04	14.950	54
Impact	40.74	25.216	54

Table 5- O11.1: Utilities Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.209	.933**
	Sig. (2-tailed)		.129	.000
	N	54	54	54
Probability	Pearson Correlation	.209	1	-.097
	Sig. (2-tailed)	.129		.483
	N	54	54	54
Impact	Pearson Correlation	.933**	-.097	1
	Sig. (2-tailed)	.000	.483	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- O11.2: Utilities Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10749.885	2	5374.942	640.078	.000[b]
	Residual	428.263	51	8.397		
	Total	11178.148	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O11.3: Utilities linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-16.552	1.759		-9.411	.000
	Probability	.294	.027	.303	10.996	.000
	Impact	.554	.016	.963	34.957	.000

a. Dependent Variable: Risk

Table 5- O11.4: Overheads regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3.36	49.87	22.81	14.242	54
Residual	-6.467	10.134	.000	2.843	54
Std. Predicted Value	-1.366	1.899	.000	1.000	54
Std. Residual	-2.232	3.497	.000	.981	54

a. Dependent Variable: Risk

Table 5- O11.6: Equipment's Maintenance Regression Residuals Statistics showing the Mean value of population Error.

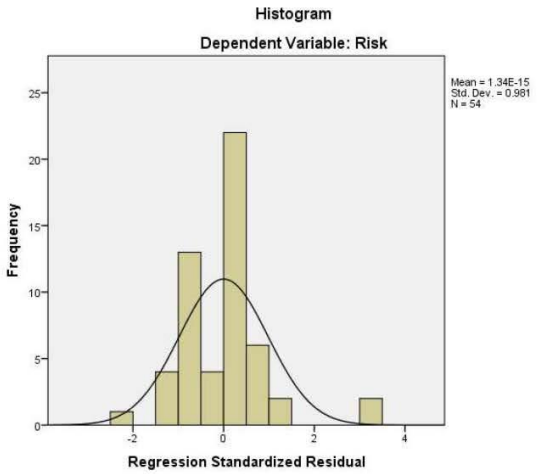


Figure 5- O11.3: Normality of Overheads Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.981[a]	.962	.960	2.898	2.303

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O11.5: Overheads regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

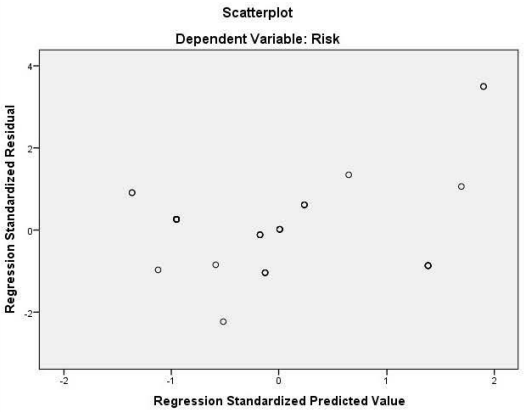


Figure 5- O11.2: Homoscedasticity Overheads normal Error (i.e. Constant Variance).

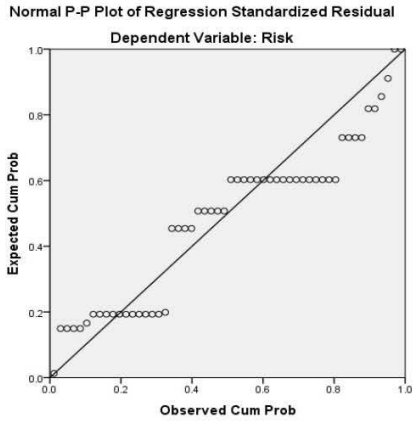


Figure 5- O11.1: Overheads normal Predicted Probability of the residual.

12- **Cleaning**:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.408, P-value= 0.002 (P-value < α), So H_O is ***Rejected***.
- r= 0.408 (0.3 to 0.5), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.802, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.802 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O12.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O12.1} = -14.313 + 0.285 X_{prob} + 0.480 X_{imp} \quad \text{(Eq.5-O12)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O12 is equal to **15.1%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O12.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 83.6% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	15.09	12.363	54
Probability	53.00	19.058	54
Impact	29.81	21.101	54

Table 5- O12.1: Cleaning Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.408**	.802**
	Sig. (2-tailed)		.002	.000
	N	54	54	54
Probability	Pearson Correlation	.408**	1	-.038
	Sig. (2-tailed)	.002		.782
	N	54	54	54
Impact	Pearson Correlation	.802**	-.038	1
	Sig. (2-tailed)	.000	.782	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- O12.2: Cleaning Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6772.347	2	3386.173	130.023	.000[b]
	Residual	1328.190	51	26.043		
	Total	8100.537	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O12.3: Cleaning linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-14.313	2.328		-6.148	.000
	Probability	.285	.037	.439	7.739	.000
	Impact	.480	.033	.819	14.435	.000

a. Dependent Variable: Risk

Table 5- O12.4: Overheads regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.97	45.44	15.09	11.304	54
Residual	-18.927	14.557	.000	5.006	54
Std. Predicted Value	-1.421	2.685	.000	1.000	54
Std. Residual	-3.709	2.853	.000	.981	54

a. Dependent Variable: Risk

Table 5- O12.6: Equipment's Maintenance Regression Residuals Statistics showing the Mean value of population Error.

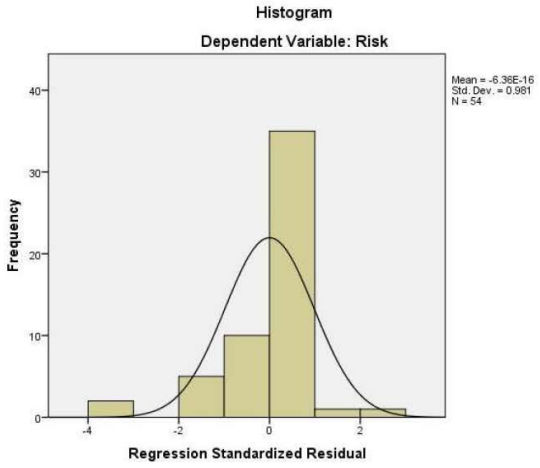


Figure 5- O12.3: Normality of Overheads Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.914[a]	.836	.830	5.103	1.901

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O12.5: Overheads regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

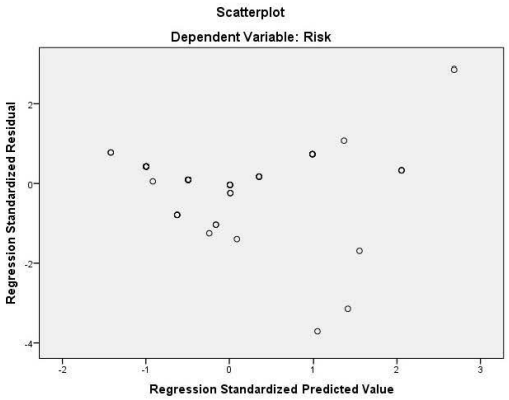


Figure 5- O12.2: Homoscedasticity Overheads normal Error (i.e. Constant Variance).

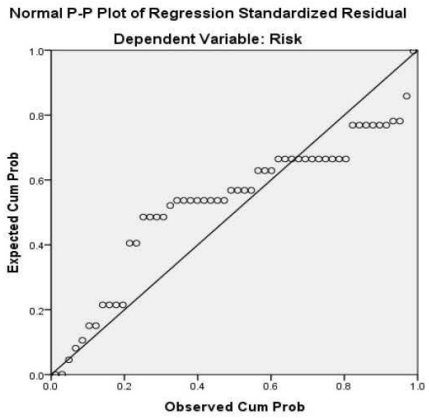


Figure 5- O12.1: Overheads normal Predicted Probability of the residual.

13- Percentage of Current Replacement Value:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_o: ρ = 0, (i.e. No Correlation between variables),
H_i: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.396, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.396 (0.3 to 0.5), indicate that a positive weak linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.915, P-value= 0.000 (P-value < α), So H_o is ***Rejected***.
- r= 0.915 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O13.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O13.1} = -15.053 + 0.287 X_{prob} + 0.539 X_{imp} \quad \text{(Eq.5-O13)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O13 is equal to **17.8%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O13.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 97.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	17.76	14.762	54
Probability	53.07	16.018	54
Impact	32.59	24.265	54

Table 5- O13.1: Percentage of Current Replacement Value Data Descriptive Statistics of Risk, Probability and Impact Variables.

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.396**	.915**
	Sig. (2-tailed)		.003	.000
	N	54	54	54
Probability	Pearson Correlation	.396**	1	.095
	Sig. (2-tailed)	.003		.493
	N	54	54	54
Impact	Pearson Correlation	.915**	.095	1
	Sig. (2-tailed)	.000	.493	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- O13.2: Percentage of Current Replacement Value Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10785.738	2	5392.869	359.933	.000[b]
	Residual	764.132	51	14.983		
	Total	11549.870	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O13.3: Percentage of Current Replacement Value linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-15.053	1.919		-7.844	.000
	Probability	.287	.033	.312	8.620	.000
	Impact	.539	.022	.885	24.470	.000

a. Dependent Variable: Risk

Table 5- O13.4: Overheads regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-3.74	49.60	17.76	14.266	54
Residual	-12.661	10.403	.000	3.797	54
Std. Predicted Value	-1.507	2.232	.000	1.000	54
Std. Residual	-3.271	2.688	.000	.981	54

a. Dependent Variable: Risk

Table 5- O13.6: Equipment's Maintenance Regression Residuals Statistics showing the Mean value of population Error.

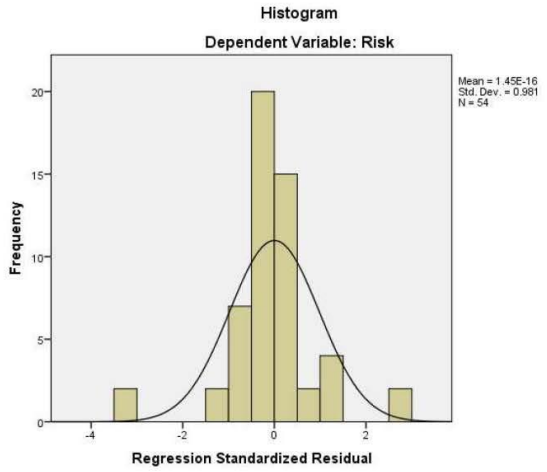


Figure 5- O13.3: Normality of Overheads Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.966[a]	.934	.931	3.871	2.041

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O13.5: Overheads regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

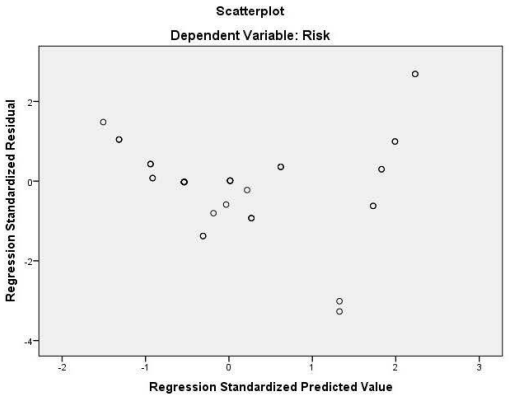


Figure 5- O13.2: Homoscedasticity Overheads normal Error (i.e. Constant Variance).

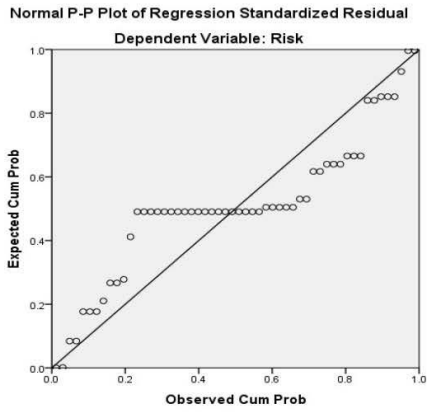


Figure 5- O13.1: Overheads normal Predicted Probability of the residual.

14- Ratio of Maintenance to Capital Cost:

Correlation Analysis:

Let, **ρ** represent the Correlation of Pearson Population, then
H_0: $\rho = 0$, (i.e. No Correlation between variables),
H_1: $\rho \neq 0$, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.547, P-value= 0.000 (P-value < α), So H_0 is ***Rejected***.
- r= 0.547 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.908, P-value= 0.000 (P-value < α), So H_0 is ***Rejected***.
- r= 0.908 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O14.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O14.1} = -14.588 + 0.291 X_{prob} + 0.538 X_{imp} \quad \text{(Eq.5-O14)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O14 is equal to **19.2%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O14.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.2% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	19.19	15.857	54
Probability	52.35	19.217	54
Impact	34.44	24.326	54

Table 5- O14.1: Ratio of Maintenance to Capital Cost Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.547**	.908**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.547**	1	.235
	Sig. (2-tailed)	.000		.087
	N	54	54	54
Impact	Pearson Correlation	.908**	.235	1
	Sig. (2-tailed)	.000	.087	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5- O14.2: Ratio of Maintenance to Capital Cost Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12558.219	2	6279.109	417.011	.000[b]
	Residual	767.929	51	15.057		
	Total	13326.148	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O14.3: Ratio of Maintenance to Capital Cost linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-14.588	1.603		-9.103	.000
	Probability	.291	.029	.353	10.206	.000
	Impact	.538	.023	.825	23.859	.000

a. Dependent Variable: Risk

Table 5- O14.4: Overheads regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-6.30	50.28	19.19	15.393	54
Residual	-13.178	9.717	.000	3.806	54
Std. Predicted Value	-1.655	2.020	.000	1.000	54
Std. Residual	-3.396	2.504	.000	.981	54

a. Dependent Variable: Risk

Table 5- O14.6: Equipment's Maintenance Regression Residuals Statistics showing the Mean value of population Error.

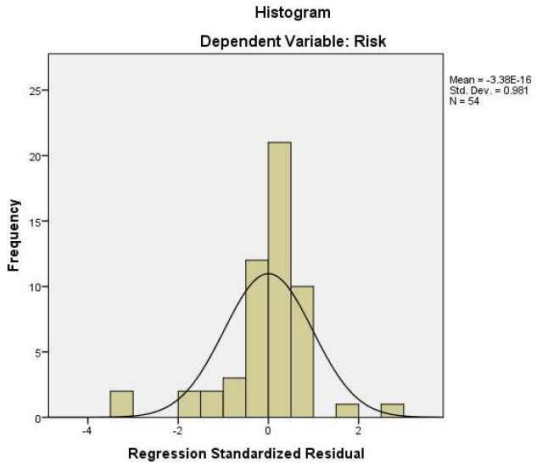


Figure 5- O14.3: Normality of Overheads Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.971[a]	.942	.940	3.880	2.123

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O14.5: Overheads regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

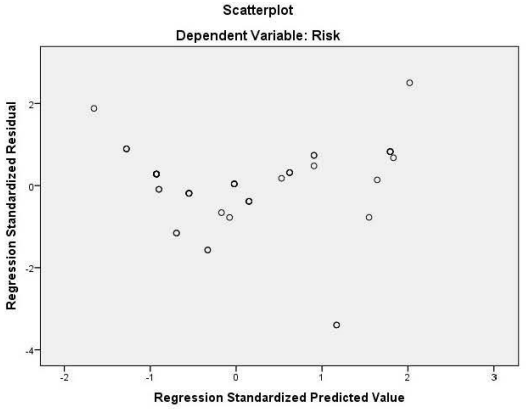


Figure 5- O14.2: Homoscedasticity Overheads normal Error (i.e. Constant Variance).

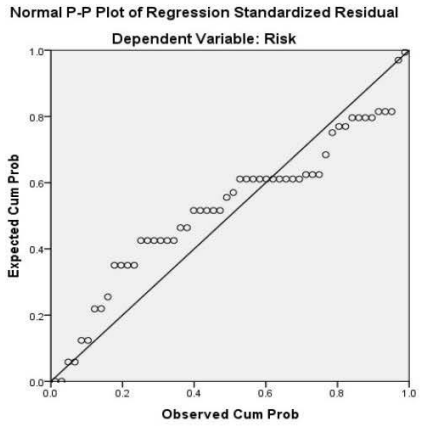


Figure 5- O14.1: Overheads normal Predicted Probability of the residual.

15- Ratio of Operation to Capital Cost:

Correlation Analysis:

Let, ρ represent the Correlation of Pearson Population, then
H_O: ρ = 0, (i.e. No Correlation between variables),
H_I: ρ ≠ 0, (i.e. Correlation is available between variables)

Risk vs. Probability:

- r= 0.617, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.617 (0.5 to 0.7), indicate that a positive moderate linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Risk vs. Impact:

- r= 0.894, P-value= 0.000 (P-value < α), So H_O is ***Rejected***.
- r= 0.894 (> 0.7), indicate that a positive strong linear relationship exist between Risk and Probability variables.
- Therefore, there are enough evidence that between Risk and Probability Correlation Exists.

Regression Analysis:

All regression Error assumptions validation of table 5-1 has been completed through the tables and figures shown in this section.

Based on Eq. 5-1, the final Project Selection Method regression equation will be as the following:

$$Y_{O15.1} = \beta_0 + \beta_{prob} X_{prob} + \beta_{imp} X_{imp} + \xi$$

$$Y_{O15.1} = -17.726 + 0.363\, X_{prob} + 0.525\, X_{imp} \quad \text{(Eq.5-O15)}$$

The Risk of changing the project cost/unit of Project Selection Method variable using Eq.5-O15 is equal to **22.2%**. This result shall be reflected in the systems dynamics model equations due to Durbin-Watson Value.

- Finally, from Table 5-O15.5, the Durbin-Watson is between 1.5 and 2.5; hence, there is no auto correlated data.
- This Model is reflecting 94.7% of the studied population.

Descriptive Statistics

	Mean	Std. Deviation	N
Risk	22.22	16.769	54
Probability	52.15	18.612	54
Impact	40.00	25.009	54

Table 5- O15.1: Ratio of Operation to Capital Cost Data Descriptive Statistics of Risk, Probability and Impact

Correlations

		Risk	Probability	Impact
Risk	Pearson Correlation	1	.617**	.894**
	Sig. (2-tailed)		.000	.000
	N	54	54	54
Probability	Pearson Correlation	.617**	1	.273*
	Sig. (2-tailed)	.000		.046
	N	54	54	54
Impact	Pearson Correlation	.894**	.273*	1
	Sig. (2-tailed)	.000	.046	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5- O15.2: Ratio of Operation to Capital Cost Correlation significance analysis of Risk, Probability and Impact Variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14138.404	2	7069.202	471.324	.000[b]
	Residual	764.929	51	14.999		
	Total	14903.333	53			

a. Dependent Variable: Risk

b. Predictors: (Constant), Impact, Probability

Table 5- O15.3: Ratio of Operation to Capital Cost linear regression significance analysis table of Risk, Probability and Impact Variables while Risk is dependent and probability and impact variables are independent.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-17.726	1.647		-10.763	.000
	Probability	.363	.030	.403	12.222	.000
	Impact	.525	.022	.783	23.754	.000

a. Dependent Variable: Risk

Table 5- O15.4: Overheads regression coefficients of Probability and Impact Variables.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-4.20	51.53	22.22	16.333	54
Residual	-11.190	8.469	.000	3.799	54
Std. Predicted Value	-1.618	1.794	.000	1.000	54
Std. Residual	-2.889	2.187	.000	.981	54

a. Dependent Variable: Risk

Table 5- O15.6: Equipment's Maintenance Regression Residuals Statistics showing the Mean value of population Error.

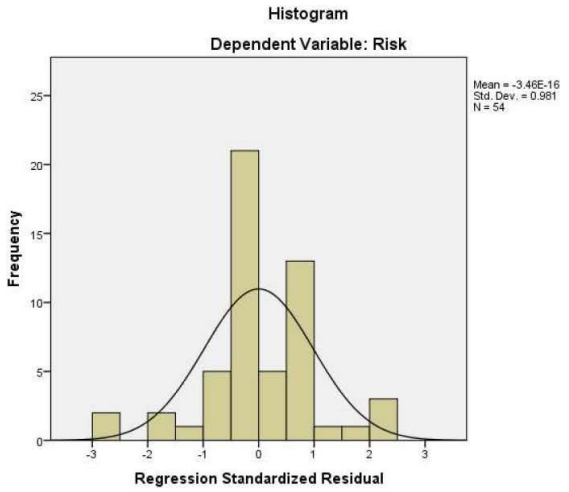


Figure 5- O15.3: Normality of Overheads Error distribution (i.e. Bell Shaped).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.974[a]	.949	.947	3.873	2.124

a. Predictors: (Constant), Impact, Probability

b. Dependent Variable: Risk

Table 5- O15.5: Overheads regression Model Summary showing how much in percentage (%) the population is represented by the integrated model.

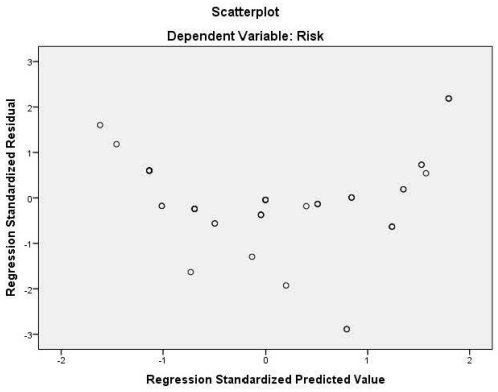


Figure 5- O15.2: Homoscedasticity Overheads normal Error (i.e. Constant Variance).

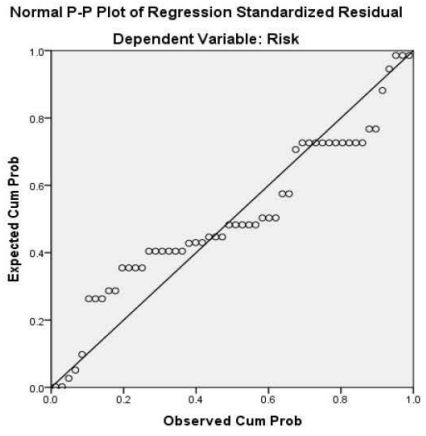


Figure 5- O15.1: Overheads normal Predicted Probability of the residual.