Modelling the final cost of construction projects in Kingdom of Bahrain

تطوير نموذج للتكاليف النهائية للمشاريع الانشائية في مملكة البحرين

by

BADER NASSER MOHAMMED

A dissertation submitted in fulfilment of the requirements for the degree of MSc PROJECT MANAGEMENT

at

The British University in Dubai

Professor Boussabaine Halim

October 2017

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that the content of this research is the direct result of my own work and that any use made in it of published or unpublished copyright material falls within the limits permitted by international copyright conventions.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

____

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 of Education 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

The report aimed at providing the insight towards the various factors in the construction industry which add up to the cost of the project. The report identifies the relation of the project cost with several factors which are considered to be dependable or independent. The research work recognizes the importance of every single dependent, and independent factor and the analysis based on data interpretation helped to locate the various areas which influence the overall project cost in the construction industry. For better vision to the effect on cost, the report submits the analytical data such as graphs and tables which were determined on researching over the base of previous research work.

نبذة مختصرة

يهدف التقرير إلى توفير نظرة ثاقبة للعوامل المختلفة في صناعة البناء والتي تضيف إلى تكلفة المشروع. يحدد التقرير علاقة تكلفة المشروع بعدة عوامل تعتبر موثوقة أو مستقلة. يدرك العمل البحثي أهمية كل عامل مستقل ، ومستقل ، والتحليل المستند إلى تفسير البيانات يساعد على تحديد المناطق المختلفة التي تؤثر على التكلفة الإجمالية للمشروع في صناعة البناء. من أجل رؤية أفضل للتأثير على التكلفة ، يقدم التقرير البيانات التحليلية مثل الرسوم البيانية والجداول التي تم تحديدها في البحث على أساس العمل البحثي السابق.

Acknowledgements

Praise be to the God and thank him for his blessings and mercy that helped me to complete this research successfully.

I would like to express my thanks and gratitude to my supervisor Dr. Halim Boussabaine for his supervision of the completion of this research. His recommendations and guidance have had great influence in overcoming the obstacles encountered during the research years. I am pleased that I was one of his master students who were under his supervision in the master stage to take advantage of the scientific expertise he possesses.

I dedicate this achievement to my dear mother, who always sent her prayers to me. She inspired me and tightened my determination to learn more.

Also I dedicate this achievement to my dear father who had drawn my way to the knowledge in the early stage of my life.

I extend my thanks to my wife, children and all members of my family for their support and encouragement.

And many thanks to Dr. Raed Hussain Abuzeyad, Dr. Amer Alaya and Khames Alshehyari for their appreciated support and corporation.

Finally, I thank all my colleagues and friends for their good handling, advice, and exchange of ideas during the study period.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

1.1 Introduction

This introductory chapter describes the research problem through introducing the contextual aspects of this research. The chapter further presents the research questions, aims, and objectives. The final section of this chapter provides an overview of this research and the structure of this thesis.

1.2 Research Context and Background Information

Variations in the construction context refer to the eventual differences in the planned and actual materialization of events (Kerzner, 2013). One common theme in the international construction sector has been the drive to pinpoint the causes of variations with a view to suggesting mitigations needed to avoid or minimize the consequences caused by variation (Kerzner, 2013; Alnuaimi et al., 2010; Arain and Pheng, 2005). As far as construction and engineering projects are concerned, the concept of variation in projects is still a challenging topic, not only to study and analyze but even to define.

Variation can be defined as the difference between the actually constructed works compared with that which was planned, e.g., according to a task's start time or its duration. Therefore, any alteration in the planned start time of a task and/or its construction time would inevitably disrupt other tasks as a result. Consequently, the quality and/or cost of the project could be effected. Thus any addition, removal or any other amendment to project objectives and scope of work is considered to be a variation (Ibbs et al., 2001). In an alternative definition, variation is a clause that describes any modification to the feature or volume of the works with respect to the original contract documents (Hibberd, 1986). Ayodele et al. (2008) cited that The Joint Contracts Tribunal (JCT) documents (1980), Standard Form of Contract for Building Works in Nigeria (1990) and Standard Form of Contract for Building and Engineering Works for Local

Government Councils in Nigeria (1996) define variation as the alteration or modification of the design, quality or quantity of the works as shown in the contract drawings.

Likewise, Bin-Ali et al (2008) clarified variation orders as "any deviation, i.e., alteration, addition or omission, from the contract with regard to contract drawings, specifications, and/or bills of quantities". Consequently, variation orders are issued after implementation of the contract to authorize a change in the work or an amendment in the contract quantity and/or the contract programme (Clough, 1994). Hence, this modification would amend the original agreement and is considered as an additional reference to the contractual relationship (O'Brien, 1998a). Therefore, in most construction projects certain boundaries should be agreed in relation to the total cost of the project to overcome any possible variation that could occur.

Ssegawa et al. (2002) further explained that it is hardly possible to finish a construction project without any variations in plans or the process of construction itself because of the complex activities taking place during construction. Moreover, Al-Dubaisi et al. (2000) described that variation orders are the principal reason for compromised performance in construction projects in Saudi Arabia. Variation in construction projects is almost inevitable (Aziz, 2012). It is emerging as a genuine cause of a number of problems in construction projects. These problems include delays that range from minor delays of a few months to major delays of more than double the original project duration. The problems also include surpassing the project budget. Delay and over-running the budget cause a range of negative consequences and could be massively significant, especially in construction projects relating to public sector services.

This study argues that projects cost variation can take place during all phases of a construction project and can be defined as any change during the project cycle that might affect the contracted cost, time or quality parameters. This work also assumes that variation in construction projects has four main sources – the client, the contractor, the consultant and external sources. This research explores the relationship between a selected dependent variable and independent variables using engineering modeling techniques for construction projects in the Kingdom of Bahrain.

Naturally, for a country to successfully accommodate an expansion in population, it needs to build different types of projects. These projects must not only take into consideration the needs of the intended users, but also the resources available to those ordering their creation. Certain variables accompany construction processes, whether they are material, such as money, or abstract, such as time, and inevitably lead to undesired consequences when they are breached. The Kingdom of Bahrain has a vibrant construction and engineering industry that executes assorted projects in various subsectors. This research, therefore, explores the projects price changes in construction projects, with a particular focus on construction projects in the Kingdom of Bahrain. The thrust of the research is to develop a model for analyzing the influence of Project Price on construction project outcomes in Kingdom of Bahrain for clients to use.

1.3 Research Statement

The problem for this research emanated from the gap in the literature on how to develop a model for analyzing the influence of Project Price on construction project outcomes in Kingdom of Bahrain for clients to use. The preliminary literature review found that there is a gap in estimating the influence of variation in construction projects regarding whether it has positive or negative impacts on project outcomes. This created a research necessary to develop a new model for analyzing the impact of cost overrun in construction projects, which could lead to a new contribution to the literature on the construction industry. From the onset, it is clearly known that variation can be the difference between the actual constructed work compared with what was scheduled in terms of a task's start time or its duration (Ibbset et al., 2001); variations are also known as any change to the basis on which the contract was signed '(Baxendale and Schofield, 1986; Bin-Ali, 2008; Oyewobi, 2015)'. Variation involves not only changes to the issues relating to the work according to the conditions of the contract but also changes to the working conditions themselves (Ssegawaet et al., 2002); meaning that 'any deviation i.e., alteration, addition or omission, during construction processes with regard to contracted drawings, specifications, and/or bills of quantities' (Bin-Ali, 2008). Deviations tend to be triggered by management decisions or actions (and inactions) by those responsible for managing projects. For instance, a variation in productivity can be calculated as the change in daily productivity and the baseline productivity (Hsiang et al., 2011). This shows that there is potential to incorporate variation models into the process of project budgeting, particularly in the contingency estimation of project risks.

Several recent studies have attempted to investigate cost overrun from different perspectives.

1.4 Research Aim

The main aim of the research is to establish a model that could be used to estimate the price of projects in construction projects in the Kingdom of Bahrain.

1.5 Research Objectives

- To investigate the relationship between the selected dependent variable and independent variables and their impacts on project success criteria of construction projects in the Kingdom of Bahrain.
- To develop a model for analyzing the influence of Project Price on construction project outcomes in Kingdom of Bahrain for clients to use.

1.6 Research Questions

The following research questions have been used as a guide to generate data necessary to achieve the aim:

- What is the relationship between a selected dependent variable and independent variables on a construction project in the Kingdom of Bahrain?

- How to develop a model for analyzing the influence of Project price on construction project outcomes in Kingdom of Bahrain for clients to use?

1.7 Research Methodology

29 completed case study projects were randomly collected from the database in Kingdom of Bahrain. The SPSS is a program available as a software package which enables the user to create a batched and unbatched statistical model for analyzing the influence of Project price on a construction project. The software package has similar products which are used for surveying, data collection or data mining for various construction projects. SPSS stands for Statistical Package for the Social Sciences, and it is a high utility program for creating statistical analysis between different factors on which project depends. SPSS results help in establishing the relationship between various factors to check their inter-dependency which can affect the contract details of the project and the infrastructure.

1.8 Structure of the Thesis

This thesis is divided into 4 chapters to cover the area of the topic clearly.

Chapter one introduces the research, explaining the background as well as the knowledge gap that was used as a motivation for the research. The chapter also examines the aim, objectives, and research questions.

Chapter two covers the most recent literature review topics that similar to the research topic.

Chapter three discusses the regression models, based on a case study of 29 projects in the Kingdom of Bahrain.

Chapter four reports discussion, chapter five is the conclusions and recommendations from the research, and the areas for future research.

CHAPTER TWO – Literature Review

There are different factors and elements that influence the cost of any construction contract. It has been analyzed that there are different factors associated with pre and post contract conditions in the Kingdom of Bahrain. Along with this, there are certain conditions that can help to model the cost associated. The literature review presents the different factors that impact the cost during both the pre-contract and post-contract timings.

Warsame, *(*2011*)* provided an overview of the construction industry and its role in the welfare of society as related to other industries. The main aim of this study contains two main objectives. Firstly, it attempts to explain the experimental disparity which increases the construction cost between big and small regions. Secondly, it focuses on explaining the level of quality problems in the infrastructure projects after the transfer of quality responsibilities and also suggests some procedures that could help to improve the quality of transferred projects. On the other hand, the author used to survey and interviews to collect the data concerning both the factors relating to housing construction i.e. cost and quality of projects. This research offers the understanding of the performance of contractors in commercial situations. It also provides the analysis of current understandings related to the Government structure and how it influences the construction cost. The author suggests that quality of infrastructure has not reduced after the transmission of superiority assurance from consumer to contractor. He argued that client or customer competence is important to build up the proper information management and training systems. For this, the purpose it suggests that retention of new skilled and experienced workers is an essential for continuous quality improvements so that goals and objectives can be achieved easily. The second opinion suggested in the research is that experts and committees have to be focused on the superiority aspect of the projects in the delivery of substructure transfer projects. Finally, the study demonstrates that without the client's capability and a company's ethos one could never create the right inducements for the work, any procurement method would help to guarantee the high quality of work which is helpful for the developing the new goals [1].

Ubani, K.A. Okorocha, K.A. Okorocha (2013) identified and examined the factors that influenced the time and cost under the construction projects in south eastern Nigeria. The study elaborates that high level of dereliction and worsening of roads and other construction infrastructural facilities are required to trait the performance of a construction project. For the better results, a survey technique for haphazard sampling procedures was used they defined will be necessary for the study. For this purpose, they proposed the methods of data analysis that helps to evaluate the factors, which affect the time and cost. These two methods were Spearman's rank correlation coefficient and Kendall's coefficient. Spearman’s rank correlation coefficient was used for the sample test, which helps to regulate the level of implication regarding the pair of project parties. On the other hand, Kendall’s coefficient helps to ascertain the degree in agreement among all the project parties. In their research, they also proposed some recommendations that would help to analyze those two factors. These recommendations are constructor should be aware of using the project material which is used in construction. It is the responsibility of the contractor to suggest the right quantity and quality material, which is used during the process. They have to avoid the shortage and surplus of materials so that it cannot affect the construction of the project. The final result shows that the substantial factors and exterior factors enormously postponements in the construction project. To complete the construction work in a better way, it is necessary that a contractor, as well as a consultant, uphold their responsibilities. There should be a contractual relationship for the cost overrun and time overrun. By evaluating these results, it is clear that client, contractor, and consultant must pay more attention to material and external factors so that the construction projects for the Gulf Corporation council will be done at the right time and cost [2].

Olawale, Y., and Sun M. ***(*****2010*****)*** explored the various control techniques and project control software for the work of construction. But the research was not successful to achieve the cost and time objectives during the working procedure. For this purpose, they conducted the research which helps to identify the causes of cost and time overruns. But there are limited research factors exhibiting to control the projects effectively. On the other hand, they advised that common factors constrain both time and cost during the overall procedure of construction projects. They have developed top five leading constraints factors that would help to evaluate the overall working procedure. Subsequently, they proposed 90 justifying measures, which are related to the design of the project, evaluating project time/ duration, difficulties and non-presentation of the subcontractors. It has been further classified that justifying measures into defensive, prognostic and remedial measures .is very necessary The authors used this as a specification of good practices, and this could also help the project managers to improve the effectiveness of the work. It also provided useful information about the issues, which mainly surrounds the projects. They also discussed the main issues that affect the overall construction such as time and cost control techniques, the frequency of time and cost overrun. For these types of issues, they suggested the above mitigating measures that can be used to resolve the issues. At the end, results show that effectiveness of these measures helps to control the processes. It also suggests the solution's control over these issues on the other hand, will also help to investigate further in this field [3].

Jennifer S. Shane, et al. ***(*****2015*****)*** represented the construction projects through the cost escalation factors. This research is a collection and classification of individual cost-related factors, which was depth through the-determined in literat .ure reviewThis research classified it with 20 state .primary factors that impact the cost of all types of the construction projects 18 .highway agenciesThese factors signify thedocumented causes which determined the cost Engineer address all the factors during the assessment of future cost .escalation problems related to any project and alsopursue to mitigate the effect of these factors which help in improving the accuracy of program budgets and cost estimates. Transportation projects have the long lead time between construction and planning of the project. In the United States, 50% of the large transportation have overrun their initial budgets. This research also reviewed many research projects, which result in increased cost of the project. In this research, many factors were determined which influence privately funded projects and their effects on the publicly funded projects. The public funds are very limited for several types of projects which create a backlog of the critical infrastructure needs. The result also shows that if the cost of any project exceeds its budget then other projects would be dropped from the program, which results in a decrease of the scope to provide the fund which is necessary to cover the growth. These types of actions intensify the weakening of a state's transportation infrastructure [4].

Zhao, L., Mbachu, J., & Domingo, N. (2017) demonstrated the exploratory factors. Which influence the building development costs in New Zealand. This research determines the cost drivers and also helps in improving the efficiency and effectiveness of any project. The result indicated that there are forty-five indicators, which influence the building development costs in New Zealand. These forty-five indicators were divided into seven categories. There are only three categories out of seven which are considered as the factors, which expressively impact the building development costs in New Zealand. The influencing factors for building development costs are general factors or specific factors of the particular project. Lack of the comprehensive list makes it difficult for the researchers to determine the movement of the building development costs. This research provides a framework, which classifies all the influencing factors and their impacts on the building development costs. With the help of questionnaire survey, ranking and determination of cost drivers are carried out, which are distributed to key professionals who are working in New Zealand construction industry. In this research, structural equation modeling (SEM) software was used for the analysis of the gathered data. The main advantage of this software was to provide the p-value according to research model structure. The result also demonstrated the major factors that affect the building development costs such as socioeconomic factors, statutory and regulatory factor, property market and construction industry factor in New Zealand [5].

Choon, T. T., Sim, L. C., & Connie, T. (2016) explained the influential factors in estimating and tendering the construction work. The main cost estimating issues investigated in the research include the cost overrun, estimating accuracy, cost bid decision, and cost estimation. Some factors also examine which influence the four MCEI i.e. external market conditions, contract procedures and procurement methods, project characteristics, contractor attributes, consultant and design parameters and client characteristics. Very less consideration is given to the comparison factors ranking across the four MECI. The results obtained from the comparing factor helps in improving the understanding of the cost estimating issues. The persistence of this research is to compare the ranking actor across four MECI and determining the degree of agreement between four sets of ranks for influential factors. The influential factors from previous research related to the various categories such as environment, contract, project, contractor, and consultant were considered in detail. For accessing inner judge reliability, Kendall's coefficient of concordance was used. The computed correlation shows the moderate degree of association among the four sets of ranks. The result indicated that four MECI were influenced by the various factors which have different ranks and they are treated as the different MECI, and they also managed differently [6].

Cheng, Y. (2014) presented the exploration of cost-influencing factors on the construction projects. The main issue in the construction industry is of construction cost overrun. The main aim of this research was to determine the cost-influencing factors with new concepts and methods that help in controlling the expenditure. In this research, the Modified Delphi Method (MDM) was used with two rounds and two groups. The first group helps in verifying all the views whereas the second group contains the experienced experts from the consulting firms, public sectors, and the several construction companies. Also, Kawakita Jiro method (KJ) was used to consolidate the opinion of experts and ranking the factors which affect the cost of the project. In this research, ninety-nine factors are gathered from several literature reviews with the expert's interview to control the practical cost control in the companies of construction. To consolidate these factors, KJ method was used which divide the factors into four categories. The analysis result indicated that there are 16 cost influencing factors. To rank the cost-influencing factors, severity index computation was used in this research. This research determined the scope of the project in the cost control and contract which are the main determinants of cost overrun [7].

Callegari, D. A., & Bastos, R. M. (2007) monitoring and described the cost-determining factors of an Infrastructure project. The main objective of this research was to analyze the cost benefit which precondition for all the project of infrastructure having the value of ECU 25 million or more than this value. The second objective was an evaluation of interim and ex-post of programs. The main purpose of the research was to provide the basic understanding of the process to desk officers which help in the cost estimation of the project so that they can be better review through the project sponsors. This research helps in solving the issues which were faced during implementation of major infrastructure projects at the time and given the cost. This research was divided into four section which described project development process, initial project cost and varying cost factor, various methods of controlling costs, and cost-appraisal and monitoring method. The method which is used for assisting desk officers is to compile some standards or unit costs for various types of infrastructure which involves the evaluation of the actual project turn cost for a different range of project types. This provides a standard against which desk officers can access revised and new project cost estimates. But this approach is rejected because it does not allow the variety of conditions under which projects were implemented in practice which includes topography, location, institutional differences and much more. In this research, the programmer and the project were monitored by the desk officers which helps in improving the overall development of project process. This research is used by officers who have the experience in various levels of project monitoring and program. This research helps in providing the more efficient evaluations within the available limited time. The result indicated that this guide also helps in resolving all the issues or problems which were related to time and cost overruns [8].

Allwright, A. and Oliver, R (2007) described the contract management. This guide also described all the activities which were related to the contract management. It also involves the formation of business case and confirmation of all the requirements by contract administration and relationship management which examine the performance of the contract. The activities were classified into two distinct, but they have the independent phases. These phases are downstream and upstream of the award of the contract. This guide provides the basic principles which were intended to valid from the simple order by framework contracts to service contracts or the complex constructions. The result indicated that they are equally applicable to contract in public sector and the private sector. Contract life cycle management basically a process which efficiently and systematically manages the creation, execution and the analysis of the contract. It helps in increasing the financial and operational performance. It also helps in reducing all the risks from the contract. A contract life cycle management is successful and more efficient if pre-award or upstream activities were carried out properly. This guide also described the importance of contract management which minimizes the cost and improves the operational and financial performance of public and private organizations. New regulatory requirements, increase in contract volumes, globalization and complexity enhancing the benefits of the effective contract management. It is found that the contract management was successful if the expected business value of money and benefits were achieved, the supplier was cooperative and responsive. This guide also presented the upstream or pre-award activities in which the author firstly prepared the business case for the management approval. Secondly, they assemble the project team. After that contract strategy was developed. After that, all the risk assessment was described, and contract exit strategy and contract management plan was developed. At the end of the project, ITT documents were prepared to make the basis for the future research [9].

Enshassi, A and Mohamed, S and Abdel-Hadi, M (2013) demonstrated the factors affecting the accuracy of pretender cost estimates in the Gaza Strip. In the construction project, pre-tender cost estimated needs the extensive expertise and knowledge. The main goal of this research was to determine, estimate and rank the important factors which affect the pre-tender cost estimating accuracy from the viewpoint of consultants and clients. In this research, a survey questionnaire was conducted to prompt professionals' opinions on and knowledge with aspects which affect the accuracy of pre-tender cost estimates. In the survey, total 70 organizations were responded in which there 46 clients, and 24 consultants were operating in the Gaza Strip. The result of the survey indicated that total 64 factors were considered in the questionnaire survey which tells that there are top five factors which affect the accuracy of pre-tender cost estimating. The first factor is materials availability, price, quality, supply, and imports. Second is the blockade and closure of borders. The third is the experience of the project team in the construction type. Fourth is the skill and the experience level of the consultant. The last factor is detailed and clear drawings and specifications. In this research, Kendall’s coefficient of concordance was used to measure the agreement among the two respondent’s groups. These two groups are of consultants and clients which help in ranking the various factors. The group of consultant and client should concentrate on the main factors of this research in order to develop the effective approaches for accurate cost estimating which results in the success of projects [10].

Cunningham, T (2013) presented the various factors which affect the cost of building work. The main problem of the cost of building work is essential for the immense majority of construction clients. This research outlined the main factors which affect the cost of building work. It was found in the research that the client's priorities concerning cost, quality and time constraints are the main factors in making an actual brief. The selection of the design team is revealed to be a main decision in the development process and evaluating the nature, and cost of the project. This research also concluded that the design factors affect the cost of building with their geometry, functions, life cost, specifications, socioeconomic factors and legislative constraints. The physical and the environmental conditions, the location of the site also affects the cost of the project. This research also examined the impact of the market conditions and procurement choices which provide the overview of all the factors which affect the contractor site production costs. The main issue of the cost of construction work was related to design teams, construction clients, constructors, and quantity surveyors. For the construction client, the main concern was related to the cost of constructing the building project. The main objective of quality surveyors was to predict the cost of building work and how to manage the evolving project design in order to ensure that the client approved budget does not exceed. The indicative cost ranges were needed for the several types of the development which were frequently published by the larger quantity surveying practices. This research presented the priorities of the client, nature of the project and site, cost of the design and the various methods of the procurement [11].

Cong and Mbachu, J and Domingo, N (2014) described the various factors and prioritized which influence the accuracy of pre-contract stage estimation of the final contract price in New Zealand. The result of the multi-attribute analysis indicated that thirty-seven factors impact the final contract price, completeness of project information, the complexity of design & construction and the three most influential which being poor tender documentation. In this research, the other factors relating to the project were also established and prioritized such as estimating practice, external factors, design consultants and tendering conditions and client and contractor characteristics. The analysis of concordance showed the high level of agreement from among the survey participants in the rank ordering of the identified factors. In this research, the author established and prioritize the factors which influence final contract price for the proper analysis of the risks and reliable forecasting. This research also compares the obtained results with the previous research result. The aim of the research was to fill the information gap by examining the priority factors. For this, total 150 responses were analyzed from the professional members of New Zealand Institute of Quality Surveyors with the multi-attribute method. A similar result was found in 80% of the cases, and 20% of the result was different. The exclusive culture and appearances of the New Zealand operating environment and construction industry were responsible for the variance. The results of this research assist the quality surveyors in creating the more reliable contract price estimates at the pre-contrast image. This research helps in improving the construction-stage cost monitoring and control. In this research, an online questionnaire was used for collecting the data because of the limitation of the time [12].

Knott, R. J., & Davis, E. R. (1982) presented the overview of the project control which was the process of the project management. There is no need for a lot of creativity in the Control Phase of the project management. This research presented the various recommendations for the project control which are described in it. All the control processes which are described in this research apply to the methodology of DIS Project Management. In this research, various phases of the Project Management were explained. A project management function compares the actual performance and the planned performance. After this comparison, some appropriate corrective action was taken and also direct the other to take that action which results in the desired outcome of the project. This research also described the working process of project control which includes reviewing the reports regularly and the metrics for determining variances from project outline. All the variance in the project were identified by the comparison of the actual performance metrics in the execution phase during the planning phase. The result indicated that the relationship between Project control phases with the project phases should be clear and concise which is very tough to implement as the formalized method in an organization. Project control is essential because it helps in evaluating the success of the project by the stakeholders. Project success is related to the completion date, project cost, performance, customer expectations, etc. [13].

Archibald, R, and Filippo, I and Filippo, D (2012) presented the holistic systems perspective of projects and the programs in order to achieve the whole benefits of system thinking in the project management. For this, it is required to establish comprehensive project life cycle and promote it all the applications which were used in all important projects. Comprehensive project life cycle identified that there is Feasibility phase or project incubation for the existing project starting phase for many project management standards. From this research, it is also identified that there should be need of additional post-project evaluation phase after standard project close-out phase. These types of phrases were discussed and defined on the basis of two types of project. These projects were transformational project and delivery or commercial projects. From the result of the research, it is recommended that comprehensive project life cycle model can be used or used as the standard for the important projects. Many of the project management authorities and experts restrict the scope of project management to the traditional start-plan-execute-closeout phases. All the project starts with the existence before the traditional start phase. The results and the evaluation of the project continue until these projects are closed out. These before and after phases identified within the domain of the project management. This research also described the post-project evaluation phase which helps in differentiating between project value and project success. The results also demonstrated that project management could apply in the pre-execution stages. Also, the seven-organization life cycle survey indicated that these companies expect the practices and principles of project management which were applied to pre-execution phases in the downstream executions. This research shows the evaluation of projects which generate the new information that needs by the emergent enterprise policy [14].

Comer, B. (1996) demonstrated about project finance. Project finance is the form of financing at the high-risk, and it is the development-oriented ventures. Presently, project finances need large capital which is the highly leveraged ventures obtained on a non-recourse or restricted recourse basis. At the center of these types of transactions in the project company which is a single purpose entity having the finite life linked to the several participants through contractual arrangements. It covers all the details of the project implementation and operation. The critical task of the project advisors is to allocate all the risks to the parties who are able to manage the particular risk. The emergence of the project finance resulted in several favorable trends such as the multilateral agencies, new attitudes in the direction of the role of the private sector in developing countries, deregulation of industries and privatization, etc. This research also described the various structures of the project finance transactions and role of the major participants in the project finance transactions. In this research, the author presented the various risks and mitigated which were associated with the project financing and its transactions. The results indicated that the infrastructure of the developing countries needs the critical appraisal of political risk and incorporates with the risk premiums margins. The private project sponsors and sovereign government can access to capital at the lower rates as compared to project financing. The result also indicated that the project financing requires high transactions costs because of the specific nature of the project of the financing vehicle [15].

Kirkham, et. al (1999), investigated that the running cost of sport and leisure centers are increasing frequently in order to maintain the comfort and safety levels. In this paper, data elicited from the Liverpool Leisure Services Directorate helps to investigate all 19 sports centers in Liverpool. It also has taken the initiative to examine the cost of the energy running of leisure centers. The cost of running leisure centers is directly depended upon the numerous energy consumption influencing factors. Among the numerous factors the two major factors affect the cost are - a number of users and the area, are used to develop models (linear and non-linear). Validation and testing have been conducted on the models to ensure the level of correctness. Selection of any model is dependent to the feasibility of the model. Before accessing the model, the user has to understand its assumptions. The introduced models were developed for professional use which involved feasibility studies at different levels of design. To construct the cost models, a sample of data was collected from Liverpool city. The data was gathered by documentary source mailed questionnaire, direct observation and interviews. After the formation of models, a discussion was conducted over calculating accuracy and efficiency of the linear as well as non-linear models. It was concluded that both the models can be used as an initial stage of the design process. [16]

Boussabaine & Kirkham (2004) analyzed to predict the maintenance cost facilities which can be an important management tool during the operational stages. The utilization of existing metrics and techniques introduced the simulation-based approach to maintenance costs modeling in UK local authority sports buildings. The simulation-based approach was used on multiple latent variables. Floor area, pool size and a number of users are the principles on which this approach is built. The simulation techniques have been proved itself as the latest approach to the maintenance cost of forecasting and analysis. For forecasting maintenance cost, random cost methods are used. Numerous sport center buildings have taken the advantage of simulation-based approach to maintenance costs. The multiple techniques are developed in order to model the maintenance costs of buildings such as - Integrated Logistics Support (ILS), it is used for modeling cost-effective maintenance strategies in existing buildings, a combination of information management systems & fuzzy logic theory for modeling of maintenance and facilities management costs etc. For the research methodology, raw data was collected from Liverpool Leisure Services Directorate. With raw data, models are developed to maintain the costs of the buildings. After developing the models, the models reveal the difference between the actual and forecasted maintenance costs derived from the model. Testing and validations were conducted to ensure that this approach is best fitted to maintain the cost. Budgeting and financial planning can be implemented by this approach. [17]

Alsohiman (2017) explained that variations in construction projects have some main sources such as the consultant, the external source, the client and the contractor. The study reveals the major reasons for variations in construction projects and their impacts in terms of scope, time, quality and cost on the project. The variation model process consists of five steps – step 1) collects data variation causes and their impact on the project success of Kingdom of Saudi Arabia. Step 2) in this step, to qualify the related costs of variation, as a dependent and its independent variables and as a proxy of cost overrun, multiple linear regression models were used. Step 3) For probability distribution fitting, cost of variation by the multiple regression equations are designated. @Risk software to perform Monte Carlo simulation was used for statistical tests. Step 4) one of the most powerful techniques for stochastic modeling is a simulation. The linear equations that developed in the previous step, are used to proceed the activities of this step. The Monte Carlo simulation process will generate the cost of variation. Step 5) The upper and lower limits of risk impact events are revealed in this step by identifying and confirming the distribution of the best-fitting distributions. All the above-specified steps of variation modeling process are executing in this sequence, the reason is the output of every step is act as an input of its next step. To find the cause of variation in construction in Kingdom of Saudi Arabia (KSA) need to evaluate both the primary and secondary data. To address the issue from all perspectives, a questionnaire survey is also required. To design the questionnaires, it was recommended to use an online engine in order to test the reliability and validity of the questions, that are supposed to be used in the survey. The survey was conducted by the all four sources of variations (namely, owners, consultants, contractors and external factors). [18]

It has been identified from the literature survey that there are many factors that affect the cost of both pre- contract and post contract in the Kingdom of Bahrain. Few of them include the followings:

According to “Tony Cunningham, 2013” the factors which effects in the pre- contract of the Kingdom of Bahrain are based on the quality and quantity considerations. It is important to consider the quality of material which is used during the construction work because the quality is recalled long after the cost or price of the product. It considered that project may be completed on time and within the required budget but if it does not specify, the quality performance then it definitely affects the cost which is incurred on working process. On the other hand, it is basically found that 30 % of buildings fail to meet the expectations of the owner because the quality of the building not express the determinations of the client. When a contractor does not understand the requirement of the client, then there is high certainty that the project will fail. So, it is essential to use the quality material during the construction of the building.

Another important factor that affects the cost in Pre- the contract is related to the time consideration (Olawale, Y., and Sun M. (2010) because if the construction project is not accomplished at the suggested time, then it definitely affects the cost. Once the decision has been made then the client will be worried to complete it as soon as possible. Time is the essence in emergency situations such as during the flood or fire. So, speedy completion is required unless it does not affect the cost of the material because if the project is not completed at the specified time, then it disturbs the overall budget.

On the other hand, the factors which affect the cost during post contract are based on the client characteristics which is especially related to the lack of experience and knowledge about the construction project and the second factor is based on the project characteristics such as the type, scope and period of the project.

The proposal and scope of the project are incurred in the pre –contract of Kingdom of Bahrain. If the design of the project is not developed according to the consideration of client, then it automatically affects the cost of the project. The accessibility of design should be made according to owner's accountability [1]. Another important aspect is related to the scope of the project. If the proper scope of the project is not determined by the budget of the project, then it may affect both the cost and time consideration of the project. The last aspect which affects the overall cost budget is related to the characteristics of the client. The contractor has to work according to the owner of the project, but if it is not established, then it affects the overall structure of the project.

By concluding above factors, it is clear that the whole working procedure of project of the Kingdom of Bahrain affects the cost if it is not done and maintained in an effective way. All the considerations have been important whether it is related to time, quality, design or scope. If this one of the things is not operated in a proper way, then it disturbs the budget of the project, and the cost which is suggested during the working progress is also reached up to a high level. So, the overall budget of the cost should be done or maintained according to this way that it cannot affects the schedule of the work and it would be run under the cost control procedures.

The existing models for the cost project are executed by the quantity surveyors in both the contracts [1]. In the pre- contract, existing models of costs is related to the following factors

- **Initial cost advice** – Initial cost advice is related to the procurement of the cost which is necessary for the implementation of the project. The allocation cost will be suggested by the project manager so that it cannot affect the overall budget and gives the quality work to the client [2].
- **Approximate estimating-** The approximate estimating the cost should not be existed higher according to the construction work. In this process, the budgeted cost of the project should not be exceeded to estimating cost. Otherwise, it affects the overall working structure of the cost.
- **Cost planning-** The other important aspect which exists in the modeling of the cost is related to the cost planning in which the total construction cost should be adjusted according to the budget of the client or according to the procurement of design which is suggested by the owner. By enabling these procedures, the effective cost model is established which does not affect the budget of the project.

In the post contact, the existing model of the cost is related to the following factor-

- **Preparation of final accounts-** The cost model is not completed if the preparation of the final account is not established properly because the overall cost of the budget is only operated through the final accounts.
- **Premeasurement of the whole or the part of work:** The other important aspect is related to the remeasurement of the whole part of the work. The pre measurement helps to analyze the problems which generally arise during the construction of the project.
- **Cost analysis-** Cost analysis is another important part of the cost modeling. It is better to analyze all the sections which are related to the cost and time considerations [2].

So, the overall structure of the cost modeling is mainly sustained with these points which are helpful before starting the work. The cost and time are two important factors of the construction project if it is not taken into important consideration then it affects the overall price of the project.

CHAPTER THREE – Data Presentation and Analysis

The research collected data from 29 projects. The data format is designed with the aim of obtaining general background information about the project cost, duration of the construction, size of the project, type of project and how a particular project is affected by the causes of variation. The raw data of the projects is shown in Appendix A. The descriptive statistics of the projects data is shown in Table-1 for descriptive statistic.

The below result simply shows the descriptive details of the values present in the dataset. Total 29 records are there in the dataset. The NetM^2 is dependent variable and rest are independent variables. The increased value of the projects area results in the increased cost and duration to set up the projects.

It can be seen from the Table-1, that in the dataset, the area of smallest project area is 260m^2 and the largest land area is 62000m^2. The minimum price for Project is 135 per meter square and the maximum is approx. 655.7 per meter square. Table- 1 shows the descriptive statistics of other variables.

Table-1: Results for Descriptive Statistic

Descriptive Statistics

	N	Minimum	Maximum	Sum	Mean	Std. Deviation
AREAm2	29	260.0	62000.0	281836.0	9718.483	13187.3789
EpriceM2	29	135.0	655.7	8532.611152	294.2279708	115.4752297
EdurationM2	29	.014516129	.692307692	4.423984283	.152551182	.146017769
AdurationM2	29	.014516129	1.153846154	6.179908442	.213100291	.24464861
Net	29	63558.0	40525000.0	133311439.3	4596946.181	8707861.239
Var1	29	-1100000.0	1074000.0	2943883.25	101513.21	377545.31
Var2	29	-1886955.0	36625000.0	48953257.25	1688043.353	6759958.385
Var3	29	-2166000.0	36547000.0	46009374.0	1586530.138	6770677.92
Ratio1	29	.107004817	10.18728004	43.83594862	1.511584435	1.696459023
Ratio2	29	.120915444	10.39102564	45.20818484	1.558902926	1.727157894
Valid N (listwise)	29					

The percentage of duration from the case study is computed using the following simple equation-1. This basically meant that data from the 29 projects was categorised into estimated duration and actual duration in order to establish the final duration of the project at the time of the research.

$$Duration\ Overrun = Actual\ Duration - Estimated\ Duration$$

The raw data from the 29 projects are presented in Figure-1, which shows that 2 projects had a contract duration of about 1080 days, meaning that in real terms the projects were estimated to be about 36 months – plus or minus a few weeks. The shortest duration for the case study was about 150 days – about five months' contract duration.

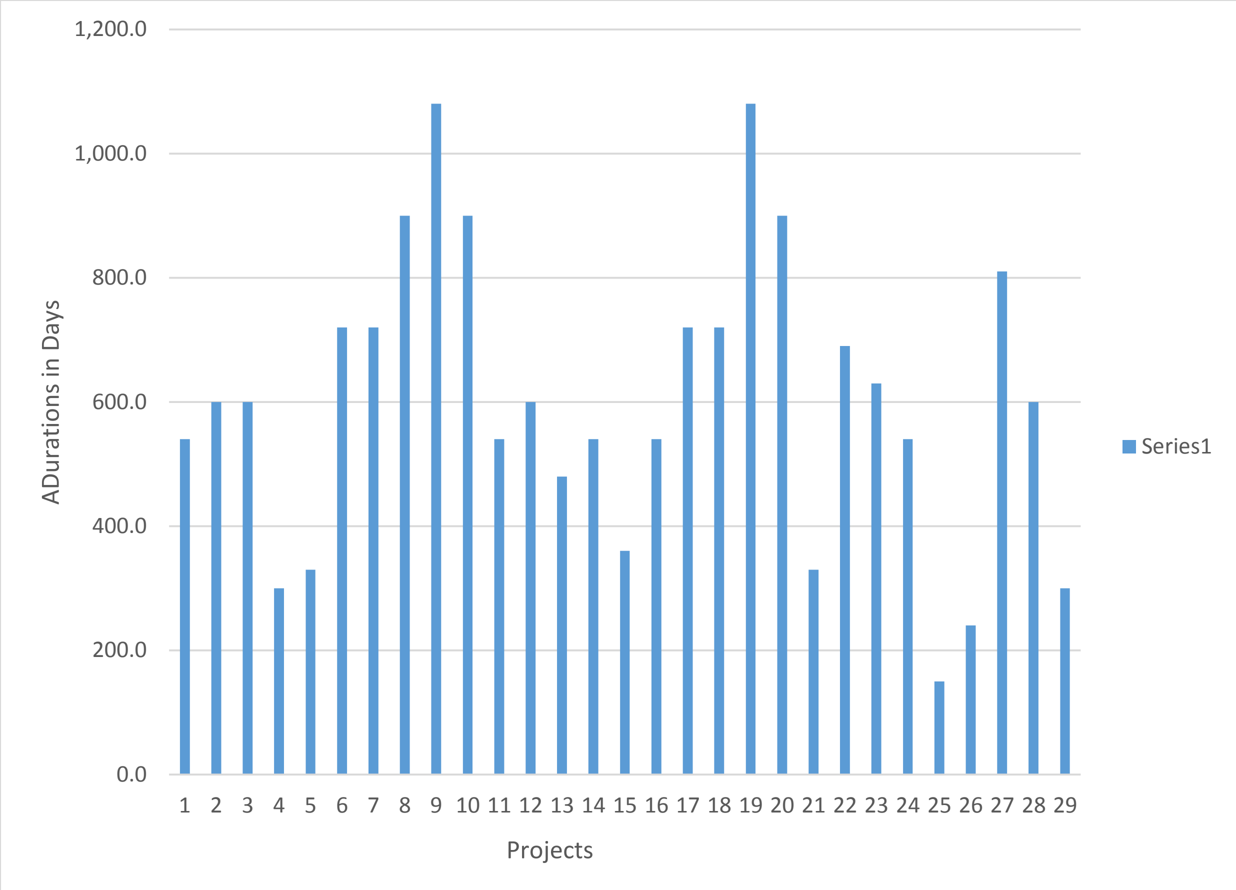

Figure-1: Project duration for all the 28 case study projects used in the research

Adopting a comparative analysis of projects with different durations has a likelihood of distorting the meaning behind the data. For instance, a project with six months' duration cannot easily be compared with one with a duration of 24 months because their structure could be totally different, hence making the comparative analysis of the data a bit weaker. Instead of presenting project duration overrun against the actual schedule for each case study, it was prudent to standardise the data by adopting an approach that can create duration overrun as a percentage of the actual duration. By so doing, project duration overran as a percentage of overall duration creates data that make projects comparable. Equation-2 depicts the processing of data from the 29 case studies in order to arrive at the percentage of project duration overrun.

$$Percentage\ of\ Duration\ Overrun = \frac{Duration\ Overrun}{Estimated\ Duration} X100$$

Equation-1: Equation for the estimation of project duration overrun as a percentage of estimated project duration

The results of computing data using Equation-2 show that only project 24 had overrun its schedule by more than 120%; while the next tier of overruns were projects 9, 19, 21, 22, 27, 28, and 29 which had overrun between 60% and 100% overall– see Figure-3 for details.

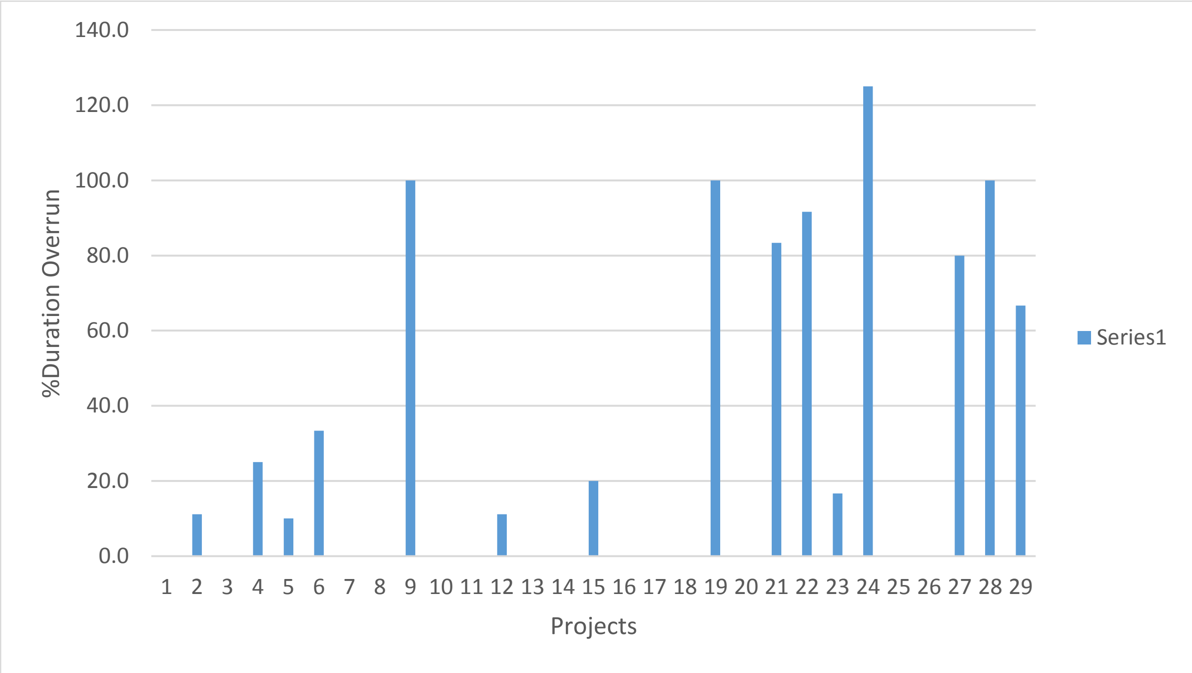

Figure-2: Project overrun as a percentage of the overall cost

The data presented in Figure-3 also shows that there were two (2) projects that had overrun by between 20% and 40%; five projects had an overrun of less than 20%; only two projects had not overrun their schedule. Based on this information, it can be argued that duration overrun has been a serious issue for the projects used in the case study.

Another cardinal issue to assess was the cost of each project. Figure-4 summarises the profile of costs for the 29 projects. Notice, though, how the cost of project 20 dwarfs the cost of the other projects in comparative terms, making it difficult to undertake a meaningful analysis.

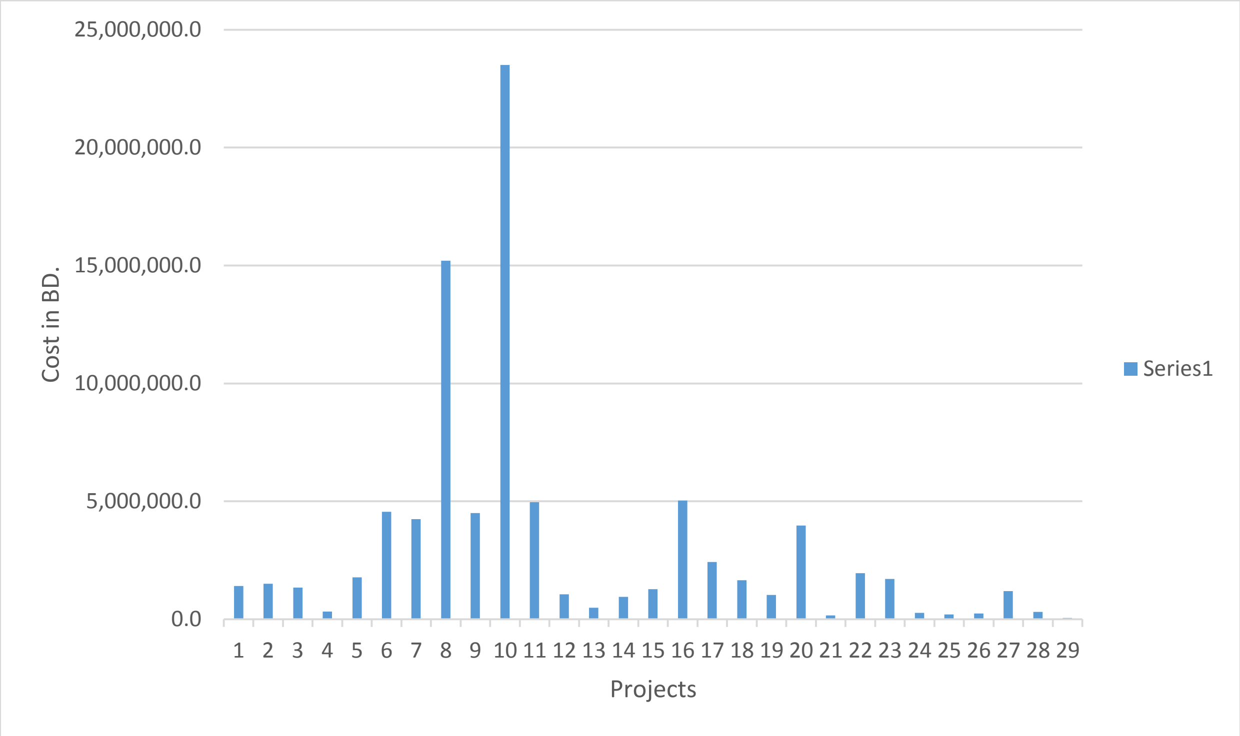

Figure-3: Projects cost in BD. of the 29 projects used as case studies

Therefore, it was reasoned that if the cost values are used as reported there could be a distortion in the equation terms that will represent the relations between causes of variations, and that the variables causing cost variations could be difficult to pinpoint. Thus, the costs were normalised using the surface area of each project using equation-3

$$Estimated\ Cost\ Per\ M^2 \ = \frac{Estimated\ Cost}{Project\ Surface\ Area}$$

Equation-2: Normalised cost of the project per square metre

Figure-4 presents information after cost normalisation using equation-3 where cost is expressed per square metre of the project, making the projects more comparable. It can be observed that project 22 had the highest value per square metre, ranging between 600 and 700 Bahraini Dinars. The second highest tier of cost per square metre for projects was 4, 6, 8, 10, 11, 13, 14, 16, 18, 19, 20, 25, 26, 27, and 28, with a range of 300 and 600 Bahraini Dinars. The final and lowest tier of 0 to 300 Bahraini Dinar per square metre had only thirteen projects.

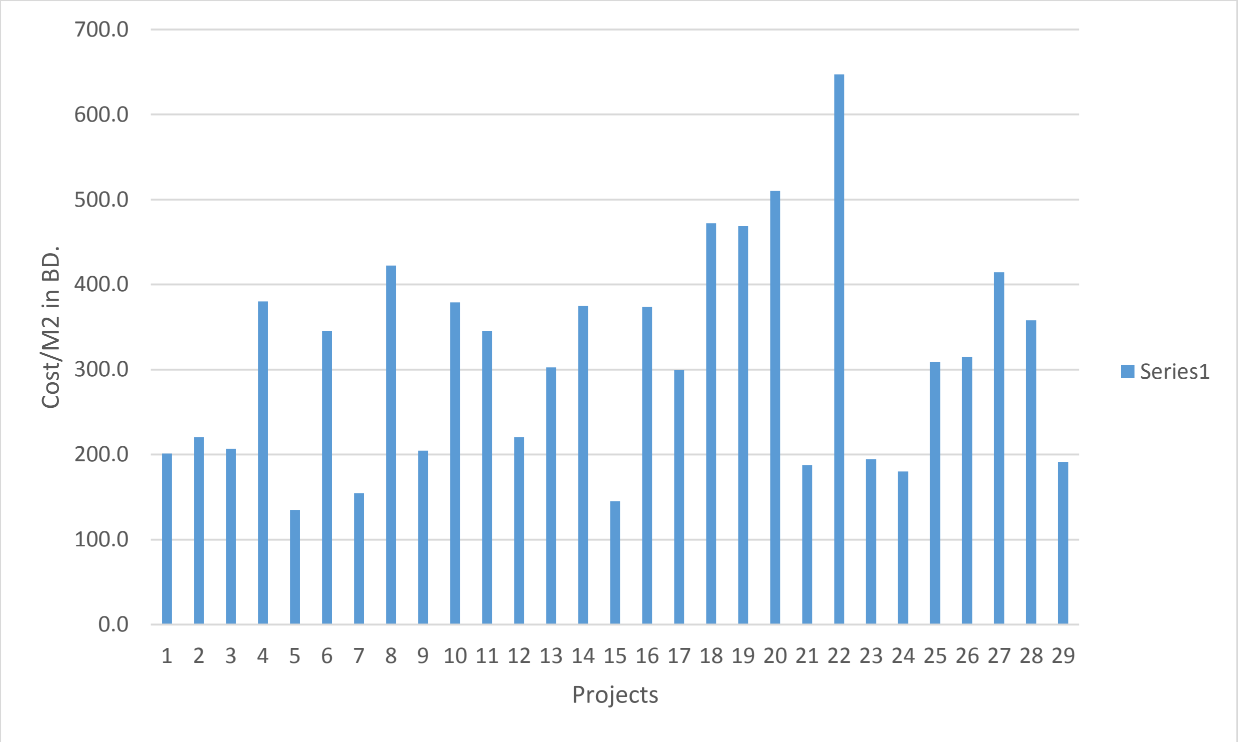

Figure-4: Cost of projects per square metre of the project area

Figure-6 shows the variance in the actual cost divided by actual duration, where project 10 has the highest score about 26,111 Bahraini Dinars, followed by project 8, which was approximately 16,888 Bahraini Dinars. Using the information from the rest of the projects it could be seen that they were dwarfed by the data from these two projects.

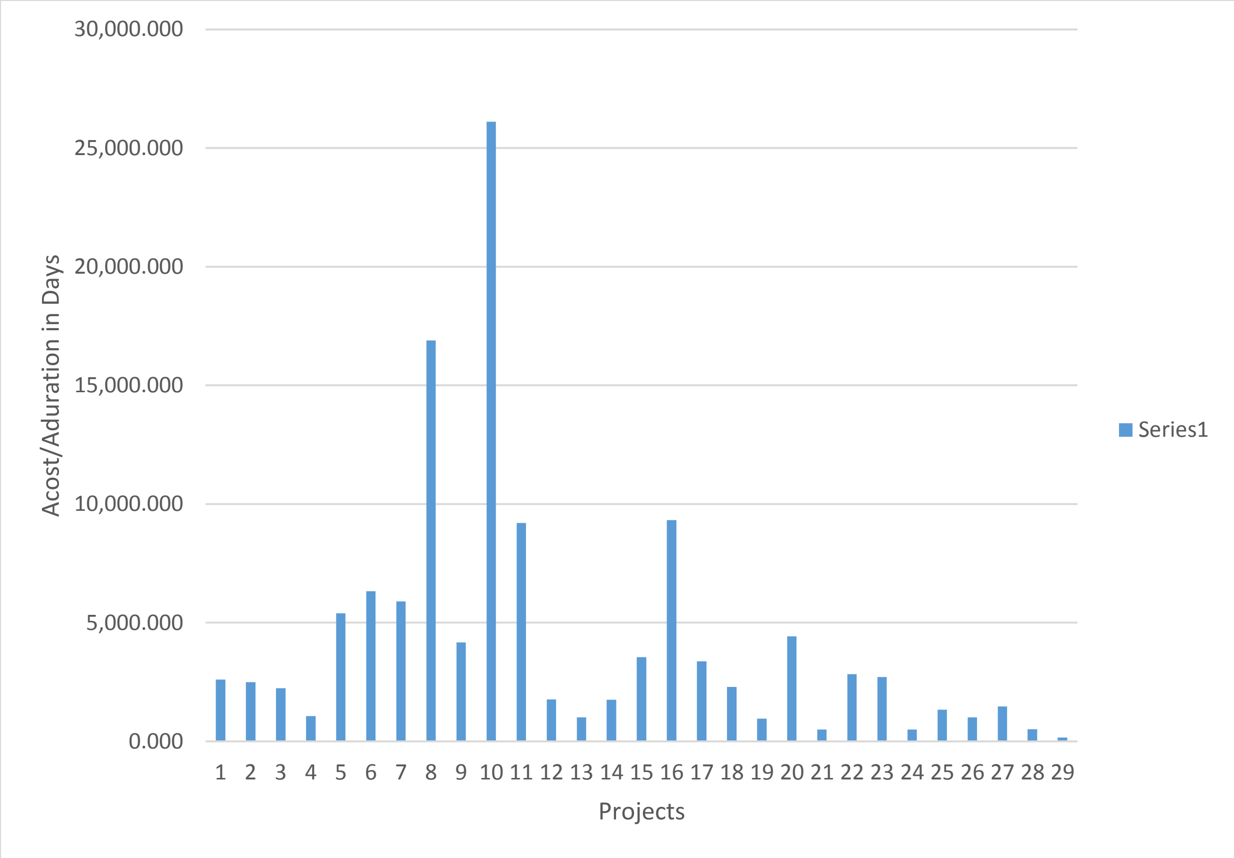

Figure-5: Ratio of actual cost divided by actual duration

Based on the information from the 29 case studies, it is possible to advance the following arguments:

i. Estimated project durations and cost: Figure-5 showed that the duration of the studied projects is not characterised by outlier cases. However, there appears to be one project that has high estimated cost compared to the other projects in the set. This may have an impact on the regression results. Thus, it was decided to use the cost per m^2 unit in the regression. This should overcome the problem of outlier cases.

ii. Percentage of duration overrun: Figure-2 showed that most of the projects were subjected to duration overrun. This finding reinforces the use of the duration overrun as a proxy for assessing the causes of variation.

iii. Ratio of actual duration to cost: Figure-5 shows that one project has a very high ratio. However, this ration is not used in the regression.
iv. Ratio of estimated cost to surface area: the figure-4 shows that the majority of projects have a cost duration ratio less than 200 Bahraini Dinars. This uniformity will help in extracting highly significant regression equations to represent the causes of variety.

Using the information from case studies, and the literature review chapter, it was possible to identify key variables that needed further investigation. For example, the data for the variables in Table-1 was used to derive mathematical relationships between the causes of variation and a select predictor of project success criteria.

3.1 Modelling cost overrun

The project success outcome is an essential aspect while designing and constructing buildings. The Net Price of the projects is dependent upon all the factors that influence the cost of the project. The area and duration are directly proportional to the net price of the project. It can explain as if the total actual duration (Aduration) is more than the estimated period (Eduration) there will increase in Net price (NetM2) as more time worker will be employed rising labor cost and other expenditures. Therefore, if the complete state of cost overrun are known it will improve the successful outcome regarding price, quality, and duration.

3.2 Correlation analysis

The 'Pearson' investigation is used to find out the correlation between the dependent and independent variables. The Test for Correlation between the dependent and independent variables is shown in Table 2. The causes of the dependency of the variables have also been a list out so that it can understand how the variables are dependent and independent of each other.

Below are some of the essential aspects required for selecting the dependent and independent variables from the dataset.

- One dependent variable (NetM2) have strong direct linear relationships to the other independent variables.
- The dependent variable has a strong relationship with the independent variables as the correlation is higher than 0.90.
- The independent variables AdurationM2 (Actual Duration), EdurationM2 (Estimated Duration) and AreaM2, are dependent on Net Price (NetM2) having high correlation coefficient 0.947 for AdurationM2, and 0.954 for EdurationM2.
- In non-linear equations, the values of R-square from both cubic and quadratic are useful in understanding that dependent variable NetM2 influences other independent variables that are EdurationM2, AdurationM2, and AreaM2.

The below table shows the correlation of independent variables with dependent variables. From the below chart we see the relationship between the variables that caused variation and increased the duration overrun of the project. The relationship between the variables will help us to predict the dependency of variables on the independent variables. So when knowing the dependent variables that significant measure is taken to reduce the cost and duration to overrun of the project.

Below table shows the correlation between the selected dependent and independent variables.

Table 2. Test for Correlation between the dependent and independent variables.

		NetM2	AREAm2	EpriceM2	TpriceM2	EdurationM2
NetM2	Pearson Correlation	1	.990**	-.018	-.030	.954**
	Sig. (2-tailed)		.000	.924	.876	.000
	N	29	29	29	29	29
AREAm2	Pearson Correlation	.990**	1	-.014	-.021	.950**
	Sig. (2-tailed)	.000		.942	.915	.000
	N	29	29	29	29	29
EpriceM2	Pearson Correlation	-.018	-.014	1	.995**	-.088
	Sig. (2-tailed)	.924	.942		.000	.650
	N	29	29	29	29	29
TpriceM2	Pearson Correlation	-.030	-.021	.995**	1	-.101
	Sig. (2-tailed)	.876	.915	.000		.603
	N	29	29	29	29	29
EdurationM2	Pearson Correlation	.954**	.950**	-.088	-.101	1
	Sig. (2-tailed)	.000	.000	.650	.603	
	N	29	29	29	29	29
AdurationM2	Pearson Correlation	.947**	.963**	-.077	-.083	.982**
	Sig. (2-tailed)	.000	.000	.692	.669	.000
	N	29	29	29	29	29
Var1	Pearson Correlation	.264	.364	.040	.096	.264
	Sig. (2-tailed)	.166	.052	.836	.620	.167
	N	29	29	29	29	29

Var2	Pearson Correlation	.674**	.610**	.338	.335	.575**
	Sig. (2-tailed)	.000	.000	.073	.075	.001
	N	29	29	29	29	29
Var3	Pearson Correlation	.516**	.405*	.305	.274	.421*
	Sig. (2-tailed)	.004	.029	.108	.150	.023
	N	29	29	29	29	29

		AdurationM2	Var1	Var2	Var3
NetM2	Pearson Correlation	.947**	.264	.674**	.516**
	Sig. (2-tailed)	.000	.166	.000	.004
	N	29	29	29	29
AREAm2	Pearson Correlation	.963**	.364	.610**	.405*
	Sig. (2-tailed)	.000	.052	.000	.029
	N	29	29	29	29
EpriceM2	Pearson Correlation	-.077	.040	.338	.305
	Sig. (2-tailed)	.692	.836	.073	.108
	N	29	29	29	29
TpriceM2	Pearson Correlation	-.083	.096	.335	.274
	Sig. (2-tailed)	.669	.620	.075	.150
	N	29	29	29	29
EdurationM2	Pearson Correlation	.982**	.264	.575**	.421*
	Sig. (2-tailed)	.000	.167	.001	.023
	N	29	29	29	29
AdurationM2	Pearson Correlation	1	.380*	.545**	.333
	Sig. (2-tailed)		.042	.002	.077
	N	29	29	29	29
Var1	Pearson Correlation	.380*	1	.179	-.327
	Sig. (2-tailed)	.042		.354	.083
	N	29	29	29	29
Var2	Pearson Correlation	.545**	.179	1	.872**
	Sig. (2-tailed)	.002	.354		.000
	N	29	29	29	29
Var3	Pearson Correlation	.333	-.327	.872**	1
	Sig. (2-tailed)	.077	.083	.000	
	N	29	29	29	29

Note: The independent variables used for collinearity violation because of their high correlation between the variables. The dependent variable NetM2 influences all the other factors that increase the cost, length, and quality of the project.

3.3 Regression Analysis

The multiple regression is a technique used by researchers to model the impacts of objects of variation in the length of the project. The range of projects is directly dependent on the reasons that affect the working and construction of the project. The changes have a significant impact on the success rate of the project. The user can make estimates for a key by using historical data from causes of various case studies.

The linear and non-linear equations are used to estimate the dependency of variables for the project. In the current dataset, there are total 29 different cases or records that are analyzed for setting up the plan. The Net Price (NetM2) is the only dependent variable, which influences all the factors that are independent of each other. It is essential to find out the relationship between dependent and independent variables to reach a conclusion. For setting up a project, we have considered the dependent and independent factors for the dataset that are collected from the information of various projects.

Below table shows the R and R-squared values that represents the regression and percentage of variation in the variables (independent variables) respectively. It can be seen that there is a high degree of correlation between the dependent variable NetM2 and independent variables AreaM2, EdurationM2, and AdurationM2. The correlation lies in range 0.90 – 0.99 that is significantly higher.

- Var1 = Tprice - Eprice
- Var2 = Net – Eprice
- Var3 = Net – Tprice
- Ratio1 = Net / Tprice
- Ratio2 = Net / Eprice

The non-linear regression is performed using the cubic and quadratic equations to analyze the effect of the independent variables on the dependent variables. For the cubic equations, the independent variables are analyzed with respect to the dependent variables in the following form:

$$a * X^3 + b * X^2 + c * X + d$$

Similarly, the quadratic equations are in the following form:

$$a * X^2 + b * X + c$$

The results obtained from the non-linear regression using cubic and quadratic equations are shown below. The R squared value of the model is calculated using the below formula:

R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares)

3.3.1 Linear Regression Modelling Analysis

NetM2 to AreaM2

Table 3: Model Summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.990[a]	.979	.979	2845.89072	.979	1286.679	1	27	.000

a. Predictors: (Constant), AREAm2

Table 3 results indicate that NetM2 to AREAm2 are correlated with a value of R = 0.990 which proves a strong positive correlation. From the analysis, it is realized that the R-squared correlation coefficient between NetM2 to AREAm2 is 0.979. Certainly, this indicates a fairly strong predictive variance between them and suggests that up to 97% of NetM2 values can be accurately predicted using the AREAm2 variable. To further confirm these results analysis of variance (ANOVA) was done to find the correlation of variance of the two data sets. The ANOVA results are summarized in table 4 below.

Table 4: ANOVA Results

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10420930147.053	1	10420930147.053	1286.679	.000[b]
	Residual	218675537.232	27	8099093.972		
	Total	10639605684.285	28			

a. Dependent Variable: NetM2

b. Predictors: (Constant), AREAm2

From table 4 above, it is noticed that Sig. value .000 i.e. $p<0.05$. As a result, a conclusion is made that the means of the NetM2 to AREAm2 data sets were statistically different.

At the same time, the various standardized and unstandardized coefficients were captured in table 5. The standard error represent the average distance of the observed values from the trend line. As such, small values are preferred because they show that the precision of the data gathered in the research. In the table 6 results, it is noted that the standard error for AREAm2 was 29%

Table 5: Standardized and unstandardized coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	567.883	637.819		.890	.381	-740.813	1876.579					
	AREAm2	1.055	.029	.990	35.870	.000	.995	1.116	.990	.990	.990	1.000	1.000

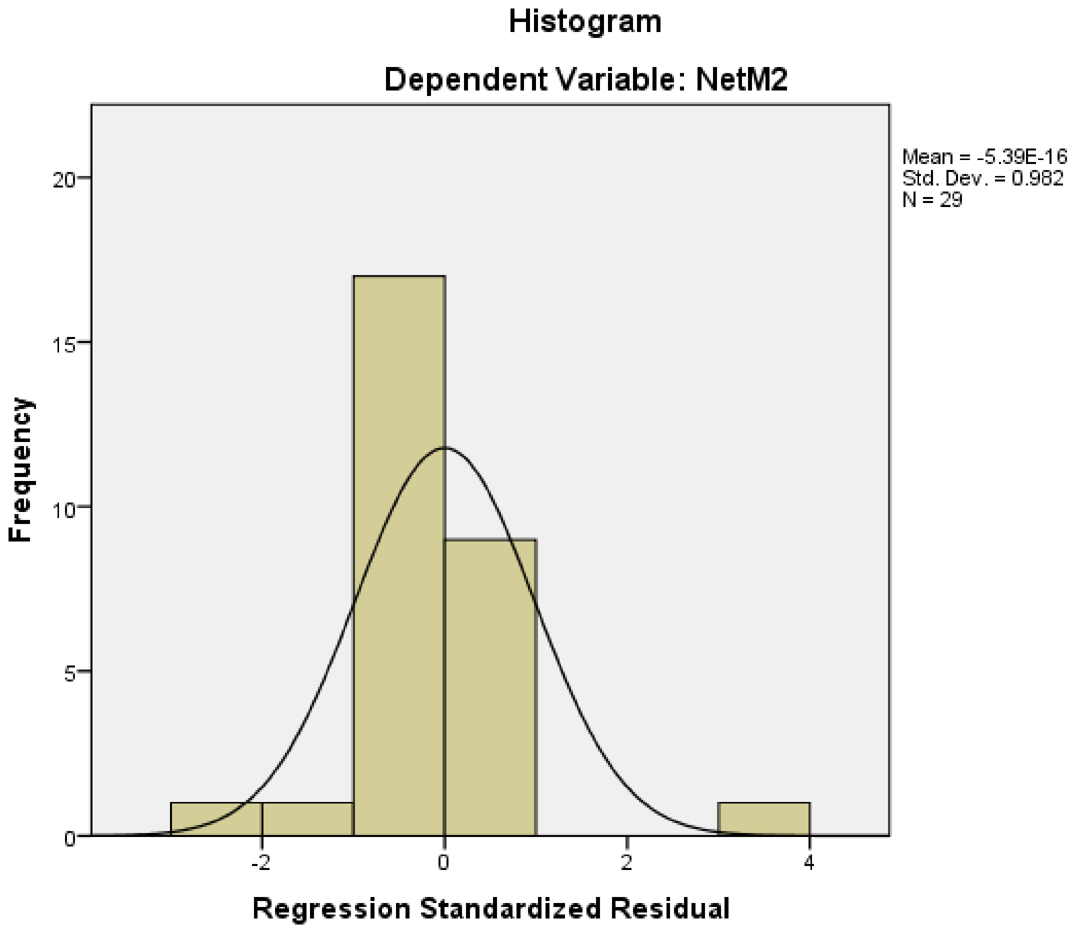

Figure 6: Histogram of the frequency of the regression standardized residuals

Figure 6 shows the residual histogram. The histogram is used for assessing the residual normality. The figure shows that standardized residuals follows the normal curve pattern. This suggests that the residual is acceptable and the normality assumption is not violated.

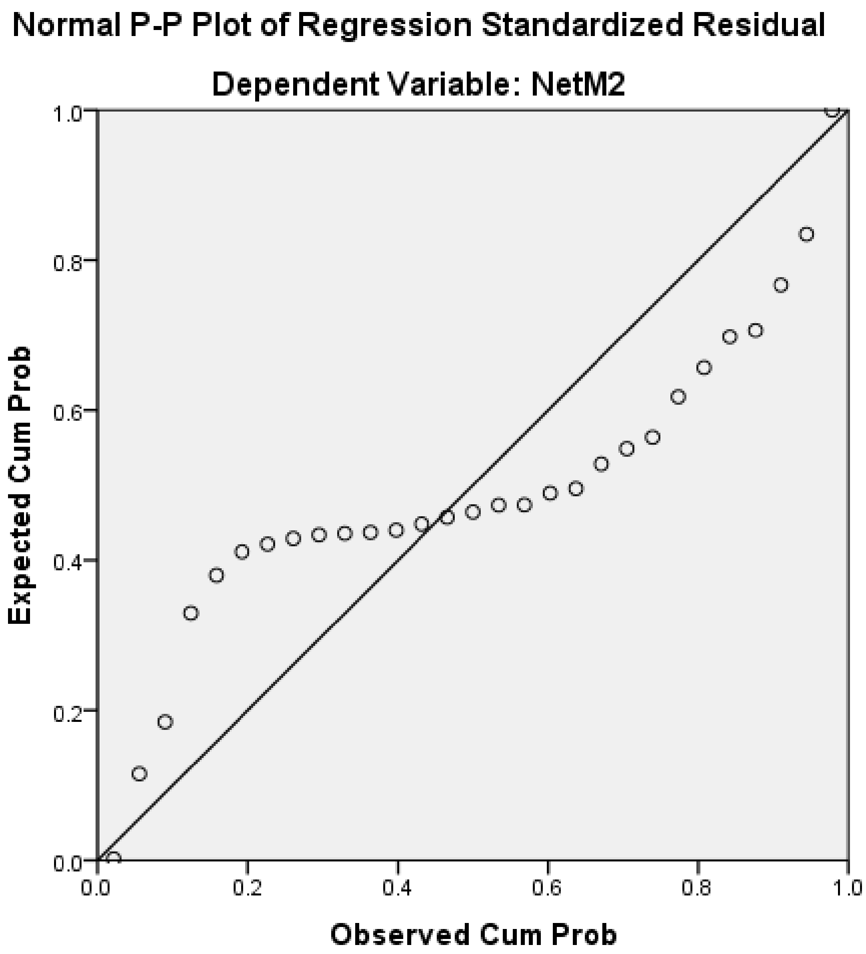

Figure 7: Normal P-P plot of regression standardized residual for the observed cum porb

The result shown in the plot shown in Figure 7 demonstrate that the model line is nearly superimposed over the theoretical line. This confirm that the normality assumption is not violated.

NetM2 to EdurationM2

Table 6: Model Summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.952[a]	.907	.903	6068.00638	.907	261.957	1	27	.000

a. Predictors: (Constant), EdurationM2

Table 6 results indicate that NetM2 to EdurationM2 are correlated with a value of R = 0.952 which proves a strong positive correlation. From the analysis, it is realized that the R-squared correlation coefficient between NetM2 to EdurationM2 is 0.907. Certainly, this indicates a fairly strong predictive variance between them and suggests that up to 91% of NetM2 values can be accurately predicted using the EdurationM2 variable. To further confirm these results analysis of variance (ANOVA) was done to find the correlation of variance of the two data sets. The ANOVA results are summarized in table 7 below.

Table 7: ANOVA results

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9645446745.833	1	9645446745.833	261.957	.000[b]
	Residual	994158938.452	27	36820701.424		
	Total	10639605684.285	28			

a. Dependent Variable: NetM2

b. Predictors: (Constant), EdurationM2

From table 7 above, it is noticed that Sig. value .000 i.e. $p<0.05$. As a result, a conclusion is made that the means of the NetM2 to EdurationM2 data sets were statistically different.

At the same time, the various standardized and unstandardized coefficients were captured in table 8. The standard error represent the average distance of the observed values from the trend line. As such, small values are preferred because they show that the precision of the data gathered in the research. In the table 9 results, it is noted that the standard error for EdurationM2 was 1.8%. This implies that the predictions for the data can be made above 95% significance level.

Table 8: Standardized and unstandardized coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-3179.153	1521.894		-2.089	.046	-6301.822	-56.484					
	EdurationM2	29.274	1.809	.952	16.185	.000	25.563	32.985	.952	.952	.952	1.000	1.000

a. Dependent Variable: NetM2

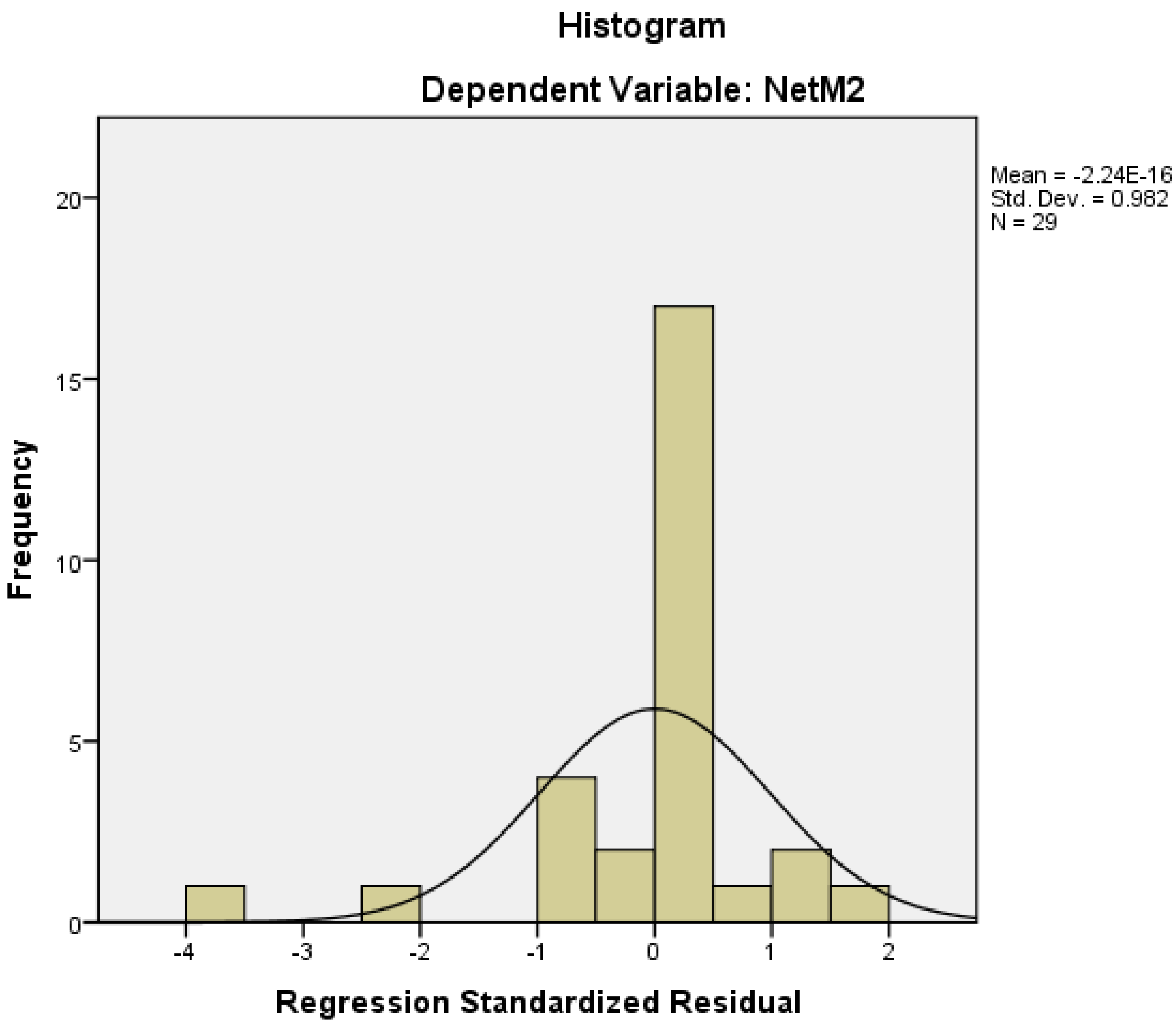

Figure 8: Histogram of the frequency of the regression standardized residuals

Figure 9 shows the residual histogram. The histogram is used for assessing the residual normality. The figure shows that standardized residuals follows the normal curve pattern. This suggests that the residual is acceptable and the normality assumption is not violated.

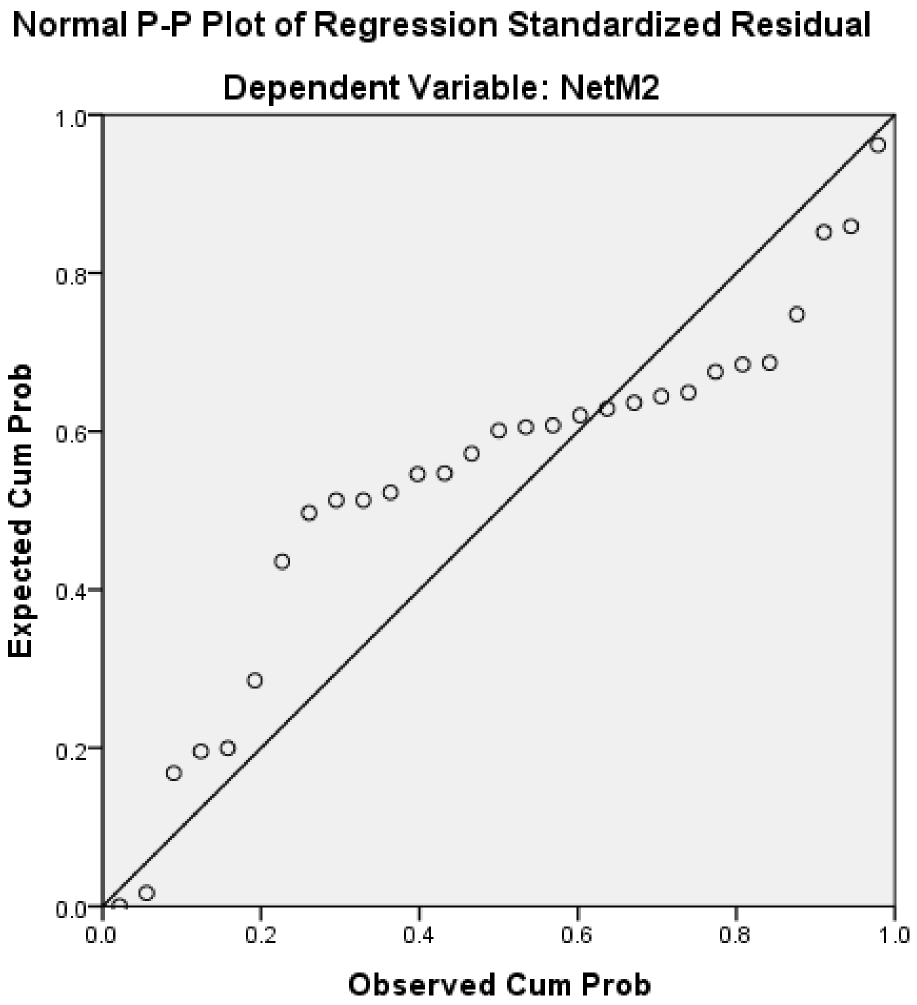

Figure 9: Normal P-P plot of regression standardized residual for the observed cum porb

The result shown in the plot shown in Figure 9 demonstrate that the model line is nearly superimposed over the theoretical line. This confirm that the normality assumption is not violated.

NetM2 to AdurationM2

Table 9: Regression coefficient Model Summary

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.945[a]	.894	.890	6464.98349	.894	227.560	1	27	.000

a. Predictors: (Constant), AdurationM2

b. Dependent Variable: NetM2

Table 9 results indicate that NetM2 to AdurationM2 are correlated with a value of R = 0.945 which proves a strong positive correlation. From the analysis, it is realized that the R-squared correlation coefficient between NetM2 to AdurationM2 is 0.894. Certainly, this indicates a fairly strong predictive variance between them and suggests that up to 89% of NetM2 values can be accurately predicted using the AdurationM2 variable. To further confirm these results analysis of variance (ANOVA) was done to find the correlation of variance of the two data sets. The ANOVA results are summarized in table 10 below.

Table 10: ANOVA Results

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9511113374.688	1	9511113374.688	227.560	.000[b]
	Residual	1128492309.596	27	41796011.467		
	Total	10639605684.285	28			

a. Dependent Variable: NetM2

b. Predictors: (Constant), AdurationM2

From table 10 above, it is noticed that Sig. value .000 i.e. $p<0.05$. As a result, a conclusion is made that the means of the NetM2 to AdurationM2 data sets were statistically different.

At the same time, the various standardized and unstandardized coefficients were captured in table 11. The standard error represent the average distance of the observed values from the trend line. As such, small values are preferred because they show that the precision of the data gathered in the research. In the table 11 results, it is noted that the standard error for AdurationM2 was 1.9%. This implies that the predictions for the data can be made above 95% significance level.

Table 11: Standardized and unstandardized coefficients

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-1751.112	1564.309		-1.119	.273	-4960.809	1458.585					
	AdurationM2	29.566	1.960	.945	15.085	.000	25.544	33.587	.945	.945	.945	1.000	1.00

a. Dependent Variable: NetM2

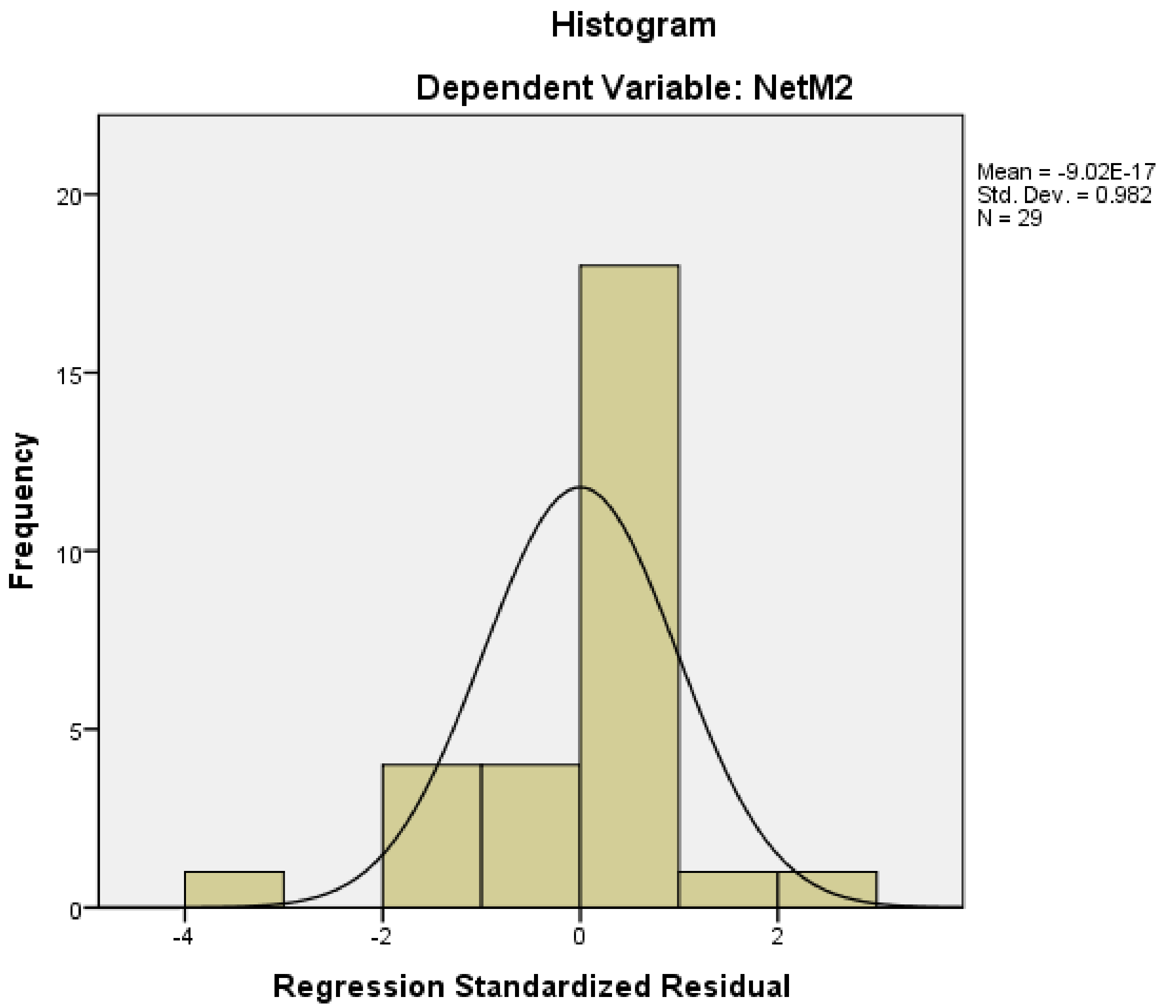

Figure 10: Histogram of the frequency of the regression standardized residuals

Figure 10 shows the residual histogram. The histogram is used for assessing the residual normality. The figure shows that standardized residuals follows the normal curve pattern. This suggests that the residual is acceptable and the normality assumption is not violated.

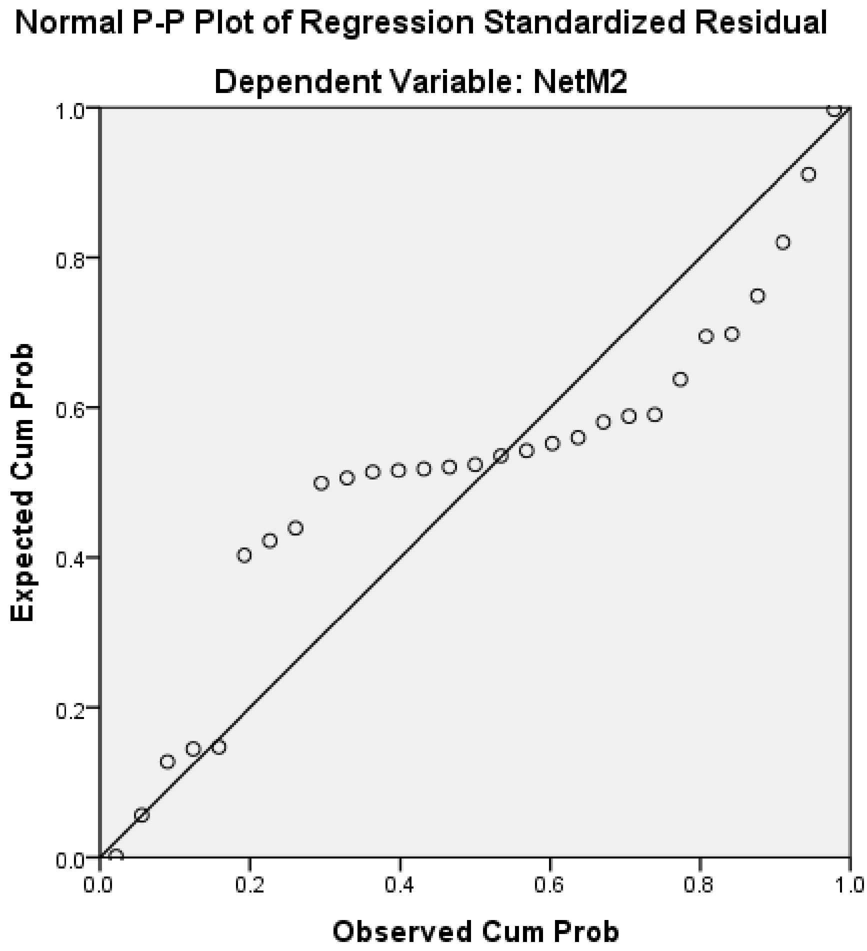

Figure 11: Normal P-P plot of regression standardized residual for the observed cum porb

The result shown in the plot shown in Figure 11 demonstrate that the model line is nearly superimposed over the theoretical line. This confirm that the normality assumption is not violated.

Table 12. Result for Linear Regression Analysis (R-Value and R-Squared Value).

Name of Independent Variable	R Value	R-Squared Value
AreaM2	.990	.980
EdurationM2	.954	.910
AdurationM2	.947	.898

Table 13. Result for Linear Regression Analysis (R-Squared Value (Quadratic Expressions) and (Cubic Expressions)).

Name of Independent variable	R-Squared Value (Quadratic Expressions)	R-Squared Value (Cubic Expressions)
EDurationM2	0.937	0.940
ADurationM2	0.912	0.912
AreaM2	0.982	0.982
Var2	0.584	0.588
Var3	0.313	0.324

From the results of non-linear regression using cubic and quadratic equations, it is clear that the independent variables EDurationM2 (Expected duration), ADurationM2 (Actual duration), and AreaM2 have a high correlation with the dependent variable NetM2. The variation of change in these three independent variables can cause the change in the NetM2. The other independent variables have very less correlation with the dependent variable. It can state that these three independent variables (AdurationM2, EDurationM2, and AreaM2) highly affects the overall cost (NetM2) of the project, i.e., dependent on all the other variables like durations and other variable costs.

Below table shows the standard error and mean squares of variation in the variables (independent variables) obtained from the nonlinear regression. It can be helpful in identifying the relations between the independent and dependent variables using the values of error and mean squares obtained from the results of non-linear regression using cubic and quadratic equations.

Table 14. Result for Non-Linear Regression Analysis (**Std. Error**. And **Mean Squares)**

Name of Independent Variable	Std. Error	Mean Squares
EdurationM2	.000	3789333403
AdurationM2	.000	3716073686
AreaM2	.000	3903412779
EPriceM2	.000	2169525883
Var2	.000	2846937484
Var3	.000	2140724553
Quad_EdurationM2	.002	5042588104
Quad AdurationM2	.002	4953593543
Quad AREAM2	.000	5203259872
Quad Var2	.000	3781554113
Quad Var3	.000	2815770416

3.4. Created prediction equations

3.4.1 Nonlinear Modeling Analysis

The non-linear regression is performed using the cubic and quadratic equations to analyze the effect of the independent variables on the dependent variables. For the cubic equations, the independent variables are analyzed with respect to the dependent variables in the following form:

Y= a * X^3 + b * X^2 + c * X + d

Similarly, the quadratic equations are in the following form:

Y= a * X^2 + b * X + c

In both the cubic and quadratic equations, the values taken of constants are:

a=0.5, b=0.7, c=4, d=20.

3.4.1.1 Cubic regression

<u>NetM2 to EdurationM2</u>

Y= a *** EdurationM2^*3* + *b* * EdurationM2^*2* + *c* * EdurationM2 + *d***

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a	-4.160E-6	.000	-1.147E-5	3.153E-6
b	.022	.013	-.005	.049
c	1.845	12.015	-22.901	26.590
d	2056.552	2236.275	-2549.143	6662.246

Correlations of Parameter Estimates

	a	b	c	d
a	1.000	-.989	.927	-.680
b	-.989	1.000	-.969	.740
c	.927	-.969	1.000	-.840
d	-.680	.740	-.840	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	15173291557.603	4	3793322889.401
Residual	656338598.805	25	26253543.952
Uncorrected Total	15829630156.408	29	
Corrected Total	10639605684.285	28	

Dependent variable: NetM2

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .938.

NetM2 to AdurationM2

$Y = a$ * AdurationM2^$3 + b$ * AdurationM2^$2 + c$ * AdurationM2 + d

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a	-1.621E-6	.000	-1.005E-5	6.808E-6
b	.011	.015	-.020	.041
c	14.118	12.755	-12.151	40.388
d	1201.689	2323.191	-3583.013	5986.390

Correlations of Parameter Estimates

	a	b	c	d
a	1.000	-.987	.902	-.585
b	-.987	1.000	-.956	.657
c	.902	-.956	1.000	-.789
d	-.585	.657	-.789	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	14876067041.440	4	3719016760.360
Residual	953563114.968	25	38142524.599
Uncorrected Total	15829630156.408	29	
Corrected Total	10639605684.285	28	

Dependent variable: NetM2

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .910.

NetM2 to Var2

Y= *a* * Var2^*3* + *b* * Var2^*2* + *c* * Var2 + *d*

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a	-1.398E-16	.000	-2.113E-16	-6.830E-17
b	4.904E-9	.000	2.227E-9	7.581E-9
c	.010	.003	.005	.015
d	3099.691	2008.904	-1037.725	7237.107

Correlations of Parameter Estimates

	a	b	c	d
a	1.000	-.999	.384	.252
b	-.999	1.000	-.428	-.229
c	.384	-.428	1.000	-.353
d	.252	-.229	-.353	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	13854198800.401	4	3463549700.100
Residual	1975431356.007	25	79017254.240
Uncorrected Total	15829630156.408	29	
Corrected Total	10639605684.285	28	

Dependent variable: NetM2

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .814.

NetM2 to Var3

Y= *a* * Var3^*3* + *b* * Var3^*2* + *c* * Var3 + *d*

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a	-9.605E-17	.000	-1.725E-16	-1.962E-17
b	3.317E-9	.000	4.700E-10	6.164E-9
c	.009	.003	.003	.015
d	5547.936	2373.505	659.611	10436.260

Correlations of Parameter Estimates

	a	b	c	d
a	1.000	-.999	.306	.297
b	-.999	1.000	-.356	-.279
c	.306	-.356	1.000	-.253
d	.297	-.279	-.253	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	12750755030.214	4	3187688757.553
Residual	3078875126.194	25	123155005.048
Uncorrected Total	15829630156.408	29	
Corrected Total	10639605684.285	28	

Dependent variable: NetM2

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .711.

NetM2 to AreaM2

Y= *a* * AreaM2^*3* + *b* * AreaM2^*2* + *c* * AreaM2 + *d*

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a	-4.782E-11	.000	-1.899E-10	9.424E-11
b	2.750E-6	.000	-1.218E-5	1.768E-5
c	1.096	.183	.718	1.474
d	107.787	912.472	-1771.483	1987.058

Correlations of Parameter Estimates

	a	b	c	d
a	1.000	-.983	.857	-.514
b	-.983	1.000	-.932	.600
c	.857	-.932	1.000	-.755
d	-.514	.600	-.755	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	15636067564.447	4	3909016891.112
Residual	193562591.962	25	7742503.678
Uncorrected Total	15829630156.408	29	
Corrected Total	10639605684.285	28	

Dependent variable: NetM2

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .982.

3.4.1.2 Quadratic Regression

<u>NetM2 to EdurationM2</u>

Y= a * EdurationM2^2 + b * EdurationM2 + c

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a	.007	.002	.002	.011
b	14.894	4.630	5.358	24.430
c	275.241	1684.412	-3193.871	3744.352
d	20.000	.000	20.000	20.000

Correlations of Parameter Estimates

	a	b	c	d
a	1.000	-.941	.621	.
b	-.941	1.000	-.763	.
c	.621	-.763	1.000	.
d	.	.	.	.

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	15137250477.289	4	3784312619.322
Residual	692379679.119	25	27695187.165
Uncorrected Total	15829630156.408	29	
Corrected Total	10639605684.285	28	

Dependent variable: NetM2

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) .935.

NetM2 to AdurationM2

*Y= a * AdurationM2^2 + b * AdurationM2 + c*

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a	.005	.002	9.091E-5	.010
b	18.676	5.520	7.308	30.044
c	663.200	1889.821	-3228.959	4555.360
d	20.000	.000	20.000	20.000

Correlations of Parameter Estimates

	a	b	c	d
a	1.000	-.940	.609	.
b	-.940	1.000	-.746	.
c	.609	-.746	1.000	.
d	.	.	.	.

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	14870082312.460	4	3717520578.115
Residual	959547843.948	25	38381913.758
Uncorrected Total	15829630156.408	29	
Corrected Total	10639605684.285	28	

Dependent variable: NetM2

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .910.

<u>NetM2 to Var2</u>

Y= a * Var2^2 + b * Var2 + c

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a	-3.237E-10	.000	-4.908E-10	-1.566E-10
b	.014	.003	.008	.020
c	5135.487	2496.351	-5.843	10276.818
d	20.000	.000	20.000	20.000

Correlations of Parameter Estimates

	a	b	c	d
a	1.000	-.994	.482	.
b	-.994	1.000	-.503	.
c	.482	-.503	1.000	.
d	.	.	.	.

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	12572983140.906	4	3143245785.226
Residual	3256647015.503	25	130265880.620
Uncorrected Total	15829630156.408	29	
Corrected Total	10639605684.285	28	

Dependent variable: NetM2

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .694.

NetM2 to Var3

Y= a * Var3^2 + b * Var3 + c

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a	-2.559E-10	.000	-4.268E-10	-8.505E-11
b	.011	.003	.005	.018
c	7373.196	2551.992	2117.271	12629.121
d	20.000	.000	20.000	20.000

Correlations of Parameter Estimates

	a	b	c	d
a	1.000	-.993	.355	.
b	-.993	1.000	-.378	.
c	.355	-.378	1.000	.
d	.	.	.	.

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	11925672142.618	4	2981418035.654
Residual	3903958013.790	25	156158320.552
Uncorrected Total	15829630156.408	29	
Corrected Total	10639605684.285	28	

Dependent variable: NetM2

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .633.

NetM2 to AreaM2

Y= a * AreaM2^2 + b * AreaM2 + c

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a	-2.192E-6	.000	-4.935E-6	5.501E-7
b	1.205	.095	1.008	1.401
c	-217.663	789.952	-1844.600	1409.273
d	20.000	.000	20.000	20.000

Correlations of Parameter Estimates

	a	b	c	d
a	1.000	-.953	.604	.
b	-.953	1.000	-.711	.
c	.604	-.711	1.000	.
d	.	.	.	.

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	15632345936.631	4	3908086484.158
Residual	197284219.778	25	7891368.791
Uncorrected Total	15829630156.408	29	
Corrected Total	10639605684.285	28	

Dependent variable: NetM2

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .981.

3.5 Summary

Based on the analysis, it is realized that all the regression methods used demonstrated fairly strong values of R-squared and very strong values of R. However, the best technique that can best describe the relationship between NetM2 and EdurationM2 was realized to be cubic regression. In particular, it showed the highest values of R and R^2 and the lowest values of RSS and F. On the contrary, the linear regression was noted to be the most unreliable for use in predicting values between the two variables. This is because it was observed to exhibit the lowest values of R and R^2 as well as the highest value of RSS. Best technique that can best describe the relationship between NetM2 and AdurationM2 was realized to be quadratic regression. Based on the analysis, it is realized that all the regression methods used demonstrated fairly strong values of R-squared and very strong values of R. However, the best technique that can best describe the relationship between NetM2 and EdurationM2 was realized to be cubic regression. In particular, it showed the highest values of R and R^2 and the lowest values of RSS and F. On the contrary, the linear regression was noted to be the most unreliable for use in predicting values between the two variables. This is because it was observed to exhibit the lowest values of R and R^2 as well as the highest value of RSS. Best technique that can best describe the relationship between NetM2 and Var2, NetM2 and Var3, NetM2 and AreaM2 was realized to be cubic regression.

CHAPTER 4: DISCUSSION

4.1 Introduction

The main aim of the research has been to investigate the variables that contribute to cost cost overrun and to establish a model that could be used to estimate the final cost in construction projects in the Kingdom of Bahrain. There was an observable gap in the body of knowledge on how to model the final cost of project in the construction industry of Bahrain. The criticality of managing cost overrun in the Bahrain has been exacerbated by the general complexities associated with the sources of cost overrun .However, literature indicated that, there are different factors and elements that influence the cost of any construction contract. It has been analyzed that there are different factors associated with pre and post contract conditions in the Kingdom of Bahrain. Along with this, there are certain conditions that can help to model the cost. The literature review presents the different factors that impact the cost during both the pre-contract and post-contract timings.

This chapter therefore presents a discussion of the research findings from the regression simulation modelling exercises. Throughout this chapter, implications of findings are discussed with respect to theory and practice.

4.2 Modelling Results Summary

The focus of the research was on the regression model is to find out the independent variables that caused variation based on their significant contribution to the prediction of the dependent variables. The various possibilities that required for constructing the project predicted with the help of predictors, which help in the successful outcome of the project.

The NetM2 is only the dependent variable, which affects the area and the other cost of the project. We can summarize that the tender value influenced by the quality of the material and the construction work as well the quantity of material used for completion of the project.

The model can be summarized based on the R square (R^2) value that represents the percentage of total variation in the variable NetM2 (dependent variable) and explained by the variable AreaM2 (independent variable).

The unadjusted multiple R^2 is much higher than the adjusted multiple R^2. Note that also the ANOVA table shows that the combination of variation of the independent variables in the model ($F = 1286.679$, $df = 1$, sig. $=0.00$) to be statistically significant the p-value has to be less than 0.05 predict for a project duration overrun percentage.

The F-statistics will give you the mean for the variations. The $p < 0.05$ means the regression model statistically predicts the outcome variable also the R^2 value shows that model accounted for 98% of the change in the data sample. About 2% not explained by model due to other various factors that were not included in the model or due to natural random variations. The model fitness estimated by the standard error.

Table 15. ANOVA results for Regression Model.

Name of Independent Variable	df	F-statistics	Sig
AreaM2	1	1286.679	.000
EdurationM2	1	261.957	.000
AdurationM2	1	227.560	.000

Here, the Sig. value 0.000 i.e. p <0.05. It simply shows that the model significantly statistically predicts the outcome variable.

When the error value is compared to the 'Standard Deviation' of the dependent variable, It was noted that its amount should not exceed 10% of the dependent variable mean value. However, we may note that exceeding this limit is not essential in regression modeling. The Standard error estimate shows that error exceeds the 10% threshold value.

4.2.1 Significance of the Estimated Coefficients

The estimated coefficients are the estimation of each variable that contributes to determining the dependent variables. The significance value of the expected constant of regression is below 0.05 (Sig. < 0.05), which is assumed to be reliable in defining the point of intercept in the regression model. The project duration can be controlled or reduced if there is periodically check and managed so that variation is not significant. The variables that have high coefficients are the ones that may cause a considerable difference in the project cost and duration.

Table 16: Results for estimated coefficients extracted from regression models

Model	Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	499.001	632.525		.789	.437
AREAm2	1.057	.029	.990	36.208	.000
(Constant)	-3401.671	1495.434		-2.275	.031
EdurationM2	29.438	1.777	.954	16.564	.000
(Constant)	-1964.355	1542.558		-1.273	.214
AdurationM2	29.729	1.933	.947	15.382	.000

4.2.2 Testing for Correlations of the dependent and Independent Variables

The correlations between the independent variables weak but some independent variables have shown partial correlation or multicollinearity. The independent variables do not have high inter-associations. The effect of independent variable reliability is minimal, due to multicollinearity.

Table 17. Non-Linear Regression Analysis for Correlations

Name of Independent Variable	Correlation
EdurationM2	1.000 to -.680
AdurationM2	1.000 to -.585
AreaM2	1.000 to -.499
EPriceM2	1.000 to -.935
TpriceM2	1.000 to -.940
Var1	1.000 to .250
Var2	1.000 to .593
Var3	1.000 to .612
Quad_EdurationM2	1.000 to .621
Quad AdurationM2	1.000 to .609
Quad AREAM2	1.000 to .595
Quad EpriceM2	1.000 to .929
Quad TpriceM2	1.000 to .909
Quad Var1	1.000 to -.422
Quad Var2	1.000 to -.205
Quad Var3	1.000 to -.257

4.2.3 Testing for Collinearity or crosstabs or chi-square test

Below table shows the crosstabs or chi-square test results of independent variables with respect to the dependent variable NetM2.

Table 18: Testing the Collinearity between variables

Case Processing Summary

	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
NetM2 * EpriceM2	29	100.0%	0	0.0%	29	100.0%
NetM2 * TpriceM2	29	100.0%	0	0.0%	29	100.0%
NetM2 * EdurationM2	29	100.0%	0	0.0%	29	100.0%
NetM2 * AdurationM2	29	100.0%	0	0.0%	29	100.0%
NetM2 * Var1	29	100.0%	0	0.0%	29	100.0%
NetM2 * Var2	29	100.0%	0	0.0%	29	100.0%
NetM2 * Var3	29	100.0%	0	0.0%	29	100.0%

Table 19: Chi Square Test Results

Chi-Square Tests

	Value	df	Asymptotic Significance (2sided)
Pearson Chi-Square	725.000[a]	700	.249
Likelihood Ratio	186.985	700	1.000
Linear-by-Linear Association	27.435	1	.000
N of Valid Cases	29		

Note: The phenomena of collinearity in regression analysis associated with the inter-correlation among independent variables.

Chapter Five: Conclusion

5.1 Introduction

This chapter will introduce the conclusions drawn out of this research and analysis did over the data from chapter 2 and 3. The robustness of the adopted methodology is examined first. Secondly, the objectives of the investigation are revisited with a view to compare expected results with the achievements accomplished. Thirdly, the limitations of this research are listed. Fourthly, the contribution to knowledge is presented. Fifthly, areas for further research are put forward.

5.2 Robustness of the Research Methodology

The research methodology adopted to accomplish the research aims and objectives was presented in Chapter 2. A mixed research approach was employed to achieve the objectives of this investigation. An in-depth literature review has been carried out to synthesize existing knowledge on the causes of variation to identify gaps in the research and to develop and refine the research questions and objectives. This has resulted in the elicitation of a large list of possible causes of variation factors. This list was cross-referenced to document for its validity. Furthermore, the list was classified and clustered according to the source of the variation. Data were coded according to SPSS standards. Also, an in-depth literature review was carried out to synthesize existing knowledge on the methods for modelling causes of variation and the final cost of projects. This led to the adoption of multiple regression and SPSS techniques to model the association between the causes of variation and their impact. These causes were then used to collect real-world data from 29 projects from a database of Bahrain Defense Force. Several fitting measurements were used to assess the validity and robustness of the developed model. For example, in regression significance, Standard Error, R2, residual plots, P-P plot, Q_Q, etc., were used to measure the accuracy of the derived model. The approaches taken in this study are considered to be suitable given the unique characteristics of the research framework developed in the course of this investigation.

5.3 Accomplishing the Research Objectives

- To identify the main sources and causes of variation in construction projects.
- This objective was achieved through a systematic literature review. To investigate the relationship between the selected dependent variable and independent variables and their impacts on project success criteria of construction projects in the Kingdom of Bahrain.

From the literature review.

These causes of variation were extracted and described in great detail in Chapter 2. The completion of this objective was a prerequisite for some of the next research objectives.

To investigate the relationship between variation causes and construction projects success criteria.

The relationship between variation causes and success criteria was investigated as described in the research methodology provided in Chapter 2 of this thesis. It was found from the literature review, the interviews, the survey and the case study files that some variation causes had an obvious impact on the project success criteria, mainly on the cost, time, quality and scope of the project. These are then used the survey to identify their impact on the project success criteria. Their impacts were ranked according to the related source group and then according to overall ranking based on professional roles. The results of the impact and ranking are shown and discussed in detail in chapter 2 and Chapter 3 of the thesis.

- To develop a model for analyzing the impact of causes of variation on project outcomes (duration overrun) in construction projects.

This research objective was carried out on the assumption that the development of a new framework for assessing the causes of variation in construction projects signifies that the existing methods are inappropriate and need to be rejected. One of the main advancements in knowledge provided by this research is the development of an integrated stochastic model for the assessment of the impact of the causes of variation during the design and bidding stages of construction projects. This objective was achieved through the development of an integrated analysis based on SPSS. The achievement of this objective is presented in Chapter 3. The development of the model is based on the sound theoretical models that were reported in the literature and reviewed in chapter 2. It is important to emphasize here that there is no single best model for every situation; every methodology is based on a particular context and underlying assumption. The model developed by this work is driven by the research gaps that were identified in the literature review. The model forges stronger links between causes of variation and their impact on a project outcome in terms of cost overrun. In theory, the model assists organizations to simulate project performance and maintain the impact of variation at a minimum level that can be financially tolerated. The model serves as a vehicle for assessing the impact of variation on project performance. It also enables clients and consultants to identify strategies for management variation and assists them in identifying the causes that may lead to undermining project performance. The developed model can be globally used to analyze the causes of variations and is not limited to any particular context, providing the primary data are changed to reflect the context of the application.

5.4 Generalizability, Applicability, and Implications of the Findings

- In this section, we discusses the generalizability of the research findings. The developed regression, stochastic models, and the modelling are more appropriate for analyzing the impact of possible causes of to investigate the relationship between the selected dependent variable and independent variables and their impacts on project success criteria of construction projects in the Kingdom of Bahrain.

Although the construction industry was the source of the primary data, commonalities across similar industries in different countries are possible, which may enable this research to be used in other settings. Certainly, the modelling framework developed in this research provides applicability opportunities for this research in many other industrial sectors. In order to do so, it would be necessary to make some adjustments or additions to the causes of variation data and probability distributions and associated possible cost overruns. This is necessary so that the probability distributions reflect the modelling context. It is also worth pointing out the possible appropriateness of the developed modelling framework to support decision-making through the computation of probability distribution of the causes of variations and their consequences. The use of probability percentile values will increase confidence in the decision-making process for estimating the impact of the causes of variation.

5.5 Research Limitations

Most, if not all, research projects are based on assumptions; thus, no research framework can claim to be complete. As such, the research framework presented in this investigation will have limitations, some of which are as follows:

- The ranking of causes of variation was based on data related to all types of projects. No analysis was made on the bases of an individual type of projects. In an ideal scenario, data should be project based. This will allow for better homogeneity of data, leading to better generalizability. However, the causes of variation are extracted from an extensive literature review, and therefore the research will be useful for many users;
- In its present form, the regression model does not include enough causes of variation to allow the user to test their impact;
- The data for the impact of the causes of variation are estimated as a proxy of the duration overrun from the case study projects. If one can obtain data records to trace the impact of variation orders on the construction cost unit, this will improve the usability of the model;
- The developed research model is based on specific-population data. The data were collected from the database of Kingdom of Bahrain.
- Only one performance criterion was used to assess the causes of variation.

Further research is needed to overcome such limitations. The next section details the study's contribution to knowledge, whilst the final section explores some possible areas for future development and research.

5.6 Contribution to Knowledge of the Research

- This research provides an increased understanding of the events that lead to cost overrun. The focus of the research was directed towards cost overrun' identification and classification, and to modelling the link between them and causes of variation and their impact (duration overrun was used as a proxy variable to measure the impact) To investigate the relationship between the selected dependent variable and independent variables and their impacts on project success criteria of construction projects in the Kingdom of Bahrain. Additionally, an approach to capture the dynamism between the causes of cost overrun and their impact was carried out through SPSS. To summarize, the research has contributed towards formalizing the estimation of the impact of the causes of cost overrun in construction projects using a combination of regression and SPSS techniques. According to the formulated research questions, the key research contributions of this investigation are summarized in the following areas:
  - The model for identifying the highest ranked factors that impact project.
  - Using this model, the research added the argument that the highest ranked factors had the highest impact on the project.
  - The researcher developed and validated probability distribution for the most important causes of cost overrun (those which correlate with the proxy variable).
  - The researcher also conducted a multiple-regression analysis to quantify the association between causes of cost overrun and their impact based on real 29 case studies. The model was used to stochastically estimate the impact of causes of cost overrun. The objective of the research was to develop a generic model to assist in developing budget contingencies for managing the impact of causes of variation in construction projects.

- The major contribution then is that the research framework can be used by businesses to model their own factors and help in their decision-making, as opposed to using anecdotal evidence.

5.7 Recommendations for Further Research

This investigation has identified a number of areas that would benefit from further research. However, the research framework developed in this research could be enhanced in many ways, including the following:

- Investigation of the other categories – scope, quality, and cost – is needed in the same way as time has been investigated in this research.
- Investigate the impact of overrun cost for other projects such as infrastructure, roads, and railways, because this research was only developed based on 29 projects. Thus, there is a need to test if it can be used for other project types within the same industry.
- Map the causes of variation to their impact, such as cost and time overrun success criteria.
- Profile the cost consequences of each of the variation causes.

Appendix A

ProjectNo	Type	Floors	AREAm2	Eprice	EpriceM2	T price	TpriceM2	Eduration	EdurationM2	Aduration	AdurationM2	Variations	Net	NetM2	Var1	Var2	Var3	Ratio1	Ratio2
1	12 Villas	2	7,000.0	1,225,000.0	175.0	1,408,750.0	201.3	540.0	0.077	540.0	0.077	233,000.0	1,641,750.0	8,157.8	183,750.0	416,750.0	233,000.0	1.2	1.3
2	8 Villas	3	6,800.0	1,428,000.0	210.0	1,499,400.0	220.5	540.0	0.079	600.0	0.088	396,000.0	1,895,400.0	8,595.9	71,400.0	467,400.0	396,000.0	1.3	1.3
3	14 Villas	2	6,500.0	1,222,000.0	188.0	1,344,200.0	206.8	720.0	0.111	600.0	0.092	75,000.0	1,419,200.0	6,862.7	122,200.0	197,200.0	75,000.0	1.1	1.2
4	168 Car park	0	840.0	255,400.0	304.0	319,250.0	380.1	240.0	0.286	300.0	0.357	58,000.0	377,250.0	992.6	63,850.0	121,850.0	58,000.0	1.2	1.5
5	Store	1	13,200.0	1,782,000.0	135.0	1,782,000.0	135.0	300.0	0.023	330.0	0.025	125,000.0	1,907,000.0	14,125.9	0.0	125,000.0	125,000.0	1.1	1.1
6	Building	3	13,200.0	3,960,000.0	300.0	4,554,000.0	345.0	540.0	0.041	720.0	0.055	568,000.0	5,122,000.0	14,846.4	594,000.0	1,162,000.0	568,000.0	1.1	1.3
7	Camp with fecilities	3	27,500.0	4,687,500.0	170.5	4,250,000.0	154.5	720.0	0.026	720.0	0.026	250,000.0	5,000,000.0	32,352.9	-437,500.0	312,500.0	750,000.0	1.2	1.1
8	Shopping mall	3	36,000.0	14,125,000.0	392.4	15,199,000.0	422.2	900.0	0.025	900.0	0.025	0.0	15,199,000.0	36,000.0	1,074,000.0	1,074,000.0	0.0	1.0	1.1
9	Medical centre	5	22,000.0	5,600,000.0	254.5	4,500,000.0	204.5	540.0	0.025	1,080.0	0.049	2,500,000.0	7,000,000.0	34,222.2	-1,100,000.0	1,400,000.0	2,500,000.0	1.6	1.3
10	Medical centre with car park	6	62,000.0	23,100,000.0	372.6	23,500,000.0	379.0	900.0	0.015	900.0	0.015	2,300,000.0	25,800,000.0	68,068.1	400,000.0	2,700,000.0	2,300,000.0	1.1	1.1
11	Building	12	14,400.0	4,320,000.0	300.0	4,968,000.0	345.0	540.0	0.038	540.0	0.038	250,000.0	5,218,000.0	15,124.6	648,000.0	898,000.0	250,000.0	1.1	1.2
12	10 villas	2	4,800.0	1,008,000.0	210.0	1,058,400.0	220.5	540.0	0.113	600.0	0.125	116,000.0	1,174,400.0	5,326.1	50,400.0	166,400.0	116,000.0	1.1	1.2
13	2 Villas	2	1,600.0	440,000.0	275.0	484,000.0	302.5	540.0	0.338	480.0	0.300	175,000.0	659,000.0	2,178.5	44,000.0	219,000.0	175,000.0	1.4	1.5
14	3 villas	2	2,520.0	756,000.0	300.0	945,000.0	375.0	540.0	0.214	540.0	0.214	96,000.0	1,041,000.0	2,776.0	189,000.0	285,000.0	96,000.0	1.1	1.4
15	Accommodation	2	8,800.0	1,276,000.0	145.0	1,276,000.0	145.0	300.0	0.034	360.0	0.041	125,000.0	1,401,000.0	9,662.1	0.0	125,000.0	125,000.0	1.1	1.1
16	Building	7	13,475.0	4,379,375.0	325.0	5,036,281.3	373.8	540.0	0.040	540.0	0.040	218,000.0	5,058,081.3	13,533.3	656,906.3	678,706.3	21,800.0	1.0	1.2
17	Building	10	8,100.0	2,146,500.0	265.0	2,425,545.0	299.5	720.0	0.089	720.0	0.089	168,000.0	259,545.0	866.7	279,045.0	-1,886,955.0	-2,166,000.0	0.1	0.1
18	Building	4	3,500.0	1,400,000.0	400.0	1,652,000.0	472.0	720.0	0.206	720.0	0.206	238,000.0	1,890,000.0	4,004.2	252,000.0	490,000.0	238,000.0	1.1	1.4
19	Building	2	2,200.0	825,000.0	375.0	1,031,250.0	468.8	540.0	0.245	1,080.0	0.491	538,000.0	1,569,250.0	3,347.7	206,250.0	744,250.0	538,000.0	1.5	1.9
20	Building	1	7,800.0	3,900,000.0	500.0	3,978,000.0	510.0	900.0	0.115	900.0	0.115	745,000.0	40,525,000.0	79,460.8	78,000.0	36,625,000.0	36,547,000.0	10.2	10.4
21	Spare part storage	0	881.0	179,000.0	203.2	165,442.0	187.8	180.0	0.204	330.0	0.375	109,323.0	274,765.0	1,463.2	-13,558.0	95,765.0	109,323.0	1.7	1.5
22	Multi hall	0	3,023.0	1,982,166.0	655.7	1,956,957.0	647.4	360.0	0.119	690.0	0.228	1,476,268.0	3,433,168.0	5,303.4	-25,209.0	1,451,002.0	1,476,211.0	1.8	1.7
23	2 Buildings	6	8,800.0	1,980,000.0	225.0	1,710,346.0	194.4	540.0	0.061	630.0	0.072	491,542.0	2,201,888.0	11,329.1	-269,654.0	221,888.0	491,542.0	1.3	1.1
24	Building	1	1,484.0	276,627.0	186.4	267,300.0	180.1	240.0	0.162	540.0	0.364	-39,507.0	227,793.0	1,264.7	-9,327.0	-48,834.0	-39,507.0	0.9	0.8
25	Building	2	650.0	187,810.0	288.9	200,743.0	308.8	150.0	0.231	150.0	0.231	53,428.0	254,171.0	823.0	12,933.0	66,361.0	53,428.0	1.3	1.4
26	Maintance hanger	0	770.0	250,888.0	325.8	242,495.0	314.9	240.0	0.312	240.0	0.312	132,576.0	374,971.0	1,190.7	-8,393.0	124,083.0	132,476.0	1.5	1.5
27	Building	2	2,870.0	1,281,471.0	446.5	1,189,000.0	414.3	450.0	0.157	810.0	0.282	776,181.0	1,965,181.0	4,743.5	-92,471.0	683,710.0	776,181.0	1.7	1.5
28	accomdation and hall	2	863.0	325,431.0	377.1	308,913.0	358.0	300.0	0.348	600.0	0.695	50,155.0	359,068.0	1,003.1	-16,518.0	33,637.0	50,155.0	1.2	1.1
29	Building and lecture hall	2	260.0	59014	227.0	49,793.0	191.5	180.0	0.692	300.0	1.154	13,765.0	63,558.0	331.9	-9,221.0	4,544.0	13,765.0	1.3	1.1

REFERENCES

[1] Warsame, A. (2011). Essays on Supplier Structure, Construction Costs, and Quality Improvement. *The performance of Construction Projects*.

[2] Ubani, E. C., Okorocha, K. A., & Emeribe, S. C. (2013). Analysis of factors influencing time and cost overruns on construction projects in South Eastern Nigeria. *International Journal of Management Sciences and Business Research*, *2*(2), 73-84.

[3] Olawale, Y. A., & Sun, M. (2010). Cost and time control of construction projects: inhibiting factors and mitigating measures in practice. *Construction Management and Economics*, *28*(5), 509-526. doi:10.1080/01446191003674519

[4] Jennifer, S. S., Keith, R. M., Anderson, S., & Schexnayder, C. (2009). Construction Project Cost Escalation Factors. *Journal of Management in Engineering*, *25*(4), 221-229.

[5] Zhao, L., Mbachu, J., & Domingo, N. (2017). Exploratory Factors Influencing Building Development Costs in New Zealand Using SEM. doi:10.20944/preprints201704.0187.v1

[6] Choon, T. T., Sim, L. C., & Connie, T. (2016). Influential Factors in Estimating and Tendering for Construction Work. *The 3rd International Conference on Civil and Environmental Engineering for Sustainability*, *4*, 5.

[7] Cheng, Y. (2014). An exploration into cost-influencing factors on construction projects. *International Journal of Project Management*, *32*(5), 850-860. doi: 10.1016/j.ijproman.2013.10.003

[8] Callegari, D. A., & Bastos, R. M. (2007). Project Management and Software Development Processes: Integrating RUP and PMBOK. *2007 International Conference on Systems Engineering and Modeling*, 1-8. doi:10.1109/icsem.2007.373327

[9] Elsey, R. D. (2007). Contract Management Guide. *The Chartered Institute of Purchasing & Supply*, 1-36. Retrieved from https://www.cips.org/documents/CIPS_KI_Contract%20Management%20Guidev2.pdf

[10] Enshassi, A., Mohamed, S., & Hadi, M. A. (2013). Factors affecting the accuracy of cost estimation of building contracts in the Gaza Strip. *Penerbit Universiti Sains Malaysia*, *18*(1), 73–94. doi:10.1108/13664380580001069

[11] Cunningham, T. (2013). Factors Affecting The Cost of Building Work - An Overview. *Dublin Institute of Technology*, 1-23. Retrieved from http://arrow.dit.ie/cgi/viewcontent.cgi?article=1028&context=beschreoth

[12] Ji, C., Mbachu, J., & Domingo, N. (2014). Factors Influencing the Accuracy Of Pre-Contract Stage Estimation Of Final Contract Price In New Zealand. *International Journal Of Construction Supply Chain Management*, *4*(2), 51-64. Retrieved from http://www.ijcscm.com/sites/default/files/issue/nid-6/jimbachu_1427439669.pdf

[13] Knott, R. J., & Davis, E. R. (1982). Project Control-An Overview. *Journal of the South American Institute of Mining and Metallurgy*, 160-164. Retrieved from https://www.saimm.co.za/Journal/v082n06p160.pdf

[14] Archibald, R. D., Filippo, I. D., & Filippo, D. D. (2012). The Six-Phase Comprehensive Project Life Cycle Model Including the Project Incubation/Feasibility Phase and the Post-Project Evaluation Phase. *Systems Thinking: Managing Chaos and Complexity*, 1-33. Retrieved from http://www.dphu.org/uploads/attachements/books/books_5917_0.pdf

[15] Comer, B. (1996). Project Finance Teaching Note. *FNCE 208/731*, 1-22.

[16] Kirkham, R. J., Boussabaine, A. H., grew, R. G., & Sinclair, S. P) .1999 .(Forecasting the running costs of sport and leisure centres .

[17] Boussabaine, A., & Kirkham, R) .2004 .(Simulation of maintenance costs in UK local authority sport centres .*Construction Management and Economics*, *22*)10(, 1011-1020 .doi:10.1080/1466433x.2004.11878565

[18] Alsohiman, N. K) .2017 .(Modelling Variation for Improving the Management of Construction Engineering Projects outcomes in the Kingdom of Saudi Arabia .*University of Liverpool* .doi:10.1515/9783110930047.102