THE IMPACT OF IMPLEMENTING MATURITY MODELS ON IT PROJECT PERFORMANCE

تأثير تطبيق معايير النضج على أداء مشاريع تكنولوجيا المعلومات

by

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Abstract

Recently, many models of maturity have emerged in IT sector, and there are few research studies on their benefits and impact on projects performance. The main aim is to study the impact of implementing project management maturity models on IT project performance. The quantitative approach was used by measuring the implementation of four basic principles shared by all maturity model. In addition, secondary research methods were used to collect data on the implementation of maturity models from academic journals, articles, and online books. A survey was conducted as a primary research method to collect data from employees of various job roles working in IT organisations. This survey is designed in three sections, the first for demographics, the second for measuring maturity models implementation, and the third for measuring project performance. Survey questionnaire was published by sending it electronically to 300 IT professionals representing the study population. 192 responses were received and therefore the participation response rate was 64%. Appropriate scientific analysis methods were used to analyze the data, including descriptive analysis, reliability, correlation, linear regression, and multiple regression. This research found that the implementation of maturity models have a significant relationship with the performance of IT projects, and plays an important role in influencing. The research offers a set of recommendations, including:

- ✓ To improve the performance of IT projects, it is recommended to implement the project management maturity models, with an emphasis on process improvement activities.

- ✓ It is recommended that IT organizations start spreading awareness of maturity models and adopt their own improvement policies.

ملخص

في الآونة الأخيرة ، ظهرت العديد من نماذج النضج في قطاع تكنولوجيا المعلومات ، وهناك القليل من الدراسات البحثية التي درست مدى تأثير تنفيذ نماذج النضج على اداء مشاريع تكنولوجيا المعلومات. الهدف هو دراسة مدى تأثير تنفيذ هذه النماذج على اداء مشاريع تكنولوجيا المعلومات. هذه الدراسة تتناول تأثير تطبيق نماذج النضج من خلال قياس اربعة مبادئ اساسية تتشارك بها اكثر نماذج النضج انتشارا باستخدام النهج الكمي. بالإضافة إلى ذلك ، تم استخدام طرق البحث الثانوية لجمع البيانات حول تنفيذ نماذج النضج من المجلات الأكاديمية والمقالات والكتب. تم إجراء استطلاع كطريقة بحث أولية لجمع البيانات من موظفيين لدى منظمات تكنولوجيا المعلومات ينتمون لادوار وظيفية متنوعه. تم تصميم هذا المسح من ثلاثة أقسام ، عناصر ديموغرافية ، وعناصر لقياس تنفيذ المبادىء الاربعة لنماذج النضج ، بالإضافة إلى عناصر لقياس أداء المشاريع. تم توزيع الاستبيان على 300 شخص وتم تلقي اجابة من 192 منها وهذا ما يقرب من 64% من إجمالي الاستطلاعات الموزعة. تم استخدام طرق التحليل العلمية المناسبة لتحليل البيانات ، بما في ذلك

(Descriptive analysis, reliability, correlation, linear regression, and multiple regression)

هذا البحث وجد أن هنالك ثلاثة عوامل لتنفيذ نماذج النضج وهي: تحسين العمليات ، وممارسات إدارة المشاريع ، ومعايير هندسة البرمجيات تمتلك علاقة ايجابية بأداء مشاريع تكنولوجيا المعلومات ، مما يعني أن تنفيذ نماذج النضج تؤثر بزيادة أداء مشاريع تكنولوجيا المعلومات.

قدمت الدراسة عدد من التوصيات منها:

- لتحسين أداء مشاريع تكنولوجيا المعلومات ، يوصى بتنفيذ نماذج نضج إدارة المشروع داخل مؤسسات تكنولوجيا المعلومات ، مع تبني أنشطة تحسين العمليات.
- يوصى لمؤسسات تكنولوجيا المعلومات بالعمل على نشر الوعي باهمية نماذج النضج واعتماد افضل الممارسات بادارة المشاريع.

Dedication

To my dear wife Maysa', our kids Talia, Sanad, and Bana for their support to achieve my ambitions to obtain the highest academic grades for a better future.

To my supervisor Prof Abubakr Suliman who was the guiding light every step of the way as I researched for this dissertation

To myself who did not give up and did not stop dreaming.

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Abbreviation

Abbreviation	Full Description
PMO	Project Management Office
PMMM	Project Management Maturity Model
CMMI	Capability Maturity Model
OPM3	Organizational Project Management Model
P3M3	Portfolio, Programme and Project Management Maturity Model
P2MM	Prince2 Maturity Model
KPM3	Kerzner’s Maturity Model
PM2	Berkley’s Maturity Model
PMBOK	Project Management Body of Knowledge
TQM	Total Quality Management
PMI	Project Management Institute

Chapter 1: Introduction

This chapter delineates the research problem at hand and explicates the primary aims and objectives of this study. It is an overture to this dissertation and provides a brief outline of the same.

1.1. Overview and Background

Recently, the importance of information technology (IT) has been acknowledged in many countries across the globe, and a massive investment has been made in this sector, among other things. Many countries and companies have allocated huge financial resources to invest in the IT sector because of the main benefits obtained. As mentioned in (Economics, 2017) report, the digital economy around the world has reached $11.5 trillion, which is equivalent to 15.5% of the global GDP, as it has grown more than 2.5 times over the past 15 years. Also, according to (Kevin Barefoot, 2018), the US digital economy grew by 5.6% between 2006 and 2016, which is equivalent to 6.5% of its GDP. Consequently, many countries have rushed to adopt the concept of e-governance and digitise their governmental and private institutions. With this rapid progress and full dependence on technology, IT organisations have dealt with a multitude of obstacles and challenges by providing appropriate and effective programs and systems that can, for example, manage time, cost, and return on investment, increase productivity, and maintain customer satisfaction (Niazi et al., 2010).

Consequently, effective management of IT projects has become one of the foremost priorities of this sector's institutions, as it has effective tools to provide business value and respond to desires and changes in organisations. To gauge and govern project management methods and processes, the importance of implementing maturity models has emerged, and it ensures the proper functioning of IT organisations and helps maintain their performance.

Maturity models evaluate the organisational levels, competencies, and processes that are being implemented within IT organisations against specific organisational standards and processes so that they can determine the appropriate level of maturity and capability by implementing standard process frameworks for organisational improvement. This study was conducted with the objective to assist IT organisations in evaluating and measuring the effectiveness of implementing various maturity standards on the progress of their development work, especially with regard to project management to achieve its goals and strategic aspirations and serve societies by ensuring efficacious project management.

1.2. Problem Definition

There has always been huge uncertainty regarding the implementation of institutional frameworks that are based on approaches and models from companies and employees because of the increase in the requirements, work, and process bureaucracy. According to (Almeida Prado Cestari et al., 2013), there is a lack of dedication and loyalty to these models because of the lack of concrete evidence measures correlating the implementation of maturity models and achieving performance.

Many scholars, for example, (Zarour et al., 2019, Santos-Neto and Costa, 2019), have reported that despite the availability and prevalence of many project management maturity models today that have been in use and implemented for several years, there is still no conclusive evidence of their effectiveness, and IT organisations still suffer from delayed project delivery and product quality issues.

Furthermore, (Tarhan et al., 2016) underlined that although the implementation of project management maturity models leads to the success of organisations through process improvements, there is still a lack of validation despite the large number of maturity models that have been developed.

Nowadays, there are a number of IT organisations looking to improve their work performance, and one of the most critical challenges they confront is the ability to measure the effectiveness of their project management and the reason behind success or failure. A number of researchers, including (Walia et al., 2009), believe that the chief causes of failure of IT projects are not related to financial resources or human competencies but rather the lack of standard frameworks for processes, which results in failure or poor quality of products and projects alike. Several IT organisations have followed their own policies and processes that govern the project management process to serve their goals and visions; there were no clear and standardised processes such as those promoted by international institutes. In addition, IT organisations suffer from a set of problems such as missing project deadlines and weak products, and there is a weakness in the administrative capabilities and lack of control over project outputs, which leads to rework and increased costs that negatively affect customer satisfaction.

(Jaleel et al., 2019) remarked that if IT organisations want to maintain their market value and have a competitive advantage in this sector through a large number of successful project implementations, they must change their traditional policies in improving project management and adopt standard maturity models.

The implementation of project management maturity models has been extensively studied in the general project management literature. Some scholars focused on the mechanisms of implementing these models, such as (Kostalova and Tetrevova, 2018, Aguiar et al., 2018). Others have demonstrated a wide array of maturity models and explained the maturity levels in each and how to assess current levels of maturity for organisations (Aguiar et al., 2018).

The performance of an IT project has also been studied by several scholars such as (Lindhard et al., 2016, Anantatmula, 2015), who have made contributions through literature review focusing on the key factors affecting project performance and critical success factors of projects and presented feasible strategies to enhance project performance.

However, there are no studies that adequately summarise, evaluate, and interpret the literature pertaining to the role of project management maturity models in enhancing the performance of IT projects. While there are literature review studies on maturity models and project performance, there are no literature reviews particularly analysing the IT project area. To help bridge this gap, this study contributes to the literature by revealing the true evaluation of such frameworks and the usefulness of their implementation in improving project management processes and leaving a positive impact on IT project performance as well.

1.3. Research Questions

The study problem can be realised by answering the following questions:

1. Is there a positive impact on IT project performance through the implementation of project management maturity models?

2. Is there strong influence on IT project performance when implementing process improvement plans?

3. Does the application of project management standards positively affect the performance of an IT project?

4. Does the existence of product quality improvement practices have a positive impact on the performance of IT projects?

5. Does the application of software engineering standards directly affect the performance of IT projects?

1.4. Research Aim and Objectives

The main aim of this research is to study the impact of implementing project management maturity models on IT project performance. This study aims to identify the main factors that influence the performance of IT projects as a result of the implementation of maturity models.

Achieving this aim is directly related to the following research objectives:

1. To explore the role of implementing project management maturity models in IT organisations and determine their impact on the performance of IT.

2. To determine the extent to which the existence of project management practices affects the performance of IT projects.

3. To investigate the extent to which the existence of process improvement plans affects the performance of IT projects.

4. To verify the impact of the existence of practices to improve product quality on the performance of IT projects.

5. To examine the extent to which the existence of software engineering standards affect the performance of IT projects.

1.5. Rationale of the Study

Through a comprehensive analysis of project management maturity models, the impact of implementing maturity models in the IT industry on project performance will be revealed. Additionally, this study will show the role of maturity models in improving the software industry's operations. This study will help enrich the knowledge of project management maturity models and demonstrate their positive impact on IT organisations. The implementation of project management maturity models has been extensively studied in the general project management literature. Some scholars have focused on the mechanisms of implementing these models, such as (Kostalova and Tetrevova, 2018, Aguiar et al., 2018).

Furthermore, a number of researchers have demonstrated various maturity models and explained the maturity levels in each and how to assess current levels of maturity for organisations (Aguiar et al., 2018). However, heretofore, there are no studies that evaluate the role of project management maturity models in enhancing the performance of IT projects, and this study contributes to bridging this gap.

This study will help IT organisations understand how the adoption of maturity models will affect their current performance. Also, through the analysis conducted in this research, IT sector entities will have a new approach on how to deal with maturity models and improve the performance of their projects. The economic challenges and competition among the organisations in the IT sector are increasing, and they must adopt new policies for innovation and change. (Sahar et al., 2019) stated that nowadays, IT organisations have to keep pace with new strategies for doing business in the digital economy. A wide array of smart applications and electronic systems has generated numerous challenges for organisations. Furthermore, (Martens and Carvalho, 2017) mentioned that recently, there has been a growing interest in the use of best practices in project management by different entities.

Hence, the findings of this study are anticipated to be useful for researchers who wish to understand this topic and study the factors affecting the software industry environment in the Middle East; this study will guide them through the state of implementation of maturity models in general and make them aware of their impact on improving organisations' operations.

1.6. Research Structure

This dissertation consists of six chapters covering all the research objectives mentioned previously. A summary of each chapter is described as follows.

Chapter 1 summarises the main research problem and develops each of the main research aim and objectives. It also provides an introduction to the dissertation and an outline of its structure.

Chapter 2 presents a review of the most important literature on project management maturity models – from their inception to their most popular adopted models these days – for example, PMI Project Management Maturity Model (OPM3) and Capability Maturity Model Integration (CMMI). In addition to a literature review on project management office (PMO), related maturity models and their role in project management processes are discussed. This chapter also presents the relationship between implementing maturity models and project performance.

Chapter 3 provides a comprehensive summary of the research method used in the research. The quantitative research method was used by conducting a survey distributed to employees of IT organisations to assess the impact of applying maturity models from their point of view.

Chapter 4 examines and analyses the result of data collection from the distributed survey of the targeted sample of the study.

Chapter 5 presents a discussion and interpretation of the data collected. This chapter also underlines this study's findings and outlines its limitations.

Chapter 6 presents the conclusion of the results obtained through this study. It highlights the aim of this study and the methodology for achieving its objectives, identifies areas that require further research, and provides a set of recommendations for future research.

Chapter 2: Literature Review

This chapter summarises the studies and literature related to the research topic. This chapter includes five sections. The first reviews literary information on PMO, their roles in directing projects, and their importance to IT organisations.

The second part deals with literature studies on the most commonly used maturity models in the IT sector such as CMMI, OPM3, and others, and explains their origins, stages of development, structures, and functions.

The third part will introduce the concept of project performance, review the relevant literature, and explain the factors that affect project performance in IT organisations.

The fourth part shows and explains the relationship between the implementation of OPM3 and its impact on projects performance.

The fifth part presents and explains the conceptual model of research, discuss the research variables and their factors, explain the relationships between them, and present a set of hypotheses based on the literary and theoretical basis of the research topic.

2.1. Project Management Office

This section presents a review of the extant literature on PMO, the related PM maturity models, and their role in project management practices. To begin to understand the concept of PMO, it is necessary to explain some concepts related to project management. The concept of project was previously defined by The Project Management Institute (PMI), and it is the most commonly used, unique, and temporary attempt to achieve service or product (Guide, 2001).

Likewise, Association for Project Management (APM) defines the term project as a unique and transient endeavour that aims to achieve the planned goals, which can be identified as outcomes or benefits (APM, 2021).

Consequently, the practice that requires employing skills and using special techniques and tools to get project activities is known as project management, as defined by PMI in its project management guide (Guide, 2001). Furthermore, (Gardiner, 2005) defined in his book that project management is a form of science or an art to turn an aspiration into reality.

Thus, the organisational entity that is responsible for assisting project managers and project teams during the project life cycle in implementing project management's tools, methodologies, and techniques is known as the 'project management office'. PMO acts as the separating layer between the top management of organisations and project managers (Martin et al., 2005).

Certain researchers like (Desouza and Evaristo, 2006) have visions of defining the PMO as a repository of knowledge and a central unit for resources and it can be used to manage IT projects effectively and efficiently. Other researchers such as (F Rad, 2002) have defined it as the organisational unit responsible for conducting project activities and procedures in line with the goals and policies of the organisations.

In this dissertation, I prefer to use the definition of PMO as defined by PMI, which is a body or organisational entity that has assigned different responsibilities related to the central and coordinated management of those projects within its field (Guide, 2001). Thus, PMO is an organisational innovation that enables organisations to improve their project management and use the best technologies and practices to serve their goals and vision.

PMOs have been used as far back as the 1930s and have been deployed in the defence and communication industries (Desouza and Evaristo, 2006). In the last decade, there was widespread interest among IT organisations to establish PMO offices to manage projects in order to address the dilemma of the year 2000 that was threatening many electronic systems in the world, as it refers to possible computer errors related to the formatting and storage of calendar data for dates in the year 2000 and after. (Dai and Wells, 2004); after the end of this dilemma, many organisations abandoned these offices, and yet the other part kept them to supervise various IT projects, which led to an abrupt expansion of the roles and responsibilities of these offices (Desouza and Evaristo, 2006).

In 2003, a survey of 704 decision makers for IT organisations about PMOs revealed that 67% of the organisations had established PMOs within their organisations (Pohlmann et al., 2003).

2.1.1. Project Management Office Models and Configurations

A PMO helps both IT project managers and related organisations understand and apply best practices and techniques for integrating and adapting organisations' insights into project management efforts (Hill, 2004). According to (Kendall and Rollins, 2003), PMOs can be categorised into four models described as follows.

I. Project Repository Model:

According to this model, the role of a PMO is to ensure that project management tools and practices are applied. This model assumes that the organisation has adopted a set of tools used in project management, design, and reporting.

II. Project Training Model:

As per this model, the role of a PMO is to provide training and direction to project managers to ensure the availability of suitable competencies to manage projects.

III. Enterprise PMO Model:

In this model, the chief role of PMO is to periodically supervise all the projects of an organisation, regardless of their sizes, assuming the project's governance by centralising the management of all projects.

IV. Delivering Value Now Model:

According to this model, the role of a PMO is to insure that the portfolio of projects linked to the policies and goals of organisations.

(Desouza and Evaristo, 2006) also proposed another model of PMO, which categorises the same into three models described as follows.

I. Strategic Model:

According to this model, the role of a PMO is to ensure that an organisation's projects comply with its strategic goals such that the implemented projects achieve the goals and visions of the organisations and the projects contribute to the strategic growth of the organisations. Additionally, a PMO ensures an effective management of knowledge in order to develop policies, practices, and project management methodologies within the organisation.

II. Tactical Model:

As per this model, the role of a PMO is to ensure achieving integration and coordination between all projects implemented in the institution through an active follow-up of each project and ensure that the deliverables are achieved as planned and are of high quality and follow a standardised methodology with cooperation among all project members.

III. Operational Model:

In this model, the chief role of PMO is to periodically evaluate the implemented projects to ensure the effectiveness of their implementation and provide a central repository of knowledge for best practices and lessons learnt to provide an opportunity to project managers to benefit from previous experiences, in addition to maintaining customer satisfaction and submitting reports to decision-makers on an ongoing basis.

(Letavec, 2006) also proposed another model of PMO, which categorises the same into three models described as follows.

I. Consultant Model:

As per this model, the role of a PMO is to ensure managing the organisation's projects on an everyday basis and acts as a reference for all project managers in the organisation by providing advice and training necessary to enhance the efficiency of project managers and the role of project management in the organisation as a whole.

II. Knowledge Model:

In this model, the chief role of a PMO is to be the centre for project management in the organisation, organises project management processes and practices, and provides a library of lessons learnt and best tools for project managers.

III. Standard Model:

According to this model, the role of a PMO is to provide training and consulting services to all project managers and is considered the main reference for project management in an organisation.

Furthermore, a number of researchers (Hill, 2007), (Kerzner, 2009), (Crawford, 2010) have developed models for the project management office. Among the most widespread models is what was proposed in 2013 by PMI (PMI, 2013b), which consists of five models described as follows.

I. Project Specific Model:

According to this model, a PMO is a unit established temporarily to support a specific projects, providing all services related to that project.

II. Business Unit Model:

As per this model, the role of a PMO is to ensure providing services related to portfolio management, operational projects, and human resource management.

III. Project Support Office Model:

In this model, the chief role of PMOs is to use the governance of processes and practices in an organisation to provide the requisite support for project management.

IV. Enterprise PMO Model:

As per this model, PMO is an office that is established to align the work and objectives of the project with the vision and strategies of the organisation and ensure the optimal application of governance within the organisation.

V. Centre of Excellence Model:

According to this model, a PMO responsible for providing an organisation with optimal project management methodologies, practices, and tools, and provide them to the organisation's project managers to support them.

A PMO's roles, duties, responsibilities, and functions in an organisation vary depending on the type of configuration adopted. In addition, the role and function of project management offices increases continuously in accordance with the needs of the organisations and the maturity of their capabilities (Aubry et al., 2008).

2.1.2. Project Management Office Roles and Functions

The PMO has many roles and functions, as mentioned briefly in the previous sections. In this section, I will highlight the literature and what researchers have mentioned about the roles and functions of PMO to raise awareness of the different roles of project management offices.

Gerard M. Hill in his book (Hill, 2007) classified PMO functions into five groups, each containing four sub-functions, which are:

- ✓ Practice Management, which is concerned with the responsibility of the PMO to establish standardised tools and methodologies for project management within an organisation and its effective role as a main centre for knowledge to provide project managers with the requisite technical and administrative support.

- ✓ Infrastructure Management, which is concerned with the responsibility of PMO in project governance and providing the necessary support of equipment and resources to manage organisation's projects with high efficacy.

- ✓ Resource Integration, which is concerned with the responsibility of PMO to manage the organisation's resources, train the workforce, and develop their skills and competence to achieve the desired success in projects.

- ✓ Technical Support, which is concerned with the responsibility of PMO in auditing and monitoring organisation’s projects and facilitate the technical support for project managers in project planning and executing.

- ✓ Business Alignment, which is concerned with the responsibility of PMO in managing the organisation's projects portfolio and directing the projects’ goals in a way that serves the organisation’s vision and achieves its ambitions.

Similar to (Hill, 2007), (Letavec, 2006) stated that PMOs are required to develop and create a repository that captures, records, and maintains projects knowledge that organisations deal with. He further explained that this knowledge has different sources, some of which come from previous experiences and projects, while others are found in books and training. (Kaufman and Korrapati, 2007) pointed out that monitoring and controlling resource availability and usage levels is an important component of the PMO's role, and thus, it must have the authority over the organisation's resources to be allocated to project management and fulfil the requirements.

From another point of view, (Kendall and Rollins, 2003) stated that human resource management is considers an important role of the project management office, as it identifies the necessary resources for projects, assigns them and monitors their work as well, and this similar to what (Hill, 2007) referred to by resource integration.

Among the other literature that discussed the roles of the PMO was by (Unger et al., 2012), who classified them into three parts, which are:

- ✓ <u>Coordinate Role,</u> which involves the role of the PMO in selecting projects and monitoring the implementation process and managing the organisation's resources in order to achieve the success of projects.

- ✓ <u>Control Role,</u> which is concerned with the role of PMO in knowledge management, which includes experiences gained from previous projects and their status reports to submit to decision-makers.

- ✓ <u>Support Role,</u> which focuses on developing project management standards, providing support to project managers, and stimulating communication among all parties.

2.1.3. PMO Maturity Models

Considering the importance of PMO's roles within organisations and its broad impact on projects success and governance, several researchers have developed maturity models to measure PMO’s effectiveness and achieve maturity levels in organisations by providing a systematic method based on a set of practices to enhance their improvement plans.

A continuum of PMO competency, with related stages and functions, was proposed by (Hill, 2007), and it consists of five phases starting from project oversight at stage one until strategic alignment at stage five (see Figure 1). The stages of this model are designed to consider the PMO competency and capability, and thus, we can see that each stage is linked to a specific role and function for a PMO.

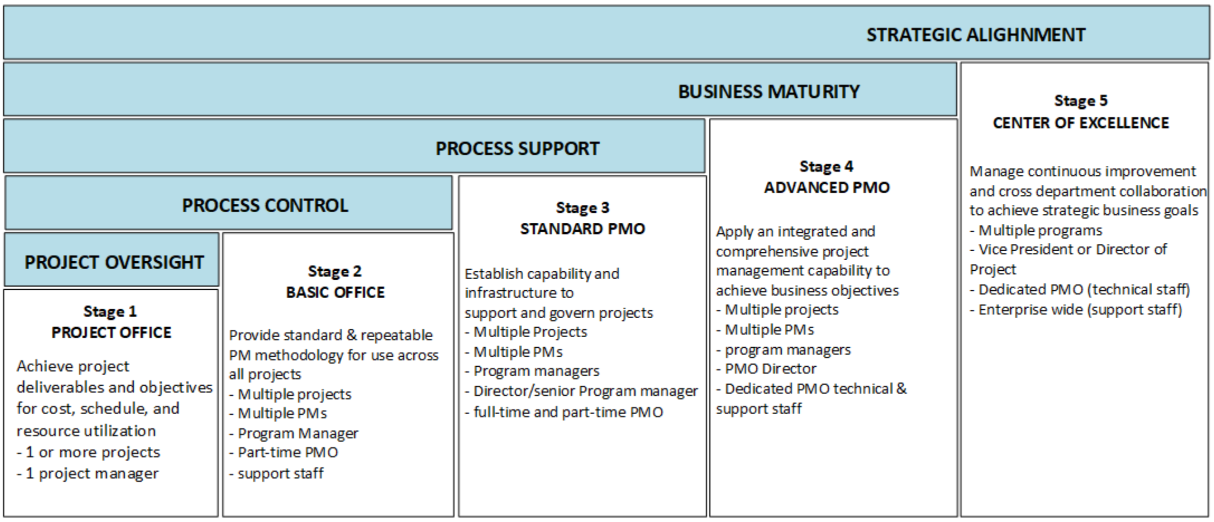


Figure 1: (Hill, 2007) PMO Maturing Model

(Rad and Levin, 2002) proposed another model for PMO similar to (Hill, 2007). This model consists of six levels and is depicted in Figure 2.

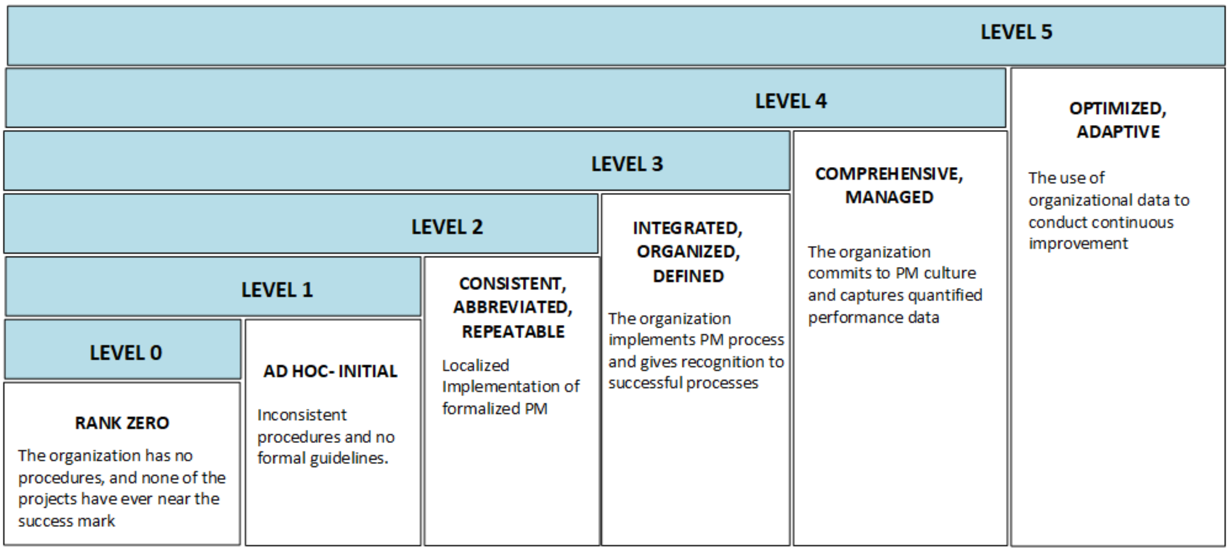


Figure 2 : (Rad and Levin, 2002) PMO Maturing Model

(Kendall and Rollins, 2003) also proposed a maturity model for PMO based on the Project Management Body of Knowledge (PMBOK) of PMI. The focus of this model is the PMO structure along with its best practices, whereas the key knowledge areas of PMBOK are appraised with regard to eight levels of maturity. (Kendall and Rollins, 2003) demonstrated in their research how can PMO develop and move from one level to another, giving a set of tips for each level as well.

2.1.4. Project Management Office and Project Performance

In the past decades, researchers have investigated the concept of ‘project performance’ by reviewing the driving factors that lead to the success of projects, which will be covered in the following sections of this dissertation.

In this section, I would like to highlight the most prominent and prevalent theory, which asserts that the success of projects is related to the fundamental project constraints, namely scope, cost, and time.

If these factors are managed well according to the plan devised in advance, the success of the project is assured in addition to achieving the strategic and financial goals of the organisations and the researchers investigating the effects of establishing PMO offices within the organisation.

According to the results of the study of both (Dai and Wells, 2004) on the nature of the relationship between the establishment of PMO offices and project performance in the organisation, there is a positive impact on project performance if they are managed by PMO. The PMO plays a vital role in promoting and contributing to the development of project management standards that positively impact project performance.

Similar to (Dai and Wells, 2004), (Anantatmula and Rad, 2013) stated that organisations that have a PMO are characterised by their ability to prioritise their projects and achieve project goals. Additionally, organisations that apply project management standards are more likely to complete projects successfully within the scheduled time and cost.

2.2. Maturity Models

This section presents a comprehensive review of the extant literature on maturity models – from their inception to the most widely adopted models nowadays, such as OPM3 and CMMI. In addition to covering their role in project management processes improvement and describing the relationships between implementing project management maturity models and project performance.

Maturity models are conceptual models consisting of several stages, describing typical standards in developing the capabilities of organisations (Solli-Sæther et al., 2010) (Kazanjian and Drazin, 1989). (PMI, 2003) defined maturity models as detailing the processes that enable organisations to advance and develop their capabilities. Thus, a series of stages of maturity models constitute a goal and an evolution in the maturity of organisations – from the initial maturity to the desired state of maturity. (Mettler et al., 2009) pointed out that the need to apply maturity models is likely to persist because it is an important tool for decision-makers. Maturity models are implemented within organisations by assessing the current situation and then driving improvement processes and measures (De Bruin et al., 2005).

In general, maturity models consist of a sequence of levels of maturity. The lower level represents an initial state characterised by an organisation that has few capabilities in a particular area. In contrast, the higher level represents to an organisation that has the concept of total maturity. Thus, the organisation's progress between the two parties is the result of continuous improvement in the former's capabilities and its operational performance.

The maturity model serves as a scale for assessing the situation throughout the course of development. It provides formula and requirements that must be met to reach a certain maturity level. During a maturity appraisal, organisation's operations are checked and compared against the standard criteria to determine its current maturity level.

2.2.1. Background

The concept of process maturity appeared through total quality management, through the implementation of techniques to control statistical processes, which showed that Improving process maturity leads to better performance (Cooke-Davies and Arzymanow, 2003).

Later in 1986, the performance measure changed from the process level to the organisation level after developing the CMM, which was established by Software Engineering Institute for software organisations. (Cooke-Davies and Arzymanow, 2003) remarked that project management maturity concept is derived from software engineering processes.

Afterwards in the 1990s and beyond, a number of models of project management maturity emerged, such as PRINCE2 Maturity Model (P2MM), and OPM3. In the following sections Project Management Maturity Model (P3M3), Berkeley Project Management Process Maturity Model, and Portfolio Program will be discussed.

Findings of different studies have revealed that so far there are more than 100 models of maturity that have been proposed. Table 1 shows the comparison of different maturity models in accordance with the following factors:

- ✓ Maturity model owner
- ✓ Scope: the model's coverage areas
- ✓ Number of maturity levels
- ✓ Date of being issued
- ✓ Reference standard : the standard used to design the model
- ✓ Organisation strategies : Considering the organisation's strategies
- ✓ Project management practices
- ✓ Programme management practices
- ✓ Portfolio management practices

Table 1 - Maturity Models

Criteria	OPM3	P3M3	Prince2 P2MM	Kerzner	Barkeley	Anderson	CMMI	BPMM
Owner	PMI	OGC	OGC	ILL	IBBS	--------	SEI	OMG
Scope	PM	PM	PM	PM	PM	PM	Software	Business
Levels Numbers	-----	1 – 5	1 – 3	1 – 5	1 – 5	--------	1 – 5	1 – 5
Date of Issued	2003	2006	2004	2005	2000	2003	2001	2007
Reference Standard	PMBOK	MSP	Prince	PMBOK	PMBOK	------	------	------
Organizations Strategies	Yes	Yes	Medium	Yes	Medium	Yes	Yes	Medium
Project Management Practices	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Program Management Practices	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Portfolio Management Practices	Yes	Yes	No	No	No	Yes	No	No

Source: (Khoshgoftar and Osman, 2009)

2.2.2. Maturity Models for IT Sector

With the emergence of the Fourth Industrial Revolution, IT support for business operations has become a vital part of many organisations as it provides opportunities to improve competitiveness (Henderson and Venkatraman, 1999). Thus, it has become the responsibility of the IT sector and software companies to provide smart and effective technological systems to meet the increasing demand for them, which has led to the investment of many companies in improving the performance of information technology operations and project management.

The required improvement of the operations of IT organisations is related to the capabilities of those organisations and the quality of their goods and services. To achieve this improvement, organisations must find a mechanism to investigate all aspects of IT operations, and it is imperative to compare the current situation with a standard measure to produce better quality products with higher competitiveness. Therefore, IT organisations require supportive tools to assess the current situation and derive new improvement measures and control their implementation. (de Bruin et al., 2006) stated in his study that project management maturity models are useful tools to address these issues. Therefore, maturity models have become an effective factor for the success of information systems organisations (Mettler et al., 2009).

The CMMI is regarded as one of the most popular models implemented in more than 3,500 companies around the world (SCAMPISM, 2010). (Scott, 2007) stated that IT entities will adopt various types of maturity models to motivate and improve their development capabilities.

Thus, we note that researchers in the field of IT have expressed an interest in the maturity models as (Rosemann and De Bruin, 2005), and they designed maturity models that simulate and fit the processes of IT project management. Maturity models have been developed to include many areas of IT, such as electronic government (Layne and Lee, 2001), e-business (Prananto et al., 2003), and software engineering (Paulk et al., 1993). In addition, the impact of implementing CMM on productivity and quality of software engineering processes has been examined.

(Polikoff et al., 2006) mentioned in her book that innovative solutions emerge by understanding the needs of the market and the capabilities of IT organisations, because technology is constantly evolving, and creativity in these organisations does not surface on its own but rather requires the availability of tools and skills for their employees. Thus, maturity models can provide IT organisations with these required tools and improve their capabilities in managing projects.

2.2.3. Capability Maturity Model Integration

The CMMI is currently one of the most widely used models in IT organisations and the software industry owing to its impact on improving business processes. It consists of four categories; each category belongs to a group of capability areas, which in turn contains areas of practice with a total of 25 practices. However, CMMI is not only a model for improving processes in information technology sector but rather a reference for other organisations in various fields that aim to improve the performance of their business operations.

CMMI model is not a process; it rather focuses on the importance of an organised process, which has become the main focus that holds everything together. In doing so, processes can help IT organisations to align the ways to do their business and enable them to expand and do things better by leveraging their resources and analysing business trends (Software Engineering Institute, 2010).

(Geddes, 2007) explained in his studies that CMMI project was launched to sustain governments and industries investments in process improvement needs and to expand the implementation of improvements across companies.

2.2.3.1. Background

The CMMI model was designed in August 1986 by establishing working team from the US Department of Defense (DoD) and the Software Engineering Institute (SEI) at Carnegie Mellon University (Humphrey, 2002). This collaboration began at the request of the Federal Government to provide it with a mechanism to evaluate its software providers (Geddes, 2007).

The SEI team relied on the development of the CMMI model on the concepts of total quality management (TQM), which have been around for a century, and it recognises that the quality of software products depends mainly on the quality of software development processes. The concepts of TQM were previously used in developing manufacturing processes and have been extended to include software engineering processes, which can be defined as a set of practices and activities used to develop information systems.

Thus, the adoption of these concepts by IT organisations leads to better and more consistent processes implementation, higher quality software production, and more effective project management.

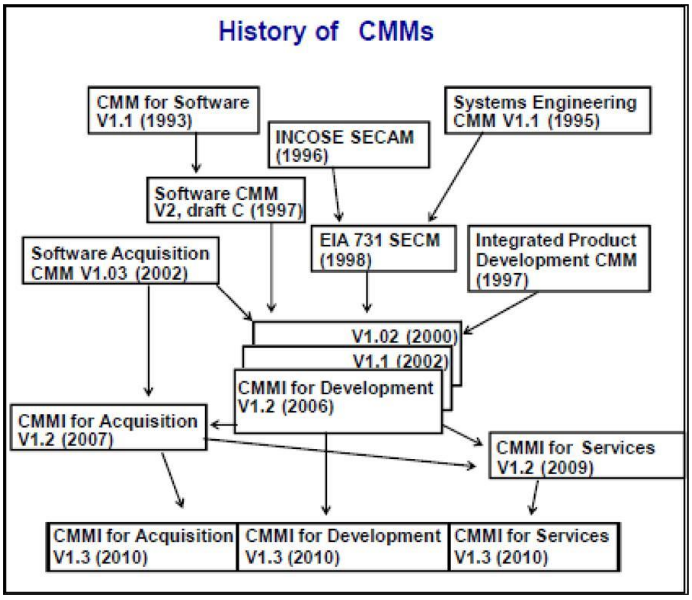
All the principles discussed above are based on the theory of Deming as shown in Figure 3. He stated in his studies (Deming, 1986) that to increase production and reduce errors within organisations, there must be continuous improvement of processes, not by laying off employees and reducing costs, as some decision-makers think so far. Continuous improvement enables organisations to eliminate waste and mitigate errors.

Figure 3 – Deming Chain Reaction

The SEI published the first version of CMMI in 1991 (Paulk et al., 1991) and updated the same in 1993 as version 1.1. In 2000, the CMMI team published the training and appraisal methods for CMMI model, which included both software and systems engineering. Then, in 2006, version 1.2 was released which had to be changed to CMMI-Dev to be more focused on software development processes. In 2010 CMMI team released new version of CMMI model version 1.3. The current version of the CMMI model at the time of writing this research is CMMI version 2.0, released in March 2018 specifically for development and introduced changes and improvements in the methodology, as well as new additions and requirements to the previous standards in last versions. On December 4, 2018, the CMMI team expanded the scope of CMMI version 2.0 with two new releases, CMMI for Supplier Management and CMMI for Services.

Figure 4 illustrates the history of CMMI model.

Figure 4 – CMMI History



Source: (Software Engineering Institute, 2010)

Today, CMMI is an internationally recognised and widely adopted model and acts as an integrated and systematic framework for process improvement. CMMI helps organisations examine their current processes, identify improvements, and then implement them for the benefit of those organisations (Tyson et al., 2003).

The CMMI framework has had an enormous impact on the evolution of the software community. There are several studies published by researchers on the effect of CMMI on increasing productivity, quality, and minimising losses (Krasner, 1997, Clark, 2000, Harter et al.).

2.2.3.2. The importance of Capability Maturity Model Integration

IT organisations constantly seek the most optimal methods and tools to improve and evaluate their software products (Staples et al., 2007). A number of researchers have given their attention to this issue and conducted studies on the importance of CMMI implementation and its role in improving the performance of IT organisations (Cheng et al., 2011, Liu et al., 2006).

In the same context, another researcher, (Riera Cruañas, 2010) through his research thesis 'Mining Opportunities for CMMI Assessments', presented an overview of the most important studies and books that discuss the CMMI model, talked about the importance of implementing this model and the benefits arising from it. (Norman, 2008) also presented an interesting paper regarding the implementation of the CMMI model in IT organisations owing to its noteworthy impact on product quality.

Norman explained in his paper the role of the CMMI model in improving software industry processes. Furthermore, (Erukulapati, 2011) talked about the role of CMMI implementation; more specifically, he reported that the quality of software systems is improved when using this model, mentioning the effective role of the model in IT organisations.

(Beadell, 2009) also discussed the importance of the CMMI model and its considerable impact on the quality of software systems, especially related to defence engineering. (Shetty, 2006) presented a detailed study using drawings on the CMMI model, explaining the maturity levels, especially the level three of CMMI.

(Sun et al., 2010) studied the impact of continuous improvement processes for IT organisations on the use of resources to serve the organisational strategy, stating that implementing the CMMI model is the way to achieve this goal and thus create a work environment that ensures the quality of products and customer satisfaction as well.

2.2.3.3. Capability Maturity Model Integration Implementation Benefits

The CMMI model was launched by the SEI, and thus, it is considered the primary and most authentic source of information for the CMMI model. The official SEI website contains many articles and reports that explain the implementation of the CMMI model and present its benefits and impact on organisations.

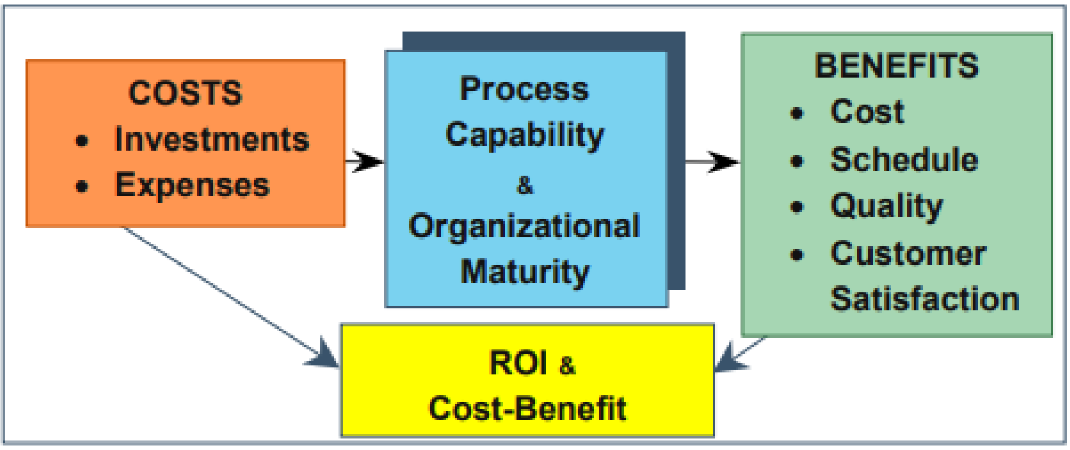
Some of the benefits of implementing CMMI according to the SEI website (Goldenson et al., 2004, Software Engineering Institute, 2021) are enumerated as follows:

- CMMI helps organisations improve their project management practices by managing business resilience including risk and opportunity management, incident resolution, and prevention. It also develops the organisation's ability to generate more accurate estimates of its projects and assists it in monitoring and controlling projects.
- One of the most important benefits of CMMI implementation is to gain customer satisfaction by providing superior-quality product that fulfils their needs while achieving project cost and time plan. In one of their studies, SEI stated that CMMI can improve and stabilise the project cost performance index and can affect the project cost by reducing the average cost of defect repair by 33% and reducing the unit software cost by 20%.
- CMMI can help IT organisations increase the productivity of their software products by implementing stricter engineering practices. This is because there are many standard CMMI procedures and practices that are considered in software engineering and implemented throughout the project lifecycle. SEI reports that implementing CMMI can increase software productivity by 30%.

(Haque, 2005) explained in his university thesis that the implementation of the CMMI model has a prominent role in improving an organisation's processes and helps it improve the quality of its products by providing a mechanism to evaluate the current practices and improve them.

(Goldenson and Gibson, 2003) studied the effect of CMMI implementation in a wide array of ways as shown in Figure 5.

Figure 5 – Impact of CMMI



Source:(Goldenson and Gibson, 2003)

- **The impact on project cost and schedule**

The study indicated that there is a noticeable impact on the project cost when implementing CMMI. Boeing Australia reported that there was a 33% reduction in the average cost to repair a defect because of CMMI. Also, Lockheed Martin organisation witnessed a substantial decrease in overhead rate. Sanchez Computer Associates also saved $2 million in cost after implementing CMMI Level 3.

Furthermore, there is an impact on the project schedule after implementation. The time required to convert versions has been reduced by more than 50 percent compared to the previous time for CMMI at Boeing. Also, General Motors Company found that the percentage of milestones achieved increased from about 50% prior to implementing CMMI to about 95%.

- **The Impact on software product quality**

(Goldenson and Gibson, 2003) asserted that quality improvement is often measured by detecting a decrease in the amount of defects in a process or in the final product, and this is what many companies have noticed after implementing the CMMI model. Northrop Grumman IT1 found that only 2% of all defects discovered belong to the field system. The same company also discovered that after implementing CMMI, there was an increase in the focus on quality among its system developers. Bosch Gasoline Systems reported that as a result of the implementation of CMMI model for software (SW-CMMI), a decrease in error cases was detected at the factory by one order of magnitude.

2.2.3.4. CMMI Models

CMMI has multiple models which are CMMI-Dev, CMMI-Services, and CMMI-Supplier Management. All these models consist of categories, capability areas, and practice areas. Each category is related to capability areas, which are related to practices with special requirements. Organisations are awarded the appropriate maturity level or capability level through an approved standardised appraisal method established by CMMI Institute and is valid for three years.

CMMI Institute assessment is based on measuring an organisation's work and eligibility. (Chrissis et al., 2011) described in their book all CMMI models, accentuating the commonalities and differences between them. They explained the main concepts of process improvement and how organisations use CMMI to develop their business operations. This book is designed to help organisations understand and implement CMMI models and identify the most optimal ways to employ CMMI to meet their business goals, and it is considered as an extension of the CMMI framework.

- **CMMI-Dev (Development)**

Software development companies are confronted with a multitude of challenges in managing their product life cycle, such as delays in delivery, poor quality products that do not satisfy their customers, and lack of effective management of organisational resources. CMMI-Dev provides standard tools to help IT organisations to solve all their problems by focusing on the key capabilities and performance improvement requirements of companies.

CMMI-Dev uses best practices to improve the capabilities of IT companies to develop high-quality software products that meet customer needs while reducing cost and improving their ability to plan and budget.

- **CMMI-Services**

Today, many of the leading IT organisations are moving towards providing services to their customers, and without the presence of standard policies and mechanisms, they will not be able to respond immediately to risks and achieve the success of their projects. CMMI-Services provide best practices in managing the services provided, which is an important part of its main product.

CMMI-Services supports the process of improving the capabilities of organisations to deliver high-quality and efficient services, exceeding expectations, meeting market needs, and developing the capabilities of organisations to deal with incidents within the required cost and quality.

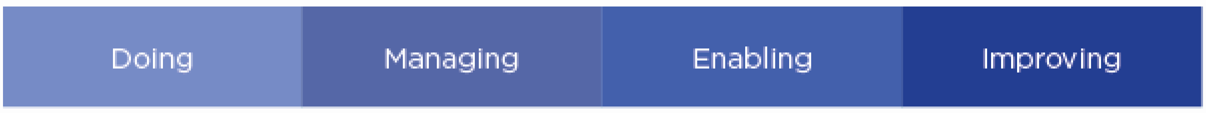
- **CMMI-Supplier Management**

Many IT organisations turn to suppliers to provide services or products to achieve their vision and project goals. Issues that typically arise include change in project requirements, type of technology required, ambiguous and not detailed contracts, lack of resources, delivery delays, low product quality, and unfulfilled customer needs after the supplier has been appointed. CMMI-Supplier Management focuses on improving the processes of organisations that acquire products from external companies. It offers the best practices to improve an organisation's capability for identifying, hiring, and managing suppliers to reduce risks.

2.2.3.5. CMMI Model Structure

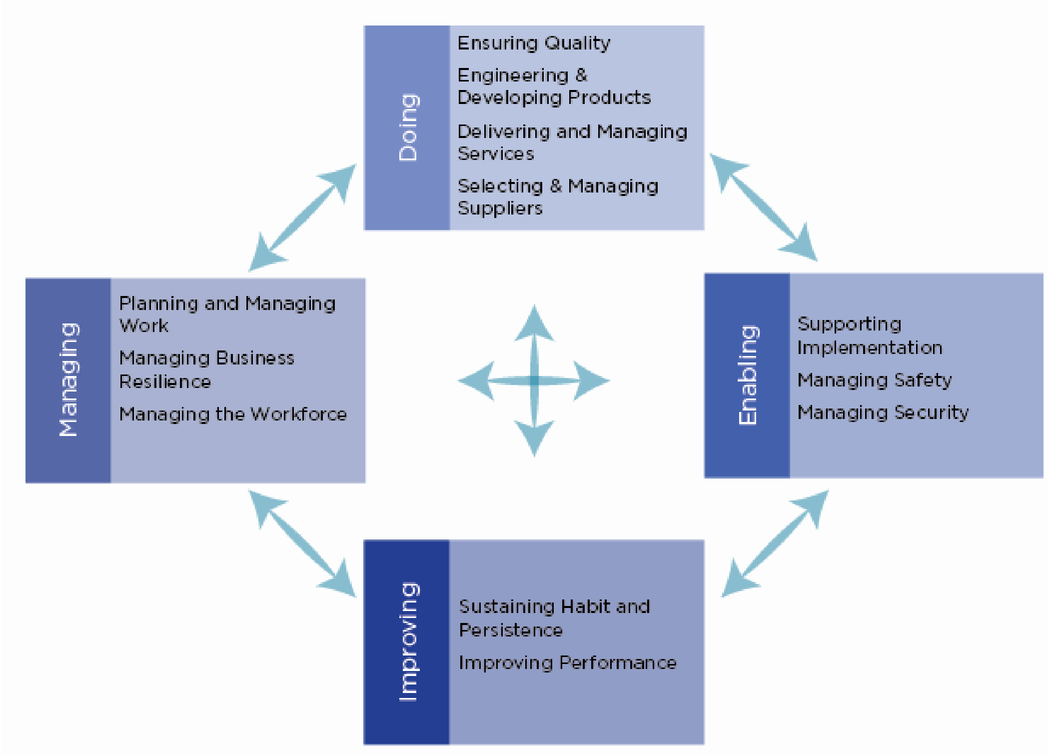
CMMI model consists of four category areas, 12 capability areas, and 25 practice areas. The category areas are connected to capability areas, which include the best practices for improving process performance for an organisation and its projects. Figure 6 illustrates the CMMI category areas.

Figure 6 – CMMI Category Areas



Each category area consists of capability areas, which are logically connected with the practices that companies use to develop and deliver products and services (see Figure 7).

Figure 7 – CMMI Capability Areas



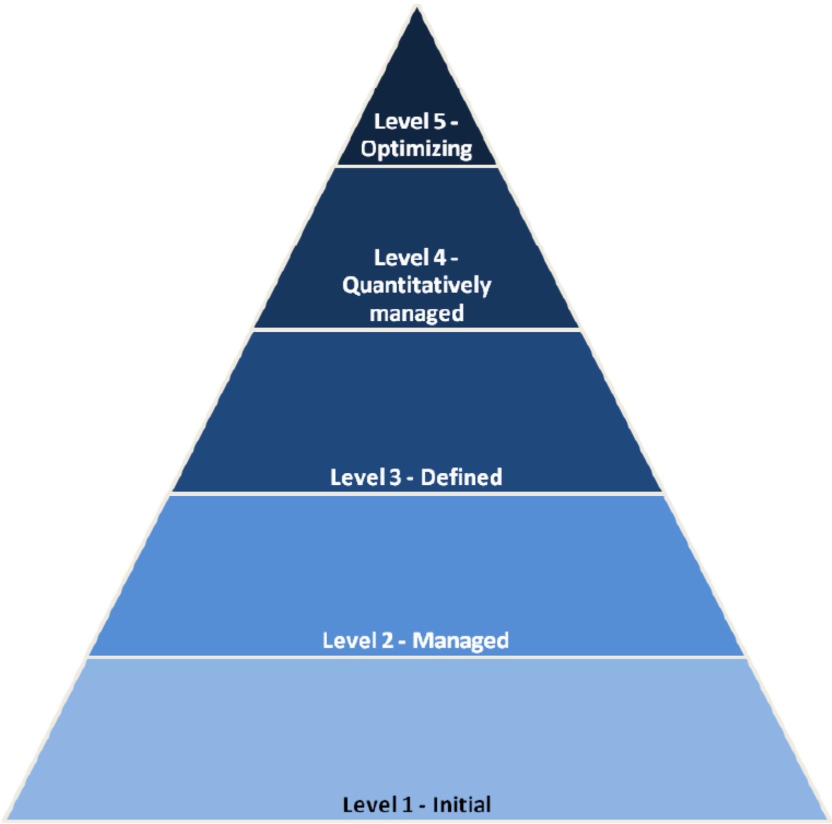
Practice areas introduce a set of requirements and details of process activities that describe the purpose of that practice (see Figure 8).

Figure 8 – CMMI Practices Areas

2.2.3.6. CMMI Maturity Levels

The CMMI model has a hierarchical representation that requires all practice areas to be measured together and is essentially an organisational maturity approach. Figure 9 summarises reviews of CMMI levels, their main concepts, and structures.

Figure 9 – CMMI Maturity Levels



- **CMMI Maturity Level 1 (Initial)**

At maturity level 1 of CMMI, organisations meet the basic requirements of practices, which are not fully implemented, so that organisations have a minimum level of maturity.

- **CMMI Maturity Level 2 (Managed)**

At this level of CMMI, organisations implement specific practices in line with the objectives of the practice area so that problems are proactively addressed.

The practice areas for the second maturity level are as follows:

- ✓ Managing performance and measurement
- ✓ Estimating
- ✓ Planning
- ✓ Monitoring and Control
- ✓ Implementation of the infrastructure
- ✓ Configuration management
- ✓ Governance
- ✓ Process quality assurance
- ✓ Requirement development and maintenance
- ✓ Supplier agreement management

- **CMMI Maturity Level 3 (Defined)**

At this level of CMMI, organisations use standard practices, have the ability to address issues, and achieve organisational vision concerning the product quality. The practice areas for this maturity level are as follows:

- ✓ Managing performance and measurement
- ✓ Supplier agreement management
- ✓ Process quality assurance
- ✓ Configuration management
- ✓ Monitor and control
- ✓ Planning
- ✓ Estimating

- ✓ Requirement development and maintenance
- ✓ Governance
- ✓ Implementation of infrastructure
- ✓ Causal analysis and resolution
- ✓ Decision analysis and resolution
- ✓ Organisational training
- ✓ Risk management
- ✓ Process asset development
- ✓ Peer reviews
- ✓ Process management
- ✓ Verification and validation
- ✓ Technical solution
- ✓ Product integration

- **CMMI Maturity Level 4 (Quantitatively Managed)**

At this level of CMMI, organisations apply standard practices and processes whose efficiency is measured by statistical methods to improve the quality of their products and achieve their goals. The practice areas for this maturity level are as follows, in addition to all the above-mentioned areas:

- ✓ Managing performance and measurement
- ✓ Planning
- ✓ Governance
- ✓ Causal analysis and resolution
- ✓ Process management

- **CMMI Maturity Level 5 (Optimizing)**

At level 5 of CMMI, organisations use statistical and quantitative techniques for optimising process improvement. The practice areas for this maturity level are as follows, in addition to the above-mentioned areas:

- ✓ Managing performance and measurement
- ✓ Causal analysis and resolution

2.2.3.7. CMMI Appraisal

CMMI assessment is an examination of organisation's processes and is performed by a specialised team using a reference model as a basis for identifying all the strengths and weaknesses of an organisation (Software Engineering Institute, 2021).

CMMI has three classes for appraisal, which are:

✓ <u>Class A Appraisal</u>

This class is typically performed when an organisation has implemented a set of improvements to its processes and needs to formally benchmark its process in relation to CMMI. This class is the only appraisal that can provide the CMMI maturity level of organisations.

✓ <u>Class B Appraisal</u>

This class is used when an organisation needs to evaluate its progress in improving its processes towards a target CMMI maturity level but at a cost that is less than the cost of evaluating Class A. Class B can help organisations understand the current state of their software engineering and project management processes in relation to the requirements of the CMMI model.

✓ Class C Appraisal

Class C is the most flexible of the three classes of CMMI appraisal. It is conducted to quickly identify gaps in an organisation's processes to prepare them for a final Class A appraisal.

2.2.4. Organisational Project Management Maturity Model

Organisational Project Management (OPM) is the standard and comprehensive management of an organisation's portfolios, programmes, and projects to achieve its vision (PMI, 2013a).

OPM is a strategic maturity model that uses portfolios, programmes, and project management with the most optimal practices to achieve better performance and results at a higher market and competitive value (PMI, 2008). OPM integrates management knowledge of projects, programmes, portfolios, and strategies of organisations that includes mission, vision, and goals, in addition to a continuous improvement of organisational processes within an organisation (PMI, 2013a).

This section provides an overview of the OPM3 maturity model, its definition and history, as well as its implementation benefits. This section will also explain the elements, domains, operations, architecture of OPM3, and finally, the OPM3 assessment methods and tools.

OPM3 defines an Organisational Project Management Maturity Model established by the PMI. This model can help organisations assess the maturity level of their project management process and work to improve the same by using best practices that take into account the organizational strategies (PMI, 2013a).

The OPM3 maturity model aims to assist organisations in improving their management capabilities for portfolio, programmes, and projects within the organisation in line with strategic objectives (Grant and Pennypacker, 2006). OPM3 is an effective tool for improving the performance of workers in organisation's projects by the implementation of organisational project management. PMI indicated that OPM3 maturity model can be implemented in all organisations of different types, sizes, and maturity because of its flexibility and scalability compared to other maturity models (Grant and Pennypacker, 2006).

2.2.4.1. Background

The OPM3 was established in 1998 with the creation of a team by PMI comprising a group of volunteers belonging to diversified professional fields. The CMMI maturity model was popular at the time, and thus, the PMI team set out to create a new, more flexible and scalable model, taking into account organisation's project and portfolio management to serve their strategies.

According to a set of characteristics, the OPM3 is considered the first of its kind compared to other maturity models. According to (Schlichter et al., 2003), OPM3 can help improve project management practices in organisations and develop their capabilities to realise their visions and strategies.

In 1999, PMI appointed John Schechter as OPM3 Program Manager after he joined the PMI team that developed OPM3. He formed a new team of 800 volunteers from several countries to participate in the development of the OPM3 (Schlichter et al., 2003). In 2000, PMI team proposed 170 standard practices for OPM3.

In 2001, PMI team expanded to include new teams to work on customer requirements and product capabilities, and they produced new key performance indicators (KPIs). In 2002, the final model of OPM3 was developed to include 586 practices. In 2003, PMI published the first version of OPM3 standard.

The second edition of the OPM3 knowledge book was published in 2008, and the third in 2013. All editions are inspired by knowledge from PMBOK Publications from the first edition published in 1987 until the fifth edition published in 2013.

2.2.4.2. Implementation Benefits

Implementation OPM3 helps organizations strengthen the relationship between their strategies and their project management practices. OPM3 increases the performance, productivity, and profitability of an organisation's projects and improves customer satisfaction (PMI, 2013a). OPM3 aims to ensure that an organization implements its projects properly and allocates its resources judiciously.

2.2.4.3. Model Architecture

The OPM3 consists of three main elements: improvement, assessment, and knowledge (see Figure 10).

The knowledge element summarises the contents of OPM3 and the concept of organisational project management, in addition to the implementation mechanism of the model by explaining the conditions, steps, and performance indicators adopted to improve the operations of organisations.

The assessment element helps organisations assess their current level of project management maturity and compare it to the standard practices of OPM3 to devise an appropriate plan to improve their process. The improvement element, after assessing the organisation's operations, it now has an improvement plan to follow by implementing effective actions to raise its level of maturity.

Figure 10 – Elements of OPM3

Source: (PMI, 2013a)

OPM3 consists of a set of basic components depicted in Figure 11, which are:

- Best practices used in project management
- Capabilities that lead to the achievement of best practices
- Outcomes that are shown when relevant capabilities are achieved
- KPIs, which measure each outcome
- Model context, which includes both project management process and model stages of process improvement
- The paths that determine the dependency between capabilities to achieve the best practice and the dependency between the best practices (see Figure 12).

Figure 11 – OPM3 Components

Source: (Fahrenkrog, 2003)

The purpose of outcome in the OPM3 model is to demonstrate that certain capabilities of an organisation have been achieved. In other words, if an organisation has acquired certain capabilities, there must be evidence of this, which is done through the outcomes. A KPI is vital for measuring outcome and is done by an expert or a direct measurement within the organisation.

One of the most important features of OPM3 is the dependencies between capabilities and the best practices. Achieving the best practices requires achieving capabilities associated with it, and there is relationship between capabilities of different best practices, as shown in Figure 12.

Figure 12 – OPM3 Dependencies

Source:(Fahrenkrog, 2003)

To date, OPM3 Team has identified over 600 best practices, 3,000 capabilities, and 4,000 dependencies between them.

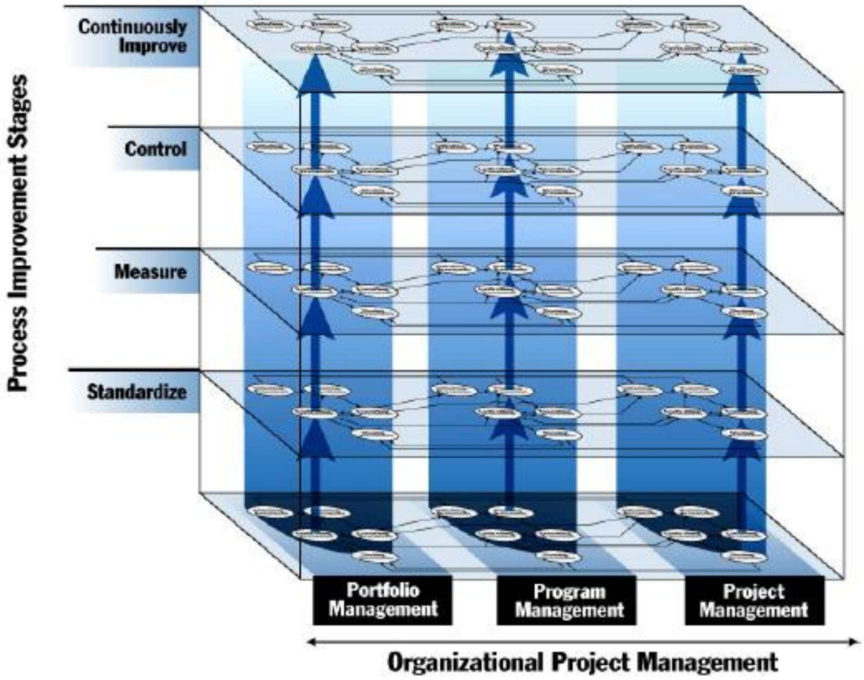
2.2.4.4. Model Maturity Stages

OPM3's improvements stages are listed by PMI as follows:

- Standardisations
- Measures
- Controls
- Improvements

OPM3 uses the process framework for project management, as described in the PMBOK Knowledge Guide. In addition to the stages of process improvement, this model has also been expanded to include project, programme, and portfolio management (see Figure 13).

Figure 13 – OPM3 Construct



Source:(Fahrenkrog, 2003)

2.2.4.5. Assessment Methods

The PMI has developed two different tools for assessing an organisation's current maturity status, and then, organisations can use these results to improve their maturity. These tools are explained as follows:

- Self-Assessment Module (SAM) – OPM3 Online

This assessment tool was developed by PMI team in 2003. First, it was published using CD with OPM3 Knowledge Foundation book, then later PMI published the same online. The assessment consists of 151 questions, all of which are only 'yes' or 'no'. Later, PMI found this tool to be ineffective, which led to its cancellation, and it was based only on the OPM3 Product Suite tool created in 2005.

- OPM3 Product Suite

It is an effective tool for assessing the maturity level of organisations. It was launched by PMI with the help of Det Norske Veritas Company. This assessment must be carried out by an accredited assessor. In order to use the tool, licenses must be purchased. The Product Suite tool contains 488 best practices, 412 of them relate to standardisation, measurement, control, and continuous improvement of managing processes for projects, programmes, and portfolios.

2.2.5. Portfolio, Programme, and Project Management Maturity Model

The P3M3 maturity model was established by the United Kingdom Office of Government Commerce (OGC). The main objective of its development is to provide an effective tool to determine the capabilities of organisations to manage programmes, projects, and portfolios and improve their processes on an ongoing basis.

OGC has presented P3M3 as a maturity model that provides a framework for organisations to be able to assess the performance of their processes and develop plans for improvement. P3M3 was created in 2006, and OGC subsequently published a series of improvements released in 2010 and 2015. P3M3 started as an assistant tool to improve OGC's portfolio and project management maturity model. It was influenced by the CMMI maturity model, which was popular at that time (OGC, 2010).

P3M3 has a positive impact and benefits in improving organisations' processes for managing portfolios, programmes, and projects.

(Goldenson and Gibson, 2003) mentioned in their study that the implementation of P3M3 can help organisations achieve a higher rate of return on investment, increase the productivity of the organisation, and enhance their product quality for improved customer satisfaction.

Maturity in the P3M3 consists of five levels, with each level assessing the organisations' processes and quality in managing portfolios, programmes, and projects, and are enumerated as follows:

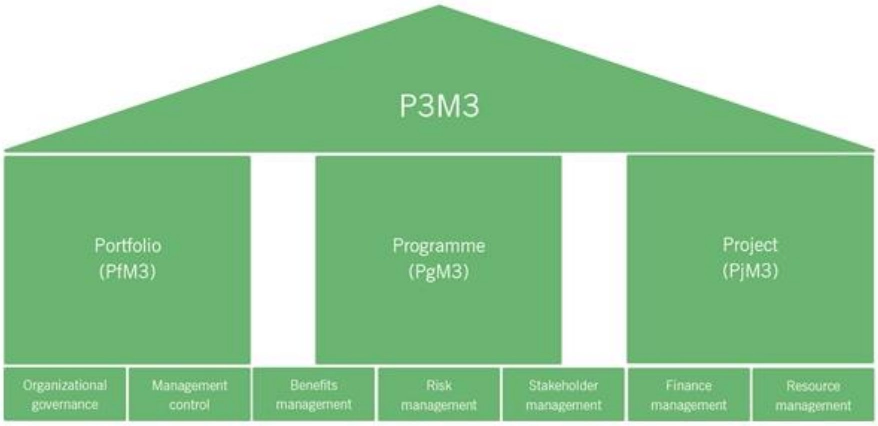
- Level 1: Awareness
- Level 2: Repeatable
- Level 3: Defined
- Level 4: Managed
- Level 5: Optimised

In addition, the P3M3 focuses on seven perspectives. As shown in Figure 14, it intersects with the three sub-models; Project (PjM3), Programme (PgM3), and Portfolio (PfM3). P3M3 is evaluated at all five maturity levels.

The seven perspectives are:

- Risk management
- Finance management
- Benefits management
- Organisational governance
- Stakeholder management
- Resource management
- Management control

Figure 14 – P3M3 Construct



Source: (Zeeshan, 2016)

Each perspective contains a number of attributes belonging to a certain maturity level on the basis of which the processes of the organisations are evaluated. These attributes are used to determine the current maturity of organisations and enable them to develop plans for improvement.

2.2.6. Prince2 Maturity Model

Today, the PRINCE2 methodology is one of the most important project management approaches around the world. It was established by the British government in 1989 (Prince2, 2021). Currently, there are several organisations that follow and manage their projects by adapting their manual processes.

The P2MM can be described as a standard that provides a framework for measuring the implementation of PRINCE2 methodology in organisations through their project management and enables them to develop improvements plans to their project management practices. P2MM was established by the OGC in 2004 (GRAHAM, 2011).

P2MM is similar to P3M3 described earlier, as it is derived from one of its sub-models, PjM3 Project Management Maturity Model. Table 2 compares P2MM characteristics with PjM3.

Table 2 - Comparison of P2MM and PjM3

Maturity Level	PRINCE2	Project Management
Level 1 – awareness of process	Does the organization recognize projects and run them differently from its ongoing business? (Projects may be run informally with no standard process or tracking system.)	Does the organization recognize projects and run them differently from its ongoing business? (Projects may be run informally with no standard process or tracking system.)
Level 2 – repeatable process	Has the organization adopted PRINCE2 but allowed the method to be applied inconsistently across projects within the organization?	Does the organization ensure that each project is run with its own processes and procedures to a minimum specified standard? (There may be limited consistency or coordination between projects.)
Level 3 – defined process	Has the organization adopted PRINCE2 and embedded it to align to other organizational processes, and can PRINCE2 be tailored to suit individual projects?	Does the organization have its own centrally controlled project processes and can individual projects flex within these processes to suit the particular project?
Level 4 – managed process	Does the organization obtain and retain specific measurements on its PRINCE2 project management performance and run a quality management organization to better predict future performance?	Does the organization obtain and retain specific measurements on its project management performance and run a quality management organization to better predict future performance?
Level 5 – optimized process	Does the organization undertake continuous process improvement with proactive problem and technology management for PRINCE2 projects in order to improve its ability to depict performance over time and optimize processes?	Does the organization undertake continuous process improvement with proactive problem and technology management for projects in order to improve its ability to depict performance over time and optimize processes?

Source: (GRAHAM, 2011)

P2MM use the same structure of P3M3, which includes:

- Five levels of organisation maturity;
- Seven perspectives representing all aspects of project management in organisations;
- Specific and general attributes that belong to every maturity level in every perspective.

P2MM maturity levels are similar to P3M3, which are:

- Level 1: Awareness
- Level 2: Repeatable
- Level 3: Defined
- Level 4: Managed
- Level 5: Optimised

Organisations can gauge their level of maturity using two available approaches – self-assessment or formal review. The former is done by simply self-reviewing the attributes of the P2MM and measuring their compliance with them, or by using the tool developed by OGC that enables organisations to perform the same. The latter is the formal assessment performed by a licensed consultant and consists of 16 process areas with practices associated with each of them.

2.2.7. Kerzner Maturity Model

Kerzner Maturity Model (KPM3) is a model that is based on the PMI methodology, for which PMBOK is the main reference. It is a simpler maturity model but has an accurate assessment method of 183 questions and consists of five maturity levels. Its implementation helps organisations to improve their techniques and project management practices through the first four levels and contributes to improving the quality of products through continuous improvement at the fifth level (Kerzner, 2000).

Kerzner model was released in 1998. It is characterised by presenting only a proportion of organisations' achievement of its implementation at each level and does not provide any final observations.

It consists of five levels of maturity, as shown in Figure 15, which are as follows:

- Level 1: Common language

    This level includes the dissemination of knowledge among organisations regarding the importance of project management and its impact on their success and prosperity.

- Level 2: Common processes

    At this level, organisation identifies and implements all the common processes required for the maturity model with a view to improving its project management practices. Also, an organisation begins to identify model principles that support them in managing projects.

- Level 3: Methodology single

    At this level, organisation integrates all its methodologies within one unified methodology to achieve a comprehensive improvement for its processes, which enables it to control its operations in a more efficient and effective manner.

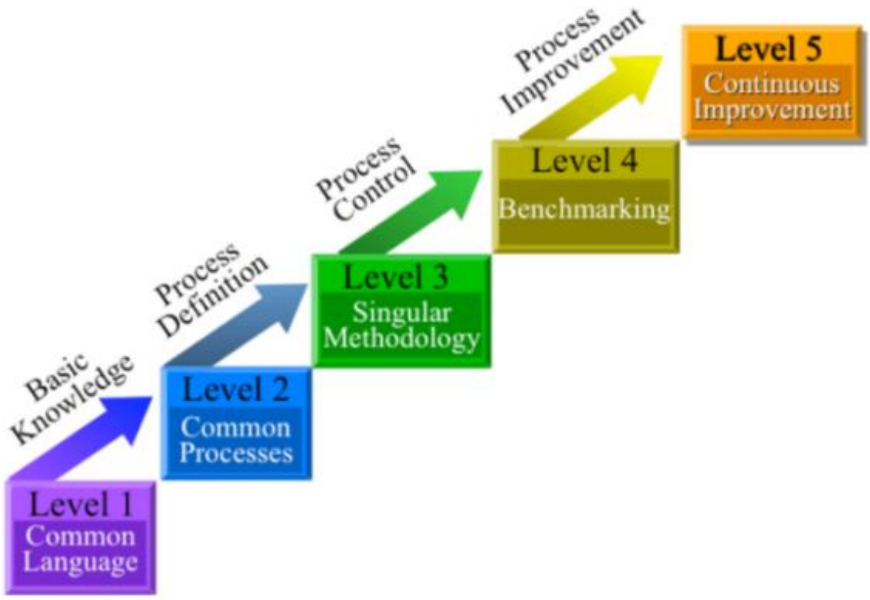
- Level 4: Benchmarking

    At this level, an organisation begins to model other organisations to maintain its competitive advantages. This modelling must be practised in an ongoing manner. The organisation must decide on the model according to specific characteristics.

- Level 5: Continuous improvement

    At this level, an organisation implements continuous improvement of its processes to achieve its goals. An organisation analyses and evaluates the information resulting from modelling and uses it to achieve its integrated methodology.

Figure 15 – KERZNER Model Construct



Source: (Kerzner, 2017)

2.2.8. Berkeley's Maturity Model (PM2)

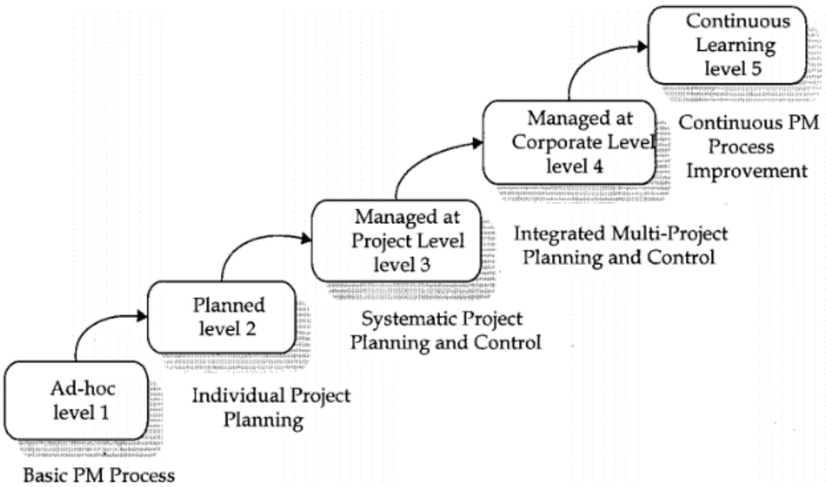
The Berkeley Project Management Model was founded in 1997 by William Epps and Professor Young. It was intended to help project managers deliver effective value to organisations by improving project management processes and methodologies (Kwak and Ibbs, 2002). In 2000, the founders of the model studied all maturity models in terms of their differences and similarities with the aim of improving their model.

Among those models are CMMI, which was focused on software development projects, McCauley Maturity Model, Process Maturity Model, Project Management Maturity Model, and others (Kwak and Ibbs, 2002).

PM2 model divides project management processes and practices into nine knowledge areas and five processes that refer to PMBOK (Institute, 2000). This allows organisations to identify strengths and weaknesses in their current project management practices and work to develop appropriate improvement plans to achieve higher levels of project management maturity. The advantage of the PM2 model, as indicated by the authors, is that it can be applied in all organisations with different specialisations, unlike other models that target a specific business category. The new model that was published in 2000 has a number of characteristics such as the financial return of projects and clarifies the relationship between the effectiveness of project management and its performance (Kwak and Ibbs, 2002).

The PM2 model consist of five maturity levels, as shown in Figure 16:

Figure 16 – Berkeley Model Construct



Source: (Kwak and Ibbs, 2002)

Tables 3, 4, and 5 present the key project management processes, the major organisational characteristics, and the key focus areas of PM2 model, respectively.

Table 3 – Key PM Processes (PM2)

Maturity level	Key PM processes
Level 5	PM processes are continuously improved
	PM processes are fully understood
	PM data are optimized and sustained
Level 4	Multiple PM (program management)
	PM data and processes are integrated
	PM processes data are quantitatively analyzed, measured, and stored
Level 3	Formal project planning and control systems are managed
	Formal PM data are managed
Level 2	Informal PM processes are defined
	Informal PM problems are identified
	Informal PM data are collected
Level 1	No PM processes or practices are consistently available
	No PM data are consistently collected or analyzed

Table 4 – Organisational Characteristics of PM2

Maturity level	Major organizational characteristics
Level 5	Project-driven organization
	Dynamic, energetic, and fluid organization
	Continuous improvement of PM processes and practices
Level 4	Strong teamwork
	Formal PM training for project team
Level 3	Team oriented (medium)
	Informal training of PM skills and practices
Level 2	Team oriented (weak)
	Organizations possess strengths in doing similar work
Level 1	Functionally isolated
	Lack of senior management support
	Project success depends on individual efforts

Table 5 – Key Focus Areas of PM2

Maturity level	Key focus areas
Level 5	Innovative ideas to improve PM processes and practices
Level 4	Planning and controlling multiple projects in a professional matter
Level 3	Systematic and structured project planning and control for individual project
Level 2	Individual project planning
Level 1	Understand and establish basic PM processes

Source: (Kwak and Ibbs, 2002)

2.3. Project Performance

There are numerous studies discuss the factors that can measure project performance and affect its success or failure. (Ika, 2009) mentioned in his study that earlier, the success of projects was measured with respect to time, cost, and quality, which is called the 'iron triangle', but many projects that achieved these elements were not successful, and it is also possible that projects that fail to achieve these elements are considered successful. Therefore, (Ika, 2009) asserted that the factors for the success of projects should be considered beyond being restricted to just these elements.

Researchers' understanding of the factors of success and failure of projects has developed and matured throughout history, and this is what (Ika, 2009) indicated in his research. As shown in Table 6, during the initial period between the 1960s and 1980s, the literature focused mainly on cost, quality, and time as factors influencing the success of projects.

The second time period between the 1980s and 2000s, researchers introduced new factors to quantify the success of projects, such as customer and user satisfaction, as well as the benefits that accrue to the organisation and project employees, such as knowledge of project management and developmental tools and techniques. The third period, which is in the 21st century, witnessed a modern perspective at the success factors of projects, as it moved from the success of project management to the success of a final product. In addition, the success of portfolio management and programmes also affects the success of projects.

In another study on the factors measuring the success of IT projects, (Peslak, 2012) stated that the success of projects goes beyond the factors of quality, time, and cost, and includes meeting user requirement and customer satisfaction. The success of IT projects can be measured by achieving the main objective of organisation's project. According to (De Wit, 1988), to measure the success of a project, it is necessary to measure the extent to which the desires of customers are fulfilled and the goal of its creation is achieved.

The opinion of end users of IT projects product is a critical factor in measuring the performance of projects, unlike other projects that consider the opinion of users as a marginal factor for the success of projects. User satisfaction is measured by the usefulness and ease of use of the software products by users. Therefore, the user satisfaction factor must be taken as one of the factors measuring the success and efficiency of projects.

(Atkinson, 1999) asserted in his study that time and cost are two factors that must be taken into account in the planning stage of projects, because any mistake in their estimation may cause projects to fail. (Beleiu et al., 2015) explained that the success of a project is attained by achieving project objectives within pre-planned time and cost.

Cost management is a key tool and important factor in success of projects so that it ensures that project is implemented within allocated budget. According to PMBOK (Guide, 2001), effective cost management can be achieved through accurate project resource planning, accurate project cost estimation, and project cost control. It is necessary to control the financial resources of projects accurately, and this is done through accurate and logical planning of project budget, because it determines the success or failure of project.

According to (Pinto and Slevin, 1999), project scheduling is one of the most important steps in project planning and a key factor in project control. It allows organisations to allocate resources correctly and effectively to achieve project goals and success, and project manager must adhere to and control the schedule to ensure that the project is completed on time.

Table 6 – Measuring Project Success

Research Focus	Period 1 1960s–1980s	Period 2 1980s–2000s	Period 3 21st Century
Success criteria	"Iron triangle" (time, cost, quality)	Iron triangle Client satisfaction Benefits to organization (org) End-user's satisfaction Benefits to stakeholders Benefits to project personnel	Iron triangle Strategic objective of client organizations and business success End-user's satisfaction Benefits to stakeholders Benefits to project personnel and symbolic and rhetoric evaluations of success and failure
Success factors	Anecdotic lists	CSF lists and frameworks	More inclusive CSF frameworks and symbolic and rhetoric success factors
Emphasis	Project management success	Project/product success	Project/product, portfolio, and program success and narratives of success and failure

Source: (Ika, 2009)

2.4. IT Project Management Maturity and Project Performance

The concept of project performance is viewed in different ways by decision-makers, and it is the best to study it by researching the success factors of projects. As previously mentioned by researchers (Jiang et al., 2000, Jones et al., 1996, Nidumolu, 1995), measuring the performance of an IT project should take into account software engineering issues such as the efficiency and effectiveness of software systems and the issues related to IT organisations such as their competencies in project control, communication, and knowledge gained when implementing software projects.

Efficiency is often measured by the extent to which the project schedule and budget have been adhered to in achieving a high-quality and efficient final product. Effectiveness is measured by the adaptability and applicability of a software product. Organisation-related issues include the knowledge that the organisation acquires during the implementation of the project, which aims to raise the efficiency of its employees and the ability of organisations to control their resources used in the project.

Maturity models have become influential as a means of improving project management processes and software development practices. The main belief is that the performance of an IT project can be improved by implementing the correct recommended software process improvement (SPI) activities. The proposed policies for improving the software development process include the availability of qualified personnel and the establishment of a standardised methodology for project management, in addition to documenting and standardising software engineering processes and adopting a mechanism for measuring and controlling the quality of the software product.

Thus, as IT organisations mature and implement the project management maturity model, software development processes become better defined, professionally executed and problem-free. As a result, many researchers argue about the impact of implementing maturity models, with some arguing that their implementation enables managers to monitor the quality of their software products produced.

There are a few studies that confirm the positive impact of implementing maturity models on project performance, including (Butler, 1995, Dion, 1993, Humphrey et al., 1991). These studies show that organisations that implement maturity models have higher-quality products and continuous improvement policies. (Herbsleb and Goldenson, 1996) conducted a survey of 61 organisations to measure the impact of applying the CMMI and found that IT organisation process maturity is associated with improved project performance.

As this study indicates, evidence is accumulating that implementing project management maturity models positively impacts an IT organisation's project performance. (Katz and Lerman, 1985) stated that a positive relationship between project success and software process management can be expected.

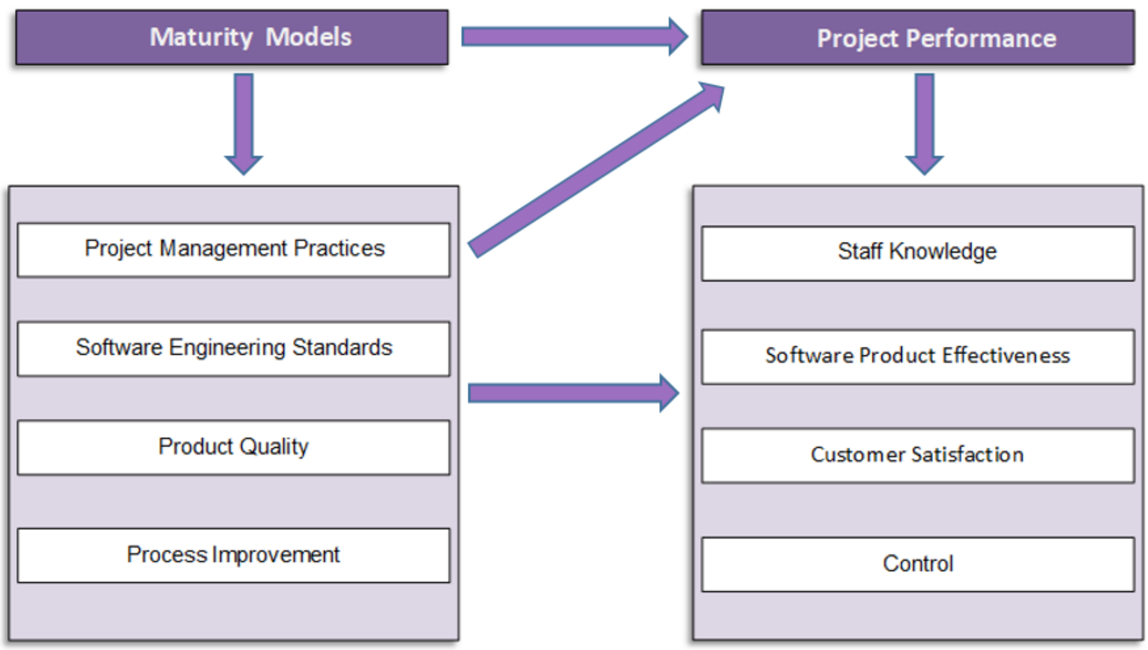
Accordingly, the implementation of PM maturity models will cause organisations to adopt a set of practices and activities that can enable senior management to monitor and evaluate the production process, and this is consistent with the literature that has found that senior managers' monitoring of production processes and project progress is positively correlated with project performance.

2.5. Research Conceptual Model

This study relied on a conceptual framework that was derived from the relevant literature and previous research (see Figure 17). This framework illustrates the relationship between the implementation of maturity models in IT organisations as independent variables, and IT project performance as a dependent variable.

This study is based on the literature related to project management maturity models that affect the performance of IT projects. It has been assumed that each independent factor affects a specific factor of a dependent variable, even though the performance of projects results from the influence of all independent factors combined.

Figure 17 – Research Conceptual Model



The independent variable – implementing maturity models in IT organisations – will be explained in detail by analysing it in accordance with the studies of various researchers. To measure project management maturity models, the research model was adapted from (Dekleva and Drehmer, 1997) studies which present an empirically determined interpretation of measuring the software engineering evolution, in addition to studies that propose maturity frameworks that contribute to characterising the software process (Humphrey, 1988).

(Dekleva and Drehmer, 1997) study is built on a previous study by the same author (Dekleva and Drehmer, 1992), which provided a fascinating interpretation of the model proposed by (Humphrey, 1988), was developed for a preliminary assessment of maturity models, considering each maturity level constituted of groups of related practices. These practices include policies, procedures, and activities.

This study examined project management maturity models by extending the scope of (Dekleva and Drehmer, 1997) to consider a cumulative hierarchy necessary to establish a growth pattern in terms of actual projects management practices in IT organisations. Furthermore, the relationship between (Humphrey, 1988) and (Dekleva and Drehmer, 1992) models is examined.

Maturity models are described in terms of four major factors, as shown in Table 7, which are: (1) *project management practices*, which are defined in terms of operational as 'a set of activities that describe how project management processes are implemented, and to what extent organisations have standardized their project management processes',

(2) *software engineering standards*, which are defined operationally as 'the conditions and restrictions that regulate software engineering processes and standardize systems programming mechanisms', (3) *product quality*, which is defined operationally as 'the mechanisms used to maintain the quality of products and to what extent they are applied in information technology organisations to reach high-level operations', and (4) *process improvement*, which is defined operationally as 'the activities that adopted by organisations to improve their process and raise their quality and adequacy'.

Table 7 – Maturity Models Measurement Indicators

Maturity Models Factors	Source
Project management practices	(Dekleva and Drehmer, 1997) (Humphrey, 1988)
Software engineering standards	
Product quality	
Process improvement	

The dependent variable – IT project performance – will be explained in detail by analysing it in accordance with different studies in the extant literature. To measure project performance, the research model was adapted from (Nidumolu, 1995) study, which presents interpretation of measuring project performance, in addition to (Beath, 1983) study, which describes the extent to which the development process was under control by complete projects on time and within the budget and it is impact on customer satisfaction.

Furthermore, (Cooprider and Henderson, 1990) study was investigated; it describes the knowledge acquired by the organisations. Lastly, (Mookerjee, 1988) study was examined, and it describes the technical performance of software products.

This study examined project performance by extending the scope of (Nidumolu, 1995) to consider the performance of IT projects and their actual evaluation from the two perspectives of software development organisations and customers.

Project performance can be described in terms of four major factors, as shown in Table 8, which are: (1) *staff knowledge*, which is defined operationally as ‘to what extent IT organisations acquire new knowledge to develop their employees competency through the implementation of software development projects’, (2) *software product effectiveness*, which is defined operationally as ‘the degree of success of information technology organisations by providing services and software that achieve the desired result and gain user satisfaction’, (3) *customer satisfaction*, which is defined operationally as ‘the extent to which users and customers are satisfied with the final software product’, and (4) *control* , which is defined operationally as ‘to what extent are IT projects successfully managed with adherence to cost and schedule’.

Table 8 – Project Performance Measurement Indicators

Project Performance Factors	Source
Staff knowledge	(Cooprider and Henderson, 1990)
Software product effectiveness	(Mookerjee, 1988)
Customer satisfaction	(Beath, 1983)
Control	

Some scholars such as (Eisenhardt, 1985, Peterson, 1984) have argued that management control can be achieved through process control, which is directed at employee behaviours. Also, (Venkatesh et al., 2018) mentioned that IT service provider organisations need a set of important changes to produce high quality output, within budget and on time. These changes are intended to improve the practices of IT project teams. According to these reasons, project management maturity models create a set of practices and rules that project team members must follow to control and improve project processes.

Additionally, this theory is consistent with the literature that managing and monitoring projects against standards positively impact project performance. (Herbsleb and Goldenson, 1996) conducted a survey using sample of 61 organisations to study the effect of implementing maturity models on project performance and found concrete evidence that maturity models have relationship with organisational project performance.

In addition, (Cacamis et al., 2014) reported that the implementation of project management maturity models within organisations means implementing a set of practices to control the operations, which can improve their processes and consequently the performance of their projects. The implementation of maturity models allows organisations to create and develop their organisational practices while achieving an increase in the efficiency of their projects (Galli, 2018). In accordance with the previous theories and empirical results, we hypothesise:

H1: Implementing maturity models positively affects the project performance.

The concept of product quality has been developed by a number of researchers such as (Sam and Dhanya, 2012, Yu and Fang, 2009). (Chang, 2009) remarked that product quality should be measured from the customer's standpoint. Also, researchers such as (Cronin Jr et al., 2000, Oliver, 2014) linked product quality to customer satisfaction and found that the former has a positive effect on the latter. (TRAN et al., 2020) also concluded through his research that there is a positive relationship between product quality and customer satisfaction.

Customer satisfaction is indirectly affected by the implementation of maturity models in organisations by increasing the quality of their products (Settlemyre, 2008). (Goldenson and Gibson, 2003) mentioned that there is a direct effect of implementing maturity models on customer satisfaction. In accordance with the previously mentioned literature, the following hypothesis can be derived:

H2: Product quality positively affects customer satisfaction.

.

Project performance is evaluated by stakeholders in different ways, but to evaluate the performance of IT projects, software-related issues such as the efficiency and effectiveness of software systems must be taken into consideration (Jiang et al., 2000, Jones et al., 1996, Nidumolu, 1995). Effectiveness is the applicability and adaptability of the software system. Other scholars (Butler, 1995, Dion, 1993, Humphrey et al., 1991) found that organisations that adopt maturity models tend to produce higher-quality software with higher development productivity. (Katz and Lerman, 1985) mentioned in his study that there is relation between project performance and software processes management. Furthermore, (Mkutano et al., 2018) mentioned that the performance of large IT projects depends on the use of effective software engineering practices that ensure a high level of product quality.

Managing software development processes is concerned with directing employees to work according to specific procedures, such as using software standards, documenting software codes, and using standard mechanisms to check systems (Henderson and Lee, 1992). (Mkutano et al., 2018) reported that the adoption of effective project management practices can lead to improvement in project performance.

In line with the previously mentioned literature, the following hypotheses can be derived:

H3: The application of project management practices positively affects project performance

H4: The application of software engineering standards positively affects the effectiveness of the software product.

Organisations in this era face many challenges, including insufficient and inadequate knowledge and maintaining customer satisfaction, as well as lack of skilled professionals. Therefore, there is a dire need to improve business processes in organisations to achieve competitive advantage and advancement (Antony and Gupta, 2019). (Galli, 2018) stated that organisations are under constant pressure to achieve a competitive advantage that requires reducing the cost of products while maintaining a high level of quality that satisfies customers. This is what prompted many of them to make changes and adopt policies for continuous improvement of their operations.

Process improvement can be defined (Jäntti et al., 2013) as the practice of documenting and analysing all activities of an organisation. It involves analyzing errors, studying their root causes, developing plans and procedures to avoid them in the future, and avoiding unnecessary actions that do not add any value. It also involves training and educating employees about the organisation's operations. Process improvement has been measured by many scholars such as (McGibbon et al., 2007), who have presented various measures for process improvement, which are project cost, quality, rework, productivity, improvement cost, cycle time, and schedule variance.

Likewise, (Gibson et al., 2006) used the following factors to measure CMMI-based process improvement: cost, schedule, customer satisfaction, and return on investment, quality, and productivity. This indicates a relationship between process improvement and control over both project cost and schedule. In accordance with the previously mentioned literature, the following hypothesis was developed:

H5: Higher levels of process improvement will lead to higher levels of project control.

2.6. Chapter Summary

The literature review leads to the following research concepts:

- ✓ The maturity of organisations and project management offices leads to a better performance of projects.
- ✓ Maturity models in organisations are instrumental in managing the continuous improvement of their projects and processes.
- ✓ Maturity models assess the current state of IT organisations' processes and projects management practices and suggest a roadmap for continuous improvement to move organisations forward.

- ✓ Project management offices have an effective role in developing organisational maturity and using standardised project management practices.
- ✓ There are many project management maturity models, which differ in their ways of applying the best practices to adopt continuous improvement policies.

To summarise the literature review, the researcher described in the first part of this chapter PMOs in detail, their definition, literature, models, structure and roles in organisations, especially IT organisations, and explained the relationship between PMOs and project performance in organisations.

The second part of this chapter covered the most important and common models of project management maturity, covering their background, definitions, and literature, described CMMI as an important example of famous maturity models used in IT organisations. Also, many other models were covered in this section, namely OPM3, P3M3, P2MM, KPM3, and PM2.

The literature review focused on the most important models of maturity, including CMMI, its establishment and how it has become one of the most mature models of IT organisations, describing its evolution and importance in improving software development processes. The CMMI structure, benefits, and impact on project cost, quality, and product quality, and CMMI appraisal approaches were then discussed as well.

The study also focused on another popular model of maturity, the OPM3. The most notable literature on OPM3, its definition, stages of development, structure, approved maturity levels, and OPM3 assessment methods were then elaborated.

Chapter 3: Research Methodology

When conducting research, all available research methods and philosophies must be considered. The main objective of this chapter is to define the study variables and measures and describe the research approach, strategy, and data collection methods, and explain the research instrument, survey structure, and analysis procedures that were used to address the formulated research questions.

3.1. Research Methods and Philosophies

Research methodology as defined by (Kothari, 2004) is a systematic way that is used to solve the main research problem, which includes the processes of collecting, analysing, and finally interpreting data to answer the pertinent research questions. (Pandey and Pandey, 2015) identified several characteristics of the research process. It is a process aimed at solving a controversial problem, a process that requires experience in the correct research methods, based on empirical evidence and accurate observations, as well as on data collected and recorded meticulously.

Research methods are classified in more than one way depending on how the research is applied, its objectives, the nature of the data used, the methods of collecting the same, whether the data are qualitative or quantitative, as well as the logical explanation used for that data (Pandey and Pandey, 2015). Quantitative methods as described by many scholars such as (Kothari, 2004, MacDonald and Headlam, 2007) is a research technique used to collect measurable and computable data, such as data that are numerical and non-descriptive in nature, the results of which can be illustrated using graphs or a table.

By contrast, qualitative methods are concerned with evaluating aspects and social phenomena that cannot be explained numerically by numbers or statistics. The results of qualitative methods reflect the researcher's opinion of these phenomena and his or her logical explanation. Examples include interviews and discussion groups (Jones, 1995, Kothari, 2004). Table 9 presents a comparison between qualitative and quantitative methods.

Table 9 – Qualitative and Quantitative Research Differences

	Qualitative Research	Quantitative Research
Focus	Quality (features)	Quantity (how much, numbers)
Philosophy	Phenomenology	Positivism
Method	Ethnography/Observation	Experiments/Correlation
Goal	Understand, meaning	Prediction, test hypothesis
Design	Flexible, emerging	Structured, predetermined
Sample	Small, purposeful	Large, random, representation
Data Collection	Interviews, observation, documents and artefacts	Questionnaire, scales, tests, inventories
Analysis	Inductive (by the researcher)	Deductive (by statistical methods)
Findings	Comprehensive, description detailed, holistic	Precise, numerical

Source:(Ivo Fon, 2018)

Although the two methods are different, they are considered complementary to each other, as mentioned by the researcher (Jones, 1995). This is the reason for the emergence of a third research method combining qualitative and quantitative methods using mixed technique, which is called triangulation.

Triangulation was previously defined by (Denzin, 1970) as mix research technique using a set of methodologies to study the same phenomenon in one research. (Campbell and Fiske, 1959) created the theory of multiple operationalism and argued that there must be more than one way to verify the validity and accuracy of the research results. (Cohen et al., 2000) described triangulation as a research method used to achieve an increase in the credibility and validity of research results. Credibility is the amount of confidence on and reliability of a study and its results, and validity relates to how accurately the study evaluates the concept or ideas under investigation (Carvalho and White, 1997). The research triangulation method helps integrate theories and methods in one research study, which ensures that there is no bias arising when using one research method.

3.2. Study Variables and Measures

This research study the impact of implementing various maturity models within IT organizations on the performance of their projects. The independent variable - implementing maturity models in IT organizations - will be studied in detail based on the relevant literature and scientific studies, by examining its main factors. To measure project management maturity models the research model was adapted from (Dekleva and Drehmer, 1997) studies which present an empirically determined interpretation of measuring the software engineering evolution, in addition to (Humphrey, 1988) studies that propose maturity frameworks that contribute to characterizing the software process.

Maturity models are described in terms of four major factors which discussed previously in the research conceptual model section. It can be stated that the implementation of maturity model is defined operationally as organisations complying with a set of operational standards that raise the level of their project management efficiency.

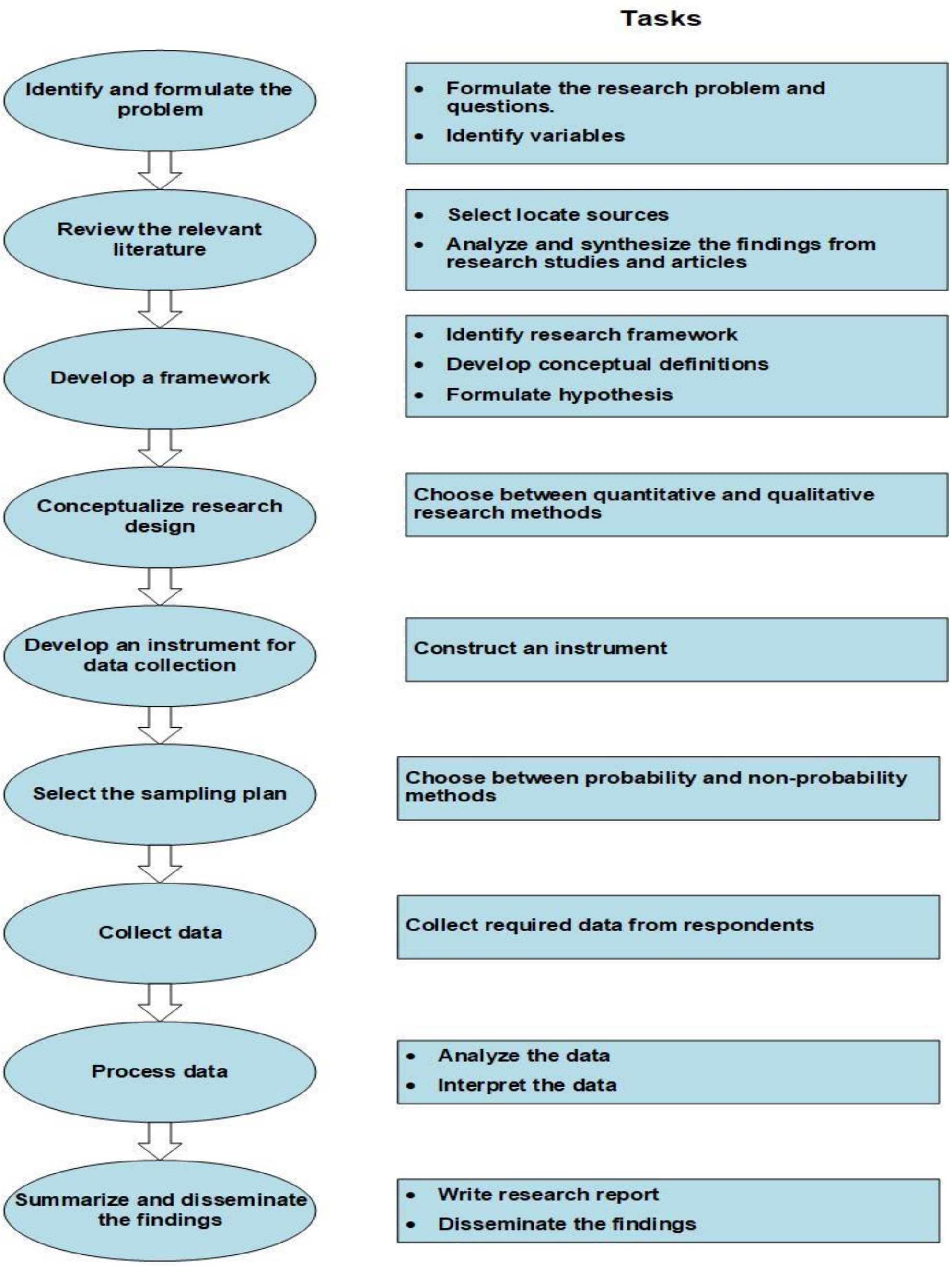
Furthermore, the dependent variable – IT project performance – will be explained in detail by analysing it in accordance with different studies in the extant literature. To measure project performance, the research model was adapted from (Nidumolu, 1995, Beath, 1983, Cooprider and Henderson, 1990, Mookerjee, 1988) studies, and it was described in terms of four major factors which discussed in previous chapter. It can be stated that IT project performance is described operationally as the process of implementing and managing IT projects in a way that contributes to achieving the goals and strategies of organisations and takes into account the interests and service of customers.

3.3. Research Strategy

Quantitative research method was used in this study, described in the previous section and as defined by (Bryman, 2016). The research process began by identifying the research topic, and then determining research questions that represent the main research problem. Next, the most critical literature on the topic was reviewed to determine the most important theories developed by researchers to develop a logical perception of the theoretical framework. After that, a research questionnaire was designed to collect and analyse data.

The literature selected for this study was from different topics and source, because the topic of this research deals with different types of maturity models related to project management, especially IT projects. Scholarly sources that were used include books, research articles, statistical reports, and journals. The search process stages are shown in Figure 18.

Figure 18 – Research Process Stages



3.4. Research Approach

The primary research design of this study adhered to a quantitative approach to examine the outcomes of previous reviews and the outcomes of the participants in the research questionnaire on the impact of implementing maturity models on project performance. The quantitative approach was used to collect the participants' views on all factors affecting the performance of projects. The research factors were studied in an objective manner.

The principal reason for applying the quantitative method was to achieve extensive knowledge and understanding of the social world. Quantitative research is used to study and analyse events that affect society and people. It is characterized by the production of objective data that can enable researchers to communicate it clearly through statistics and numbers. The quantitative research method was chosen based on the studies of researcher (Veal, 2017) on the main factors in choosing the research method, which are previous studies, data reliability and creditability, access to data, research questions and hypotheses.

Survey-based research is defined by researchers such as (Creswell and Creswell, 2017) as research that aims to quantitatively or numerically describe the attitudes or opinions of community members by examining a sample of them. Survey-based research is the most appropriate quantitative method for this research according to the time constraints imposed. Through the use of the survey technique on the Internet, the participants' opinions were collected, which enriched the study and allowed a generalisation of its results (Sue and Ritter, 2012, Babbie, 2020, Fowler Jr, 2013).

The quantitative research in this study relied on the use of a survey questionnaire for collecting data from participants with different competencies and occupations. Then a study and analysis of all the data collected statistically was conducted to examine the association between the different variables of maturity models and project performance.

3.5. Research Data Collection Methods and Sampling

Researchers use a wide array of methods to collect data, including conducting survey, experiments, theories, and case studies (Creswell and Creswell, 2017). In this study, the researcher relied on primary and secondary data sources. To collect the primary data, an online questionnaire was designed and published for the purpose of collecting participants' responses to the analysis and testing of research hypotheses.

The study participants include employees in organisations specialised in the field of IT belonging to different job profiles, including project managers, project management office managers, executive managers, in addition to technicians such as programmers and systems analysts. To distribute the questionnaire, it was published by sending it electronically to 300 IT professionals working in more than one country representing the study population, social media was used, especially LinkedIn platform. A total of 192 responses were received, and therefore, the participation response rate was 64%. In addition, the researcher used various sources for secondary data collection, including articles, journals, and specialised research publications, as well as books.

The sampling technique employed in this research is non-probability sampling, convenience sampling method, and snowball sampling method. Although there are scholars who consider non-probability sampling to be less valuable than probability sampling, there are also some who believe that the use of non-probability sampling is better (Bryman, 2016).

In this study, convenience sampling method was used; it is a method in which available participant is selected (Bryman, 2016) because of the lack of access and the presence of a network of IT professionals. This method is convenient and time efficient. However, some scholars consider that using only this method is not sufficient to target some significant categories of the study population, such as executive managers and PMO managers belonging to IT organisations, especially those who have practical experience in implementing maturity models. Therefore, the snowball method was used to reach this category by asking some participants to pass a questionnaire to them to participate in the study.

3.6. Research Instrument

A survey was used in this study as a research instrument, which is one of the most widely used methods for collecting data from a large sample of participants with efficiency and speed (Bryman, 2016). The questionnaire was created as per the theoretical framework mentioned previously. Also, its items were developed taking into account the main aim of research and its objectives, to collect accurate and objective responses from participants.

A standardised and structured questionnaire was used. Using a standardised questionnaire has several benefits, according to (Cargan, 2007), who mentioned in his book that the use of a standardisation questionnaire is characterised by the ease of comparing the data collected from the respondents. Also, a structured questionnaire is a widely used approach to collect quantitative data (Moore, 2006).

The 5-point Likert scale was used in the questionnaire, and the participants were asked to determine to what extent they agreed with the statement on the scale. Likert scale has many advantages, for example, it has the ability to measure participants' opinions in many situations, it is easy to respond by participants, and is an attractive model for participants; it has also been used in many studies that came out with important results (Nunnally, 1994).

The questionnaire was published electronically on the Internet to ensure easy access to the largest number of participants from the target sample. It was then distributed via an electronic link using social media and email. It was developed to collect respondents' answers that aim to explain the association between the various maturity models factors and their impact on IT project performance. The questionnaire consists of 38 questions, each set of questions is designed to measure a specific variable, as shown in the appendix. The questionnaire consists of three parts, which are 1) demographic information, 2) maturity models, and 3) project performance. The questionnaire begins with an introduction that provides a description of the study topic and objective, as well as an ethical statement.

The first part seeks to collect demographic data of the participants to better understand their situation. It consists of seven multiple-choice questions that include marital status, gender, age, educational level, number of years of work in the current institution, number of years of work in the current position, and finally, the level of employment status. The second part consists of a set of questions related to maturity models as an independent variable such that there are 18 items representing four factors to measure maturity models, and to measure the relationship between each factor and its impact on the performance of IT projects.

The third part includes a set of questions about project performance as a dependent variable such that there are 13 items representing four factors to measure project performance. The questions for the second and third parts are designed in line with the relevant literature. Five points in Likert format were used as a scale in the questionnaire, with the lowest scale being '1' meaning *strongly agree* and the highest scale being '5' meaning *strongly disagree*.

3.7. Experimental Study

Experimenting with the survey questionnaire is one of the most crucial research stages to measure and evaluate the contents of the survey and ensure that survey items are clear and appropriate (DeVellis, 2016, Lietz, 2010, Fink and Litwin, 1995). Also, one of the objectives of this pilot test is to verify that the questionnaire is free from any potential errors or problems. These errors include repetition of the terms used (Carvalho and White, 1997).

A pilot study was conducted to verify the reliability and validity of the questionnaire used before proceeding with its distribution to the participants. The questionnaire was presented to a group of professionals, and their feedback was requested. Then, feedback was received from all participants, studied, and taken into account, and then the survey was adjusted. Some improvements include crafting some items to be more neutral, avoiding using terms such as ‘very’ and ‘strongly’. These comments are consistent with (Lietz, 2010), who mentioned that the length of questionnaire questions must be taken into account, clearly and accurately formulated, and properly ordered. (Lietz, 2010) asserts that conducting a pilot test ensures the quality of the questionnaire used.

3.8. Ethical Obligation

Ethical adherence is one of the most important pillars when conducting any study (Bryman, 2016). Ethical principles or obligations include obtaining the consent of the survey participants, ensuring the protection of their privacy and dignity, as well as not disclosing their identities to others (Bryman, 2016).

To ensure the maintenance of ethical obligations in this research, it was conducted within the ethical principles. Participation was voluntary, and the survey included the ethical section, ensuring that the confidentiality, privacy, and identity of the participants were protected.

3.9. Data Analysis

SPSS, one of the most popular statistical analysis software, was used for analysing the data collected from the participants. Owing to its useful tools in providing various statistics, researchers can analyse, interpret, and transform the collected data into a model that can enable them to test and examine research hypotheses.

In the analysis part of this research, various types of analysis tests were conducted, namely demographic analysis, reliability, correlation, linear regression, and multiple regression.

A reliability test was used to ensure that each group of items is coherent and able to measure the related variable. The main output of this test – Cronbach's alpha (α) – was used to measure the reliability and consistency of the items (Cronbach et al., 2004). This measurement method is suitable for this study because it is based on a questionnaire consisting of several Likert questions, and the prerequisite for such a test is to measure a set of items on a continuous scale (Boone, 2012). Furthermore, according to (Bryman, 2016), Cronbach's alpha (α) can be used in measuring internal consistency and reliability. The minimum required Cronbach's alpha (α) value in reliability test was mentioned by many scholars. (Reeve et al., 2016) stated that, based on what many researchers agree on, the minimum value of Cronbach's alpha (α) should be 0.6.

In this paper, a reliability test was performed for each set of items belonging to independent and dependent factors, and Cronbach's alpha value was adopted as 0.6. For example, a reliability test is performed on a factor (product quality) to ensure the reliability and consistency of the measures used.

If the value of Cronbach alpha extracted from SPSS was more than 0.6, the measurement used was preserved. If it is less than that, specific items will be deleted using 'if the item is deleted' feature in SPSS software. Items that are deleted using 'if the item is deleted' will not be considered while calculating the average value of independent and dependent factors.

Next, the correlation test was performed to ascertain the nature of the relationship between dependent and independent variables, if any, and to test the hypotheses of this study. (Thompson, 2004) stated that the outcomes of the correlation test –the level of significance – is used to determine the sample distribution rejection area, which is concerned with knowing the validity of generalising the result of the study that was reached from the studied sample to the entire population. (Thompson, 2004) also mentioned that the standardised significance levels are 0.05, 0.01, and 0.001. However, level 0.05 is usually chosen by many researchers (Stigler, 2008). Hence, this level was adopted in this study to represent the level of significance, implying that the impact level is 95%.

In the end, after performing a reliability test and finding out whether the dependent variables are correlated to the independent variable, the regression test was conducted to define the relationship of dependent factors (project management practices, software engineering standards, product quality, and process improvement) to the independent factors (staff knowledge, software product effectiveness, customer satisfaction, and project control). In regression test, R-squared, which is one of the most important outputs of this test, represents the variance proportion of dependent variable explained by independent variable.

While the correlation test shows the strength of the relationship between each of the independent and dependent variables, R-squared reveals to what extent, the variance of the independent variable explains the variance of the dependent variable. For example, if R-squared is 0.6 when doing regression test for project management practice as independent factor and project performance as dependent variable, this indicates that 60% of the project performance variance is due to the application of project management practices in organisations.

3.10. Chapter Summary

This chapter presents the method conducted to evaluate the research hypotheses and answer research questions. This study used the quantitative method as the primary research method towing to its suitability in the general framework of the subject of this study. The data were amassed from participants using a survey questionnaire distributed to the target sample online, and snowball sampling and convenience sampling were used for this purpose. To validate the survey questionnaire used, a pilot test was conducted to test the accuracy of the instrument. Ethical considerations are also taken into account in this research to ensure that ethical issues are addressed. The statistical program SPSS used to analyse the data and the tests conducted will be covered in the next chapter.

Chapter 4: Data Analysis and Findings

This chapter presents the results of this study obtained by analysing the data collected using the SPSS program, by conducting a set of tests that were chosen in accordance with the study design, hypotheses, and research questions. The tests performed include reliability, regression, and correlation such that each of them serves a purpose; the reliability test was used to verify the reliability of the research questionnaire questions.

Regression and correlation tests were used to answer the research hypotheses by analysing the relationship between the implementation of maturity models in IT organisations and the project's performance. Additional tests were conducted to analyse and measure the importance of implementing maturity model factors and conducting multiple regression tests.

4.1. Validation of the Collected Data

As mentioned previously, the data were collected from the participants using the research questionnaire. Before proceeding with the analysis, the answers of the participants to the questionnaire were checked to ensure the accuracy and quality of the data. Initially, 192 responses were collected, but after checking the validity of the data, the total number of accepted and accurate responses became 174. All incomplete responses (18) were discarded to ensure the accuracy and correctness of data.

4.2. Descriptive Analysis

The first section of the questionnaire provides general information about the participants, which is known as demographic data. Depending on the data of the participants' responses, an analysis of their demographic characteristics was conducted to study their general information such as their educational level, occupational level, number of years working in their current organisations, in addition to other information. This was done to distribute the target population and study the relationship of their responses to the research variables.

As shown in Figure 19, the number of male participants was 122, while the number of females was 52 such that the number of males exceeds females by a percentage of 40.2%. This indicates that there was more participation in the survey from male gender, and this is related to the gender characteristics of the participants. Also, looking at the educational level of the participants, we find that the bachelor's degree occupied 46% (80 participants), followed by those with high degrees (47 participants), and a college degree with 38 participants, and the remainder of the educational levels occupied 5.2%, as shown in Figure 20.

Figure 19 – Respondents' Gender

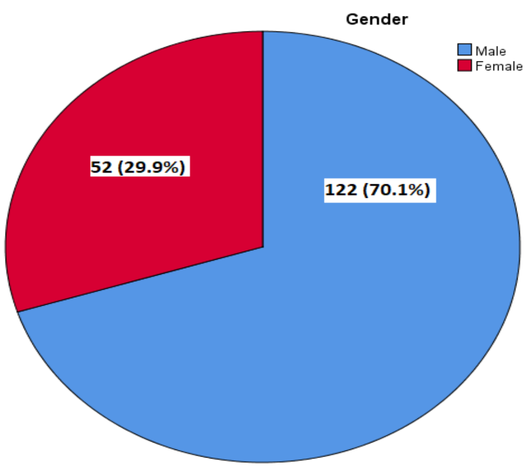
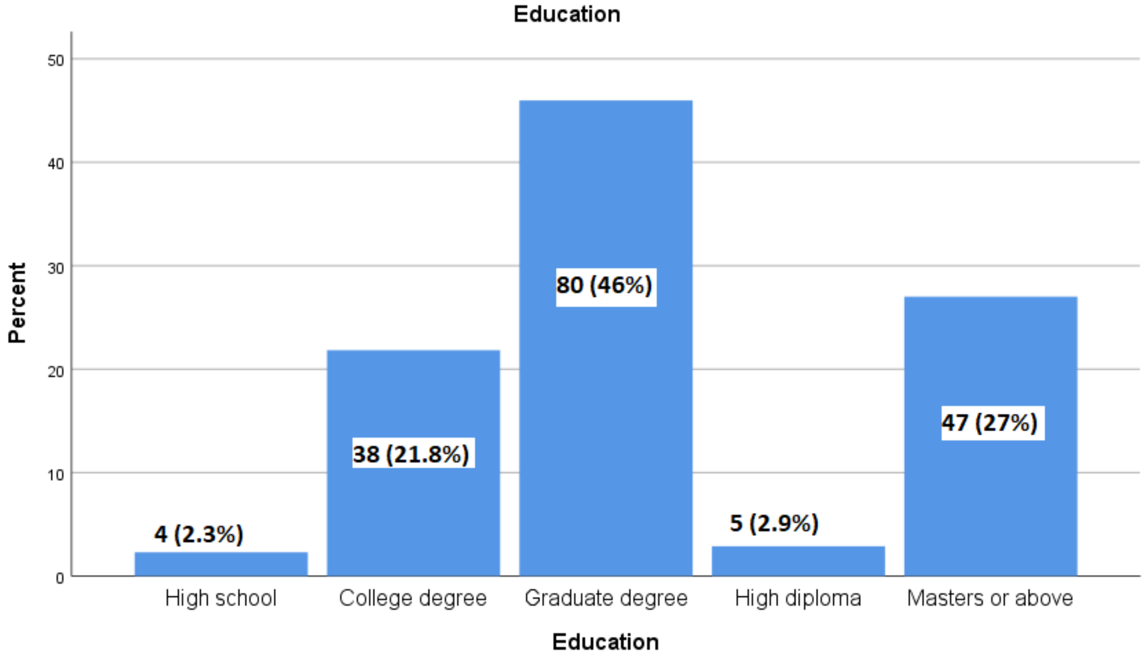


Figure 20 – Respondents' Educational Level



It shall be noted that the participants in the study belonged to different job positions, most of them belonged to the 'middle level' category, with a percentage of 49.4% with 86 participants, including systems developers, systems analysts, and quality officers, and then, the 'first level' category occupied a close percentage of 39.7% with 69 participants, including executive managers, CEOs, project managers and PMOs directors. This indicates that more than 85% of the participants in this study had sufficient experience and knowledge to enrich this study with accurate and practical data that can reflect the current state of the work in IT organisations. Lastly, a very small percentage of 10.9% with 19 participants belonged to the 'lower level' job category.

With regard to the number of years of work in the current organisation, the highest percentage was observed to be from two to seven years at 37.9% (66 participants), followed by a year or less with 31% with (54 participants), while the other time periods occupied 31% (54 participants). We conclude from this result that most of the participants in the study (68.9%) have been working in their current organisations for less than seven years. This is a good indicator because the questions were designed to cover diversified aspects of the operations of IT organisations, both administrative and technical, so the participants have sufficient experience in many aspects of IT industry operations.

Regarding the question about the number of years the participants worked in their current jobs, the results showed that 31.6% of the participants worked in their current job for two to seven years, while 24.1% spent a year or less in the same position, and 21.8% worked for 8 to 13 years, and the remainder (22.4%) continued in the same position for more than 14 years. We conclude from this result that more than half of the participants in the study (55.7%) have been working in their current positions for less than seven years, and this is an indication that many of the participants have evolved in their work and gained experience in many aspects related to the operations of IT organisations and are familiar with different kinds of projects.

Table 10 encapsulates a summary of descriptive statistics for participants' demographic data.

Table 10 – Descriptive Statistics for participants' demographic data

Item	Frequency	Percentage (%)
Sex		
Female	52	29.9
Male	122	70.1
Marital status		
Married	107	61.5
Unmarried	67	38.5
Education level		
Less than high school	0	0
High school	4	2.3
College degree	38	21.8
Graduate degree	80	46.0
High diploma	5	2.9
Master or above	47	27.0
Age		
Less than 25	0	0
25 - 35	69	39.7
36 - 46	84	48.3
47 - 57	20	11.5
58 or more	1	0.5
Number of years worked in the same organisation		
1 or less	54	31.0
2 - 7	66	37.9
8 - 13	33	19.1
14 - 19	14	8.0
20 or more	7	4.0
Number of years in the same position		
1 or less	42	24.1
2 - 7	55	31.6
8 - 13	38	21.8
14 - 19	24	13.8
20 or more	15	8.7
Job status		
First level	69	39.7
Middle level	86	49.4
Lower level	19	10.9

Table 11 presents the mode, mean, median, and standard deviations values for each item in demographic section, taking into account that each item has different values as they were entered in the SPSS program: the gender between 1 ‘"male’ and 2 ‘"female’; the marital status between 1 '‘married’ and 2 ‘unmarried’; the education between 1 ‘less than high school’ and 6 ‘master or above’; the age between 1 ‘less than 25’ and 5 ‘58 or more’; the number of years worked in the current organisation between 1 ‘1 or less’ and 5 ’20 or more’; the number of years worked in the same position between 1 ‘1 or less’ and 5 ’20 or more’; the job status between 1 ‘first level’ and 3 ‘lower level’.

Table 11 – Descriptive Statistics
(Mode, Mean, Median, and Standard Deviations)

	Gender	Marital-Status	Education	Age	Number of years worked in the current organisation	Number of years worked in the same position	Job Status
N	174	174	174	174	174	174	174
Mode	1	1	4	3	2	2	2
Mean	1.3	1.39	4.3	2.73	2.16	2.51	1.71
Median	1	1	4	3	2	2	2
Standard Deviation	0.459	0.488	1.155	0.681	1.079	1.239	0.652
Minimum	1	1	2	2	1	1	1
Maximum	2	2	6	5	5	5	3

4.3. Reliability Test

A reliability test, as (Bryman, 2016) mentioned, was used to validate the research survey questions. As remarked earlier, relying on many recommendations and researchers, the acceptable Cronbach’s alpha value, as mentioned by many scholars like (Gliem and Gliem, 2003, Reeve et al., 2016) should be above 0.60. Thus, the reliability test conducted, and Cronbach's alpha value were measured to verify the accuracy of research instrument used by checking whether the value was higher or within the acceptable limit. This test was conducted several times since the research survey consisted of several scales, implementing maturity models factors and project performance factors.

First, testing was conducted for all 31 items including the independent factors (implementing maturity models factors) and the dependent factors (project performance factors), which resulted in high value of Cronbach's alpha score of 0.90, indicating a high consistency level (see Table 12). Next, reliability testing was performed on both independent and dependent variables separately because each group measures a different scale. First, it was conducted on the independent variable, which consists of 18 items. As presented in Table 12, the resultant Cronbach alpha was 0.850, indicating a high level of consistency.

As for the dependent variable, Cronbach's alpha value was 0.80. We can conclude that there was a high level of consistency for all sets of search variables without having the need to delete any of the items.

Table 12 – Reliability Statistics

Cronbach's Alpha Values

	Dependent & Independent Items	Implementing Maturity Models Variable Items	Project Performance Variable Items
Cronbach's Alpha	0.900	0.850	0.808
Number of Items	31	18	13

Next, a reliability test was performed for each factor of independent and dependent variables to measure and confirm the consistency between each set of items. As shown in Table 13, the Cronbach's alpha results for each factor of independent variable are as follows: 0.618, 0.601, 0.616, and 0.608. Therefore, we found that Cronbach's alpha results for all independent variable factors were above 0.60, which is in line with an acceptable level of reliability (Gliem and Gliem, 2003, Reeve et al., 2016), and thus, there was no need to delete any item.

Table 13 – Cronbach's Alpha Values

(Independent Variable Factors)

Independent Variable Factors (Implementing Maturity Models)	Cronbach's Alpha Value	N of Items
Project Management Practices	0.618	5
Software Engineering Standards	0.601	4
Product Quality	0.616	4
Process improvement	0.608	5

Finally, we performed a reliability test for each factor of dependent variable as shown in Table 14, which shows the following results of Cronbach's alpha. The control factor was 0.557, and to increase the reliability, the 'Scale If Item Deleted' option in SPSS was used, and after deleting one item, the result became 0.647. The *customer satisfaction* factor was 0.496, and after deleting one item, the result became 0.606. Regarding both *product quality* and *process improvement* factors, the test results were 0.616 and 0.608, respectively, without having to delete any item.

Table 14 – Cronbach's Alpha Values
(Dependent Variable Factors)

Dependent Variable Factors (Project Performance)	Cronbach's Alpha Value	N of Items
Control	0.647	2
Customer Satisfaction	0.606	3
Software Product Effectiveness	0.621	3
Staff Knowledge	0.665	3

4.4. Correlation Test

The correlation analysis test was used by researchers to examine the link between two variables (Sheskin, 2003, Bryman, 2016). In this study, the researcher performed a Pearson correlation coefficient test to define the association between implementing maturity models variable (independent) and project performance variable (dependent). The main purpose of this test, as (Sheskin, 2003) mentioned, is to examine all the research hypotheses and determine if there is any link between the factors or independent and dependent variables and decide whether to accept or reject the null hypotheses.

This test was performed to check whether there is a strong or weak correlation between the variables such that the lack of correlation means that the implementation of maturity models in IT organisations hardly affects the performance of their projects. The Pearson correlation test was conducted in several stages, as shown in Appendix 4. The first stage was implemented to determine the relationship between the two global variables: implementation of maturity models and project performance. The result shows that there is a significant positive correlation between participant ratings of these two with r (172) = 0.719, and $p < 0.001$ (see Table 15).

Table 15 – Pearson Correlation Values
(Independent and Dependent Global Variables)

		Implementing Maturity Models Global Variable	Project Performance Global Variable
Implementing Maturity Models Global Variable	Pearson Correlation	1	.719**
	Sig. (2-tailed)		.000
Project Performance Global Variable	Pearson Correlation	.719**	1
	Sig. (2-tailed)	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

The second stage of correlation test was conducted to examine the research hypotheses and determine the association between independent variable factors and dependent variable factors. Table 16 shows the results of testing the correlation between each pair of factors. The project management practices factor shows a significant positive correlation with project performance variable with r (172) = 0.608, and $p < 0.001$. Also, the software engineering standards factor shows a significant positive correlation with software product effectiveness factor with r (172) = 0.457, and $p < 0.001$.

It can be seen that the product quality factor shows a significant positive correlation with the customer satisfaction factor with $r(172) = 0.361$ and $p < 0.001$. In addition to the previous results, we can see that the process improvement factor shows a significant positive correlation with the project control factor with $r(172) = 0.542$ and $p < 0.001$.

Overall, Table 16 reveals that there is a significant positive correlation between each of the factors. It can be seen that the highest correlation was between the implementation of the maturity models variable and the project performance variable ($r = 0.719$), and the lowest was between the product quality factor and the customer satisfaction factor ($r = 0.361$). Therefore, we conclude that the level of correlation is high for all groups, which indicates a positive correlation, and the null hypothesis was thus rejected.

Table 16 – Pearson Correlation Test

		project management practices factor	software engineering standards factor	product quality factor	process improvement factor	control factor	customer satisfaction factor	software product effectiveness factor	staff knowledge factor	Implementing Maturity Models Global Variable	Project Performance Global Variable
project management practices factor	Pearson Correlation										
	Sig. (2-tailed)										
software engineering standards factor	Pearson Correlation	.532**									
	Sig. (2-tailed)	.000									
product quality factor	Pearson Correlation	.581**	.618**								
	Sig. (2-tailed)	.000	.000								
process improvement factor	Pearson Correlation	.584**	.601**	.589**							
	Sig. (2-tailed)	.000	.000	.000							
control factor	Pearson Correlation	.460**	.515**	.437**	.542**						
	Sig. (2-tailed)	.000	.000	.000	.000						
customer satisfaction factor	Pearson Correlation	.496**	.501**	.361**	.497**	.544**					
	Sig. (2-tailed)	.000	.000	.000	.000	.000					
software product effectiveness factor	Pearson Correlation	.459**	.457**	.483**	.501**	.466**	.524**				
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000				
staff knowledge factor	Pearson Correlation	.508**	.430**	.460**	.434**	.429**	.544**	.490**			
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000			
Implementing Maturity Models Global Variable	Pearson Correlation	.830**	.815**	.830**	.841**	.589**	.562**	.573**	.555**		
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000		
Project Performance Global Variable	Pearson Correlation	.608**	.601**	.549**	.623**	.764**	.833**	.783**	.780**	.719**	
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	

4.5. Regression Test

To further understand the impact of implementing maturity models on the performance of an IT project, a regression analysis was conducted. (Weisberg, 2013) remarked that regression analysis is a statistical method used to define the amount of variance in the performance of an IT project that can be explained by the implementation of maturity models. Furthermore, the regression test was used to confirm the previous results of the correlation test and the validity of the research hypotheses. In this study, the researcher performed various kinds of regression tests. Initially, a linear regression test between the two main global variables was performed and then applied to all research hypotheses. Next, a multiple regression test was performed between all the independent factors and the dependent global variable, to investigate the strongest influencer of the four factors of implementing maturity models global variable on the project performance.

4.5.1. Linear Regression Test

Before proceeding with the regression test, first, it was necessary to verify the different assumptions about the regression analysis as stated by (Best and Wolf, 2013). Linearity assumption was verified using a scatter plot between the independent variable and the dependent variable, and was made for all research hypotheses.

By studying the diagrams included in Appendix 5, we note that all relationships are linear. In addition, the independence of residuals assumption was verified using Durbin Watson statistics evaluation for the two main global variables with a score of 1.814, and for each pair of variables in the research hypotheses (see Appendix 7). Also, the normality of the residuals was assessed using a histogram showing that the residues are normally distributed, as described in Appendix 6.

The following sections present the results of the linear regression test that was performed. It shows a summary of the test results between each pair of variables. The first test was conducted to determine the link between the two global variables, the independent variable (implementation of maturity models) and the dependent variable (IT project performance), and then, the following tests were conducted to verify the research hypotheses.

Regression Test Results (Implementation of Maturity Models and Project Performance):

Depending on the results of the linear regression test between the implementation of the maturity models variable and the project performance variable shown in Table 17, we note from the resulting variance ratio by reading the values of R, R-squared, and adjusted R-squared that the regression model has a good fit. In addition, the resultant values of F and Sig. indicate statistical significance of the model.

Regarding the statistical significance, we can conclude from the test result that the model is significant because Sig. (p-value) is less than alpha 0.05 (<.05). In addition, the implementation of maturity models significantly affected the performance of projects with F = 184.496, Sig. (p-value) = 0.000. As for the resulting variance ratio, the R value indicates a good amount of predictability.

From the test results, we note that the R-squared value is 0.518, which indicates that 51.8% of the variance in project performance can be explained by implementing maturity models with an adjusted R-squared value of 0.515.

When we see the regression coefficients values, we note the slope value (B) = 0.544 and constant = 8.422, so regression equation that describes the relationship between both independent variable and the predictable variable is Y = (B1* X) + B0, where Y is the predictable variable (project performance), X is the independent variable (implementing maturity models), B1 is the slope coefficient, and B0 is a constant. This formula is used to predict project performance according to the maturity models implementation values. Therefore, the results indicate that the more maturity models are implemented, the greater is the positive impact on project performance. In accordance with these findings and the results from the correlation tests, **Hypothesis H1 (implementing maturity models positively affects the project performance) can be accepted**.

Table 17 – Linear Regression Test 1

<table>
<tr><th colspan="3">Dependent</th><th>Project Performance</th></tr>
<tr><th colspan="3">Independent</th><th>Implementing Maturity Models</th></tr>
<tr><td rowspan="4">Model Summary</td><td colspan="2">R</td><td>0.719</td></tr>
<tr><td colspan="2">R-Square</td><td>0.518</td></tr>
<tr><td colspan="2">Adjusted R-Square</td><td>0.515</td></tr>
<tr><td colspan="2">Std. Error</td><td>4.842</td></tr>
<tr><td rowspan="2">ANOVA</td><td colspan="2">F</td><td>184.496</td></tr>
<tr><td colspan="2">Sig. (p-value)</td><td>0.000</td></tr>
<tr><td rowspan="4">Coefficients</td><td rowspan="3">Unstandardised Coefficients</td><td>B</td><td>0.544</td></tr>
<tr><td>Constant</td><td>8.422</td></tr>
<tr><td>Std. Error</td><td>0.040</td></tr>
<tr><td>Standardised Coefficients</td><td>Beta</td><td>0.719</td></tr>
</table>

Regression Test Results (Product Quality and Customer Satisfaction)

Depending on the results of the linear regression test between the product quality factor and the customer satisfaction factor shown in Table 18, we note from the resulting variance ratio by reading the values of R, R-squared, and adjusted R-squared that the regression model has a good fit. Furthermore, the resulting values of F and Sig. indicate statistical significance of the model. As for the variance ratio, from the test results, we can note that the R-squared value is 0.130, which indicates that 13% of the variance in customer satisfaction can be explained by applying product quality practices with an adjusted R-squared value of 0.125.

Regarding the statistical significance, we can conclude from the test result that the model is significant because Sig. (p-value) is lower than alpha value of 0.05 (< .05). In addition, the application of product quality practices significantly affected the customer satisfaction with F = 25.778, Sig. (p-value) = 0.000. When we see the regression coefficients values, we note the slope value (B) = 0.325 and constant = 6.657, so regression equation that can describe the relationship between both independent variable and the predictable variable is Y= (B1* X) + B0, where Y is the predictable variable (customer satisfaction), X is the independent variable (product quality), B1 is the slope coefficient, and B0 is a constant. This formula is used to forecast customer satisfaction according to the application of product quality practice values. Therefore, the results indicate that the more product quality practices are applied, the greater is the positive impact on customer satisfaction. Depending on these findings and results of correlation tests, **Hypothesis H2 (product quality positively affects customer satisfaction) can be accepted.**

Table 18 – Linear Regression Test 2

Dependent			Customer Satisfaction
Independent			Product Quality
Model Summary	R		0.361
	R-Square		0.130
	Adjusted R-Square		0.125
	Std. Error		2.168
ANOVA	F		25.778
	Sig. (p-value)		0.000
Coefficients	Unstandardised Coefficients	B	0.325
		Constant	6.657
		Std. Error	0.064
	Standardised Coefficients	Beta	0.361

Regression Test Results (Project Management Practices and Project Performance)

Depending on the results of the linear regression test between the project management practices factor and the project performance variable shown in Table 19, we note from the resulting variance ratio by reading the values of R, R-squared, and adjusted R-squared that the regression model has good fit. Furthermore, the resulting values of F and Sig. indicate statistical significance of the model.

As for the variance ratio, the R value indicates a great amount of predictability. From the test results, we note that the R-squared value is 0.370, which indicates that 37% of the variance in project performance can be explained by applying project management practices with an adjusted R-squared value of 0.366.

Regarding the statistical significance, we can conclude from the test result that the model is significant because Sig. (p-value) is less than alpha 0.05 (< .05). In addition, the application of project management practices significantly affected the performance of projects with F = 100.865, Sig. (p-value) = 0.000. When we see the regression coefficients values, we note the slope value (B) = 1.355 and constant = 15.314, so regression equation that describes the relationship between both independent variable and the predictable variable is Y= (B1* X) + B0, where Y is the predictable variable (project performance), X is the independent variable (project management practices), B1 is the slope coefficient, and B0 is a constant. This formula is used to forecast project performance as per the application of project management practice values. Therefore, the results indicate that the more project management practices are applied, the greater is the positive impact on project performance.

Depending on these findings and results of correlation tests, **Hypothesis H3 (The application of project management practices positively affects project performance) can be accepted**.

Table 19 – Linear Regression Test 3

<table>
<tr><td colspan="3">Dependent</td><td>Project Performance</td></tr>
<tr><td colspan="3">Independent</td><td>Project Management Practices</td></tr>
<tr><td rowspan="4">Model Summary</td><td colspan="2">R</td><td>0.608</td></tr>
<tr><td colspan="2">R-Square</td><td>0.370</td></tr>
<tr><td colspan="2">Adjusted R-Square</td><td>0.366</td></tr>
<tr><td colspan="2">Std. Error</td><td>5.535</td></tr>
<tr><td rowspan="2">ANOVA</td><td colspan="2">F</td><td>100.865</td></tr>
<tr><td colspan="2">Sig. (p-value)</td><td>0.000</td></tr>
<tr><td rowspan="4">Coefficients</td><td rowspan="3">Unstandardised Coefficients</td><td>B</td><td>1.355</td></tr>
<tr><td>Constant</td><td>15.314</td></tr>
<tr><td>Std. Error</td><td>0.135</td></tr>
<tr><td>Standardised Coefficients</td><td>Beta</td><td>0.608</td></tr>
</table>

Regression Test Results (Software Engineering Standards and Software Product Effectiveness)

Depending on the results of the linear regression test between the software engineering standards factor and the software product effectiveness factor shown in Table 20, we note from the resulting variance ratio by reading the values of R, R-squared, and adjusted R-squared that the regression model has good fit. Furthermore, the resulting values of F and Sig. indicate statistical significance of the model.

As for the variance ratio, from the test results we note that the R-squared value is 0.209, which indicates that 20.9 % of the variance in the software product effectiveness can be explained by applying the software engineering standards with an adjusted R-squared value of 0.204.

Regarding the statistical significance, we can conclude from the test result that the model is significant because Sig. (p-value) is less than alpha 0.05 ($< .05$). In addition, the application of software engineering standards significantly affected the software product effectiveness with $F = 45.337$, Sig. (p-value) = 0.000. When we see the regression coefficients values, we note the slope value (B) = 0.396 and constant=3.906, so the regression equation that describes the relationship between both independent variable and the predictable variable is $Y= (B1* X) + B0$, where Y is the predictable variable (software product effectiveness), X is the independent variable (software engineering standards), B1 is the slope coefficient, and B0 is a constant. This formula can be used to forecast software product effectiveness in accordance with the application of software engineering standards values. Therefore, the results indicate that the more software engineering standards are applied, the greater is the positive impact on software product effectiveness.

Depending on these findings and results of correlation test, **Hypothesis H4 (the application of software engineering standards positively affects the effectiveness of the software product) can be accepted**.

Table 20 – Linear Regression Test 4

<table>
<tr><th colspan="3">Dependent</th><th>Software Product Effectiveness</th></tr>
<tr><th colspan="3">Independent</th><th>Software Engineering Standards</th></tr>
<tr><td rowspan="4">Model Summary</td><td colspan="2">R</td><td>0.457</td></tr>
<tr><td colspan="2">R-Square</td><td>0.209</td></tr>
<tr><td colspan="2">Adjusted R-Square</td><td>0.204</td></tr>
<tr><td colspan="2">Std. Error</td><td>1.943</td></tr>
<tr><td rowspan="2">ANOVA</td><td colspan="2">F</td><td>45.337</td></tr>
<tr><td colspan="2">Sig. (p-value)</td><td>0.000</td></tr>
<tr><td rowspan="4">Coefficients</td><td rowspan="3">Unstandardised Coefficients</td><td>B</td><td>0.396</td></tr>
<tr><td>Constant</td><td>3.906</td></tr>
<tr><td>Std. Error</td><td>0.059</td></tr>
<tr><td>Standardised Coefficients</td><td>Beta</td><td>0.457</td></tr>
</table>

Regression Test Results (Process Improvement and Project Control)

Depending on the results of the linear regression test between the process improvement factor and the project control factor shown in Table 21, we note from the resulting variance ratio by reading the values of R, R-squared, and adjusted R-squared that the regression model has good fit. Furthermore, the resulting values of F and Sig. indicate statistical significance in the model. As for the variance ratio, from the test results, we note that the R-square value is 0.294, which indicates that 29.4 % of the variance in the project control can be explained by applying the process improvement practices with adjusted R-squared 0.290.

Regarding the statistical significance, we can conclude from the test result that the model is significant because Sig. (p-value) is less than alpha 0.05 (< .05). In addition, the application of process improvement practices significantly affected the project control with F = 71.627 and Sig. (p-value) = 0.000.

When we see the regression coefficients values, we note the slope value (B) = 0.392 and constant = 2.555, so regression equation that describes the relationship between both independent variable and the predictable variable is Y= (B1* X) + B0, where Y is the predictable variable (project control), X is the independent variable (process improvement practices), B1 is the slope coefficient, and B0 is a constant. This formula can be used to forecast project control in accordance with the application of process improvement practices values.

Therefore, the results indicate that the more process improvement is applied, the greater the positive impact on project control.

Depending on these findings and results of correlation test, **Hypothesis H5 (Higher levels of process improvement will lead to higher levels of project control) can be accepted.**

Table 21 – Linear Regression Test 5

<table>
<tr><th colspan="3">Dependent</th><th>Project Control</th></tr>
<tr><th colspan="3">Independent</th><th>Process Improvement</th></tr>
<tr><td rowspan="4">Model Summary</td><td colspan="2">R</td><td>0.542</td></tr>
<tr><td colspan="2">R-Square</td><td>0.294</td></tr>
<tr><td colspan="2">Adjusted R-Square</td><td>0.290</td></tr>
<tr><td colspan="2">Std. Error</td><td>1.760</td></tr>
<tr><td rowspan="2">ANOVA</td><td colspan="2">F</td><td>71.627</td></tr>
<tr><td colspan="2">Sig. (p-value)</td><td>0.000</td></tr>
<tr><td rowspan="4">Coefficients</td><td rowspan="3">Unstandardised Coefficients</td><td>B</td><td>0.392</td></tr>
<tr><td>Constant</td><td>2.555</td></tr>
<tr><td>Std. Error</td><td>0.046</td></tr>
<tr><td>Standardised Coefficients</td><td>Beta</td><td>0.542</td></tr>
</table>

4.5.2. Multiple Regression Test

Next, a multiple regression test was performed to determine the most influential predictor of the four factors of the global variable implementation of maturity models (project management practices, software engineering standards, product quality, and process improvement). This analysis was conducted to ascertain the importance of the independent factors and determine the role of each factor in explaining the variance in project performance (Weisberg, 2013, Hair, 2009).

This study used the stepwise method, one of the most popular methods for multiple regression, to determine the more significant predictors of independent factors (Kline et al., 2013). This method takes a distinctive approach by identifying the predictor of greatest significance and then choosing the next largest predictor, and it does the same in sequence until the analysis stops, when there are no significant predictors. This method was mainly used to identify the most important predictors in this study, because it is able to analyse all predictors and measure their relative contribution to the variance of the dependent variable (Kline et al., 2013).

Multiple regression was performed by introducing all factors of implementing maturity models global variable (project management practices, software engineering standards, product quality, and process improvement). The equation model was $Y = C0 + C1F1 + C2F2 + C3F3 + C4F4 + E$, where Y represents the project performance, F1 to F4 are the independent factors of implementing the maturity model variable, C0 is constant, C1 to C4 are the slope coefficients, and E represents the errors.

The validity of the multiple regression model was assessed by confirming various multiple regression assumptions. Linear regression assumption was verified using a scatter plot and partial regression plots (see Appendix 8). The scatter plot graph indicates that the relationship between project performance and independent factors is linear. The partial regression plot graphs between project performance variable and each independent factor also prove that the relationship is linear.

In addition, the independence of residuals test was performed using Durbin–Watson statistics evaluation as described in Appendix 8. The results indicate that there was no independence of residuals with a score of 1.854. Next, a histogram was used to assess the normality of the residuals and showed that the residues are normally distributed, as illustrated in Appendix 8.

The last assumption that was checked is the multicollinearity assumption to make sure that there are no multicollinearity problems between independent factors. The results of VIF (variable inflation factors) for the independent factors were 1.787, 1.925, 1.995, and 1.951. The acceptable limit, according to statisticians, is between 1 and 5; it is not considered a source of concern and does not require any corrective action. In our case, the VIF values are within the acceptable limits and so are the tolerance values for all factors greater than 0.1. These results indicate that are there are no multicollinearity problems between the independent factors.

Depending on the results of the stepwise multiple regression test between each of the four predictors (project management practices, software engineering standards, product quality, and process improvement) against the project performance shown in Table 22 and Appendix 9 , we conclude that three out of the four factors are statistically significant where the values of process improvement alone as $F = 109.189$ and Sig. (p-value) was less than alpha 0.05 ($< .05$); process improvement with project management practices together were $F = 78.556$ and Sig. (p-value) was less than alpha 0.05 ($< .05$). Furthermore, when the significant factors were grouped together, the result was $F = 61.894$ and Sig. (p-value) was less than alpha 0.05 ($<.05$).

Also, it was seen that the R-squared value was 0.385 for process improvement and 0.479 when the two factors were grouped together (process improvement and project management practices). When the three factors were grouped together (process improvement, project management practices, and soft engineering standards) the result was 0.514. These results indicate that 51.4 % of the variance in project performance can be explained by process improvement, project management practices, and software engineering standards grouped together. In addition, the B-values shown in Table 22 indicate that to increase the value of project performance, more emphasis needs to be laid to process improvement, application of project management practices, and software engineering standards as well.

Table 22 – Multiple Regression (Stepwise Method)

Predictors	R	R-Square	Adjusted R-Square	F	Sig. (p-value)	B
Process improvement	0.623	0.388	0.385	109.189	0.000	1.500
Process improvement Project management practices	0.692	0.479	0.473	78.556	0.000	0.980 0.826
Process improvement Project management practices Software engineering standards	0.723	0.522	0.514	61.894	0.000	0.693 0.660 0.750

Dependent variable: Project performance.
Removed factor: Product quality.

4.6. Chapter Summary

The data collected from the research survey have been analysed using SPSS as the main statistical analysis tool. The majority of the survey participants hold high academic degrees, including a bachelor's, a master's, or a doctoral degree, and have extensive experience in the IT sector and belong to middle or higher job levels. Analysis tests on independent and dependent variables confirmed the research hypotheses and indicated that the implementation of maturity models significantly affects the performance of an IT project. The results also proved that the relationship between the implementation of maturity models and the performance of IT projects is positively correlated. In addition, regression analyses were conducted, which, in turn, confirmed the strength of the association between the variables by determining the extent to which the implementation of maturity models affected the performance of IT projects. Also, the multiple regression analysis revealed the order of importance for the independent factors. Further explanations and discussions of the research results will be provided in the next chapter.

Chapter 5: Discussion and Research Limitation

This chapter presents a discussion of the findings of this study and compares them with the results of previous studies to identify the similarities and differences. In addition, it verifies that the objectives of the study have been achieved by discussing the main research objectives. Lastly, this chapter discusses the results of the research hypothesis testing and presents a summary of the limitations of this study.

5.1. Discussion

Through an extensive analysis of the data, we found that the performance of software projects within the IT sector is affected by the implementation of maturity models. It was noted that software process improvement plays an effective and important role in project performance and this is consistent with what (Subramanian et al., 2007) mentioned in his study that the different types of maturity models such as CMMI, TQM, and Six Sigma are considered part of software process improvement, which have a significant role in increasing the performance of software projects.

Furthermore, the results of the research are in line with (Humphrey et al., 1991), who explained in his study that the performance of software projects improves when applying a set of practices concerned with improving the performance of processes, including monitoring and improving the quality of software products, the presence of qualified and skilled personnel, the development of continuous improvement plans, and adoption of standardised policies in managing software projects.

The second factor that affected the performance of projects, which emerged from the research results, is the application of project management practices, which means that there are standard project management processes within the PMOs, such as clear policies and processes in estimating project time, cost, and risk assessment.

This is similar to what (Clark and Wheelwright, 1993) and (Shenhar, 2001) mentioned, which is that project management practices affect the success of projects and act as an effective factor in guiding the project throughout its life cycle to achieve the predetermined goals. (vom Brocke and Lippe, 2015) reported that project management planning, which has a clear and organised goal, is one of reasons for the high performance and success of projects. This is the main reason for ensuring project success and increasing its performance, and that is what maturity models provide to organisations, by developing their own project management policies and tools using the most optimal practices (Morandi, 2013).

Furthermore, there is an existing controversy, as some researchers, for example, those from PMI (Institute, 2013), have argued that the application of standardised project management practices to all projects is not correct, but rather the practices should be adapted according to the nature and characteristics of the projects. (Barbosa et al., 2021) stated in his study that to ensure higher project performance, organisations must adopt a flexible approach in their project management that depends on the project context.

The results of this study also underscore the role of applying software engineering standards in increasing the performance of IT projects. Therefore, it turns out that the use of a unified approach that includes software engineering policies and rules, data analysis, documentation and building software packages positively affects the effectiveness and quality of the final product. (Tuohey, 2002) also highlighted in his research the benefits of applying software engineering standards and stated that the application of these standards in the software industry and their adoption by organisations can lead to the success of their projects. The Standish Group (Group, 2000), known for its research studies in the field of software development, stated in one of its studies that the application of software engineering standards is a crucial factor in IT project success and increasing its performance. We also find that the results of the study (Reel, 1999) were consistent with (Group, 2000). In addition, (Liu et al., 2008) presented the importance of applying standard processes in software engineering, and whether they should be applied and adhered to or not. He concluded that the application of these standard processes is important and must be adhered to by system software engineers but must be a flexible factor to ensure the quality of the programme product.

As per the findings of this study, the last factor – product quality – does not exhibit any significant relationship to the performance of an IT project. However, this factor still contributes to improving the performance of IT projects in general. It can be seen from these results that various factors that resulted from the application of maturity models affect the performance of IT projects.

The results of the regression and correlation tests that were conducted to verify the study hypotheses confirmed that the implementation of maturity models positively affects the performance of IT projects, and this is consistent with several previous studies, including (Butler, 1995, Dion, 1993, Humphrey et al., 1991). These studies show that organisations that implement maturity models have higher quality products and continuous improvement policies. As remarked earlier, (Herbsleb and Goldenson, 1996) found that IT organisation process maturity is associated with improved project performance. This is in line with the prevailing view that maturity models provide a continuous improvement plan for different sectors, especially for IT organisations, so that they lead continuous improvement by determining the current status of organisations and drawing a future plan for the future to serve the organisation's strategies and objectives (Cooke-Davies and Arzymanow, 2003) .

On the contrary, a number of scholars have criticised the concept of maturity models and their impact on project performance. (King and Kraemer, 1984) asserted that maturity models provide a plan and practices to rise to higher levels but do not have the factors that actually influence development and change. In addition, projects differ in their nature and types, which raises doubts about the possibility of a viable improvement plan or path in all types of organisations (Cooke-Davies, 2004, Thomas and Mullaly, 2014).

In addition to the previous observations, the findings of this study reveal a good correlation between software product quality and IT organisations customer satisfaction and are in line with results of previous studies (Tellis et al., 2009, Bolton, 1998) asserting the existence of quality control policies in organisations positively affecting the performance of products, thereby leading to customer satisfaction.

Our results are also similar to the findings of (Saleh, 2008) indicating that product quality control plays a vital role in enhancing customer satisfaction. This is in agreement with the ideas of (Xu et al., 2013) and confirms our previous findings that end users can agree on product quality, implying that quality efforts focus not only on meeting specifications and reducing defects but ensure the reliability of products when they reach consumers. The success of organisations and customer satisfaction stem from the quality of their products. Increasing product quality increases customer satisfaction and leads to profitability of the organisation (Kotler and Keller, 2016).

Another notable finding of this study is the positive relationship between the application of software engineering standards and the effectiveness of the software product. This is in good agreement with (Kowalski et al., 1998), who measured the effectiveness of the software programme through a set of goals, such as the ability of programs to move from one server to another without problems, and pointed out that to achieve this goal, it is necessary to follow software standards during programming.

(Binuyoa et al., 2014) evidenced the characteristics of effectiveness of a software product, including software reliability, security, maintainability, and others, which can be achieved by complying with procedural standards in software design and development. This is in good agreement with (Gill, 2005), who stated that to enhance the effectiveness of the software product and improve the quality of the programme, procedural standards, methodologies, and tools must be applied. He also noted the important role of one of the most famous maturity models, ISO 9001, which provides a model that includes a quality assurance standard applicable to software engineering.

Contrary to previous results, some scholars including (Conradi and Fuggetta, 2002) have argued that software developers should not adhere to a particular software standard as it could negatively affect their creativity and the performance of the software product. The software engineering standard has an educational role and is not mandatory.

The final finding of this study is the relationship between the application of process improvement plans in IT organisations and the control of project cost and time. These values correlate well with (Motwani et al., 2002) and corroborate the idea of the importance of implementing policies and continuous improvement plans for IT sector organisations and their positive role in the success of projects and achieving their goals. (Motwani et al., 2002) reported that the recommended actions needed to control IT projects are through the improvement of project management processes through the use of appropriate tools and techniques.

In addition, (Whittaker and Security, 1999) summarised the principal reasons behind the lack of control over software projects, which can lead to their failure, and stated that the inefficiency of workers in organisations can cause disturbances in the outputs of projects, and a viable solution is to adopt improvement plans to enhance the efficiency of project workers. This is similar to what (Datta and Mukherjee, 2001) mentioned in his study that the success of projects within budget and time is related to the early identification and control of project risks, which is achieved by improving project management processes.

5.2. Limitations of this Study

This study has some limitations, for example, the measurable study factors are limited to project management process factors and the role of implementing various maturity models without taking into account the cultural factors of the study sample and its difference. Thus, the research hypotheses that were tested were not able to measure the cultural difference factor of the participants.

Another limitation of this study is its implementation on a specific geographical area, which is the organisations of the Middle East region, and therefore, the results of the study cannot be generalised to the global population because project management in the IT sector may differ from one geographical area to another owing to different cultures and work environments.

Another limitation is that this study examines the effect of implementing maturity models on IT industry projects only, which prevents the generalisation of the findings to projects of other sectors.

In addition, this study contained time and resource constraints. Because of the latter, it was not possible to obtain the target number of responses, so the total number of responses is 192, which is not enough to generalise the results of the study on all research population.

5.3. Chapter Summary

This chapter provides a discussion of the study findings. The results of this study showed a set of unexpected observations. This chapter explains the relationship between the implementation of maturity models and their impact on the performance of IT projects. This chapter also discussed the results of the research hypotheses test. Furthermore, the results of this study were compared with previous studies and discussed in terms of similarities and differences.

Chapter 6: Conclusion and Recommendations

This chapter presents a summary of the entire research study, including the research objectives, the main aim, and indicates to what extent it has been achieved. It identifies areas that require further study and describes the role of this study in bridging the existing research gaps and finally provides a set of recommendations for different audiences.

6.1. Conclusions

The main objective of this study was to explore the effectiveness and impact of implementing project management maturity models on the performance of IT projects. As the main research objective is rather broad because of the existence of a number of factors to measure the impact of implementing maturity models, the scope of this study was limited to four factors: project management practices, software engineering standards, product quality, and process improvement. To achieve the main research objective, the impact of each of these four factors on the performance of IT projects was investigated in accordance with the pertinent literature and primary research and divided into six research objectives.

In conclusion, we find that all the research objectives were met.

As can be seen from the prior chapters, the relationship between the implementation of maturity models and the performance of IT projects is significant, which means that the implementation of maturity models plays a central role in influencing the performance of IT projects, which is consistent with (Subramanian et al., 2007, Butler, 1995, Dion, 1993, Humphrey et al., 1991). The findings of this study reveal that the application of project management practices within organisations positively affects their project performance, and this is in agreement with (Clark and Wheelwright, 1993, Shenhar, 2001) findings.

Furthermore, the results of this study lead us to the role of applying software engineering standards in increasing the performance of information technology projects, and this result has been found to be typical of (Tuohey, 2002) findings. Also, it was observed that implementing software process improvements plans within IT organisations leads to increasing their project performance, and this is consistent with (Subramanian et al., 2007, Humphrey et al., 1991) studies that mentioned that the different types of maturity models are considered part of software process improvement and have a significant role in increasing the performance of software projects.

Last, it was noted that the application of practices to improve product quality does not indicate any significant association to IT project performance.

6.2. Research Gap Fulfilment

Owing to the lack of adequate studies on the effect of implementing maturity models on the performance of IT projects, this study has bridged the associated gap to some extent. Prior to this study, no study had addressed the impact of maturity models on IT projects and IT organisations in particular. Studies in the pertinent literature discuss the impact of maturity models on organisations in general.

6.3. Areas that Require Further Research

Through this study, the areas that require further investigation were identified. These are the areas in which inconsistencies emerged between the results of both previous and primary research. In particular, future studies should account for the culture and management methods of organisations and their role in influencing the performance of projects. It is necessary to conduct multiple studies to confirm the results of this study.

6.4. Future Research Recommendations

In line with the aforementioned research limitations, these are recommendations for future research:

- ✓ Future studies in the context of the topic in question must take into account the factors of the different organisations, their cultures and management methods such that the performance of projects is affected by the different management styles, environments, and cultures of organisations. It may then be possible to dispel the contradictions that appeared between the results of this study and the extant literature.

- ✓ It is advisable for future research to include a larger number of participants as a research sample to be adequately representative of the research population.

- ✓ Future research may have more time for a further in-depth study interspersed with case studies and interviews with IT professionals. It should take into account the change and development of project management and IT methods over time, thereby studying the impact of the latest practices on the performance of an IT project.

- ✓ Future research needs to examine a wider geographical area to include IT organisations outside the Arab world to account for the cultures of countries and different management methods and their impact on the performance of IT projects.

6.5. Recommendations for Practitioners

This section aims to provide a set of recommendations to the senior management of organisations and managers of PMO offices, in addition to project managers and implementers of various maturity models.

The top management professionals of organisations need to provide the requisite support for the implementation of effective and targeted maturity models, because it is necessary to allocate trained personnel and financial resources to implement the maturity models. The full support of senior management can help in making important improvements in the policies of the organisation.

Furthermore, senior management professionals must spread awareness regarding the importance of change in the work environment and among employees and clarify that these changes aim to achieve the visions of organisations.

Project office managers need to evaluate their processes, check all maturity models, and choose what is suitable for the organisation. If the goal is to develop software industry processes and manage its projects, then it is better to choose CMMI, and if the goal is to develop methods for managing portfolios, programs, projects, then it is better to choose OPM3. In addition, project office managers need to spread awareness among staff and project team members regarding the outcomes of each output of the implementation of maturity models to gain their active support and participation.

Organisations need to involve employees in the evaluation process and consider them an essential part of the organisation's policy development, provided they are impartial when providing evidence of compliance with the requirements of maturity models.

6.6. Chapter Summary

This chapter provided a summary of this study including the research aim and objectives and indicating the extent to which they were achieved. This chapter presented areas for further research, provided an explanation of how the current study bridged research gaps, and provided a set of recommendations for future research.

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Appendices

Appendix 1 – Research Survey Questionnaire

Questionnaire

Dear Sir/Madam

My name is Bara' Al Kailani. I am a master student at British University in Dubai, IT Project Management Program. I am kindly requesting your participation in a master research study that I am conducting titled: The Impact of Implementing Maturity Models on IT Project Performance. The intention is to assess for the impact of implementing project management maturity models in the IT sector.

The study involves completing basic demographic information and two parts: maturity models and project performance.

Participation is completely voluntary and you may withdraw from the study at any time. The study is completely anonymous, therefore, it does not require you to provide your name or any other identifying information.

I would need only a few minutes of your time to fill out a questionnaire which forms a comprehensive part of my research. Your responses hold a great significance in my quest of data collection.

If you have questions now or at a later time, you may contact the researcher, Bara' Al Kailani, via 20204122@student.buid.ac.ae. You can ask any questions you have before you begin the survey.

Thank you for your time and participation

Sincerely,

Bara' Al Kailani
Master Student
British University in Dubai

FIRST PART: GENERAL INFORMATION ***Please put circle for each question:***
A. Sex 1) Male 2) Female
B. Marital Status 1) Married 2) Unmarried
C. Education 1) Less than high school 2) High school 3) College degree 4) Graduate degree 5) High diploma 6) Masters or above
D. Age 1) Less than 25 2) 25 - 35 3) 36 – 46 4) 47 – 57 5) 58 or above
6) Number of years worked in current organization 1) One year or less 2) 2 – 7 3) 8 – 13 4) 14 – 19 5) 20 years or above
7) Number of years worked in the position or job 1) One year or less 2) 2 – 7 3) 8 – 13 4) 14 – 19 5) 20 years or above
8) Job Status 1) First level 2) Middle level 3) Lower level

SECOND PART: Maturity Models ***Please tick one box for each item:***					
Statement	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
We have a standard procedure for estimating project cost					
Our organization uses a standard format for documents used in various stages of software testing					
We use a standard procedure for code reviewing and testing					
We have a broad understanding of process improvement goals					
We have a mechanism in place to control changes on software codes					
We have a standard procedure for estimating project schedule					
Our Organization has mechanism for ensuring efficiency of software testing					
we use a standard procedure for analyzing errors conducted to determine their process related causes					
There is a mechanism used to ensure that project deliverables examined by Software Quality Assurance meets the required work					
Top management use a standard procedure for reviewing each software development project prior to making contractual commitments					
Software developers are involved to a great extent in decisions about the implementation of their own work					
Top management has a mechanism for periodic review of projects status					

Top management is supporting process improvement activities					
We use a standard procedure to define and evaluate project risks					
We use a mechanism for ensuring compliance with the software engineering standards					
SECOND PART: Maturity Models (Cont.)					
Statement	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Our Organization has mechanism to evaluate the software engineering process and implement improvements					
We use a guide for developing system requirements specifications					
We use a standard procedure for designing software applications					
THIRD PART: PROJECT PERFORMANCE ***Please tick one box for each item:***					
Statement	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
We deal with no complaints on quality of our products and services					
we gain new knowledge about use of new development techniques					
There is commitment to audit and control standards					
Our software systems are secure and use advanced cybersecurity technologies					
There is control over our organization's projects schedule					
Bugs and failures are rare with our software products					

Our clients are satisfied with meeting our projects deadlines					
There is control over our organization's projects costs					
Our software products provide both the accuracy and integrity					
we gain new knowledge about supporting users' business					
Our products are easy to use and straightforward					
we gain new knowledge about use of new technologies					
Our software products and services meet our customers' business needs					

Appendix 2 – Descriptive Analysis

Statistics

		Gender	Marital Status	Education	Age	Number of years worked in current organization	Number of years worked in the position or job	Job Status
N	Valid	174	174	174	174	174	174	174
	Missing	0	0	0	0	0	0	0
Mean		1.30	1.39	4.30	2.73	2.16	2.51	1.71
Median		1.00	1.00	4.00	3.00	2.00	2.00	2.00
Mode		1	1	4	3	2	2	2
Std. Deviation		.459	.488	1.155	.681	1.079	1.239	.652
Range		1	1	4	3	4	4	2
Minimum		1	1	2	2	1	1	1
Maximum		2	2	6	5	5	5	3

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	122	70.1	70.1	70.1
	Female	52	29.9	29.9	100.0
	Total	174	100.0	100.0	

Marital Status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Married	107	61.5	61.5	61.5
	Unmarried	67	38.5	38.5	100.0
	Total	174	100.0	100.0	

Education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	High school	4	2.3	2.3	2.3
	College degree	38	21.8	21.8	24.1
	Graduate degree	80	46.0	46.0	70.1
	High diploma	5	2.9	2.9	73.0
	Masters or above	47	27.0	27.0	100.0
	Total	174	100.0	100.0	

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	25 - 35	69	39.7	39.7	39.7
	36 - 46	84	48.3	48.3	87.9
	47 - 57	20	11.5	11.5	99.4
	58 or above	1	.6	.6	100.0
	Total	174	100.0	100.0	

Number of years worked in current organization

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	one year or less	54	31.0	31.0	31.0
	2 - 7	66	37.9	37.9	69.0
	8 - 13	33	19.0	19.0	87.9
	14 - 19	14	8.0	8.0	96.0
	20 years or more	7	4.0	4.0	100.0
	Total	174	100.0	100.0	

Number of years worked in the position or job

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	one year or less	42	24.1	24.1	24.1
	2 - 7	55	31.6	31.6	55.7
	8 - 13	38	21.8	21.8	77.6
	14 - 19	24	13.8	13.8	91.4
	20 years or above	15	8.6	8.6	100.0
	Total	174	100.0	100.0	

Job-Status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	First level	69	39.7	39.7	39.7
	Middle level	86	49.4	49.4	89.1
	Lower level	19	10.9	10.9	100.0
	Total	174	100.0	100.0	

Appendix 3 – Reliability Test (Cronbach Alpha Results)

❖ Results for all items – independent & dependent variable

		N	%
Cases	Valid	174	100.0
	Excluded[a]	0	.0
	Total	174	100.0

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.900	.901	31

Item Statistics

	Mean	Std. Deviation	N
Item no.1 of the project management practices factor	2.16	.781	174
Item no.2 of the project management practices factor	2.44	1.011	174
Item no.3 of the project management practices factor	2.59	1.112	174
Item no.4 of the project management practices factor	2.52	1.013	174
Item no.5 of the project management practices factor	2.37	1.010	174
Item no.1 of the software engineering standards factor	2.47	.995	174
Item no.2 of the software engineering standards factor	2.21	.927	174
Item no.3 of the software engineering standards factor	2.30	.933	174
Item no.4 of the software engineering standards factor	2.05	.674	174
Item no.1 of the product quality factor	2.41	.968	174
Item no.2 of the product quality factor	2.53	.989	174
Item no.3 of the product quality factor	2.36	.919	174
Item no.4 of the product quality factor	2.25	.901	174
Item no.1 of the process improvement factor	2.45	.947	174
Item no.2 of the process improvement factor	2.48	.954	174
Item no.3 of the process improvement factor	2.29	.913	174
Item no.4 of the process improvement factor	2.36	.899	174
Item no.5 of the process improvement factor	2.24	.893	174
Item no.1 of the control factor	2.39	.954	174

Item no.2 of the control factor	2.41	.980	174
Item no.3 of the control factor	2.43	.933	174
Item no.1 of the customer satisfaction factor	2.52	.923	174

Item no.2 of the customer satisfaction factor	2.83	1.045	174
Item no.3 of the customer satisfaction factor	2.28	.916	174
Item no.4 of the customer satisfaction factor	2.11	.839	174
Item no.1 of the software product effectiveness factor	2.69	1.100	174
Item no.2 of the software product effectiveness factor	2.44	.940	174
Item no.3 of the software product effectiveness factor	2.35	.911	174
Item no.1 of the staff knowledge factor	2.34	.983	174
Item no.2 of the staff knowledge factor	2.36	.974	174
Item no.3 of the staff knowledge factor	2.38	.946	174

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Item no.1 of the project management practices factor	71.86	204.551	.469	.472	.897
Item no.2 of the project management practices factor	71.58	200.858	.480	.487	.896
Item no.3 of the project management practices factor	71.43	200.153	.453	.406	.897
Item no.4 of the project management practices factor	71.49	204.020	.366	.357	.898
Item no.5 of the project management practices factor	71.65	201.108	.472	.399	.896
Item no.1 of the software engineering standards factor	71.55	200.492	.503	.545	.896
Item no.2 of the software engineering standards factor	71.81	202.224	.477	.439	.896
Item no.3 of the software engineering standards factor	71.72	204.134	.399	.442	.898
Item no.4 of the software engineering standards factor	71.97	207.120	.416	.435	.898
Item no.1 of the product quality factor	71.60	199.940	.539	.515	.895
Item no.2 of the product quality factor	71.49	201.535	.468	.453	.896

Item no.3 of the product quality factor	71.66	203.984	.412	.438	.897
Item no.4 of the product quality factor	71.77	202.640	.476	.499	.896
Item no.1 of the process improvement factor	71.57	201.946	.476	.503	.896
Item no.2 of the process improvement factor	71.53	200.840	.514	.507	.896
Item no.3 of the process improvement factor	71.72	205.530	.355	.374	.898
Item no.4 of the process improvement factor	71.66	202.630	.477	.467	.896
Item no.5 of the process improvement factor	71.78	204.545	.404	.391	.898
Item no.1 of the control factor	71.63	202.039	.468	.464	.896
Item no.2 of the control factor	71.61	201.049	.491	.473	.896
Item no.3 of the control factor	71.59	202.601	.459	.460	.897
Item no.1 of the customer satisfaction factor	71.49	202.194	.480	.473	.896
Item no.2 of the customer satisfaction factor	71.19	206.444	.270	.254	.900
Item no.3 of the customer satisfaction factor	71.74	204.496	.394	.432	.898
Item no.4 of the customer satisfaction factor	71.90	204.331	.443	.510	.897
Item no.1 of the software product effectiveness factor	71.33	202.025	.397	.407	.898
Item no.2 of the software product effectiveness factor	71.57	201.356	.502	.434	.896
Item no.3 of the software product effectiveness factor	71.67	200.674	.548	.551	.895
Item no.1 of the staff knowledge factor	71.67	203.262	.407	.465	.898
Item no.2 of the staff knowledge factor	71.66	201.383	.482	.512	.896
Item no.3 of the staff knowledge factor	71.64	201.527	.492	.496	.896

❖ Results for Independent Variable – Implementing Maturity Models

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.850	.852	18

Item Statistics

	Mean	Std. Deviation	N
Item no.1 of the project management practices factor	2.16	.781	174
Item no.2 of the project management practices factor	2.44	1.011	174
Item no.3 of the project management practices factor	2.59	1.112	174
Item no.4 of the project management practices factor	2.52	1.013	174
Item no.5 of the project management practices factor	2.37	1.010	174
Item no.1 of the software engineering standards factor	2.47	.995	174
Item no.2 of the software engineering standards factor	2.21	.927	174
Item no.3 of the software engineering standards factor	2.30	.933	174
Item no.4 of the software engineering standards factor	2.05	.674	174
Item no.1 of the product quality factor	2.41	.968	174
Item no.2 of the product quality factor	2.53	.989	174
Item no.3 of the product quality factor	2.36	.919	174
Item no.4 of the product quality factor	2.25	.901	174
Item no.1 of the process improvement factor	2.45	.947	174
Item no.2 of the process improvement factor	2.48	.954	174
Item no.3 of the process improvement factor	2.29	.913	174
Item no.4 of the process improvement factor	2.36	.899	174
Item no.5 of the process improvement factor	2.24	.893	174

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Item no.1 of the project management practices factor	40.32	73.431	.496	.400	.841
Item no.2 of the project management practices factor	40.04	70.998	.508	.426	.840
Item no.3 of the project management practices factor	39.89	71.779	.407	.306	.845
Item no.4 of the project management practices factor	39.95	73.709	.342	.213	.848

Item no.5 of the project management practices factor	40.11	71.924	.451	.340	.843
Item no.1 of the software engineering standards factor	40.01	71.607	.480	.413	.841
Item no.2 of the software engineering standards factor	40.27	71.909	.503	.388	.840
Item no.3 of the software engineering standards factor	40.18	73.431	.399	.326	.845
Item no.4 of the software engineering standards factor	40.43	75.356	.416	.327	.845
Item no.1 of the product quality factor	40.06	71.019	.534	.429	.839
Item no.2 of the product quality factor	39.95	71.645	.481	.361	.841
Item no.3 of the product quality factor	40.11	72.345	.479	.367	.841
Item no.4 of the product quality factor	40.23	72.872	.455	.373	.842
Item no.1 of the process improvement factor	40.03	72.097	.478	.399	.841
Item no.2 of the process improvement factor	39.99	71.809	.492	.406	.841
Item no.3 of the process improvement factor	40.18	73.330	.417	.279	.844
Item no.4 of the process improvement factor	40.12	73.552	.410	.291	.844
Item no.5 of the process improvement factor	40.24	73.950	.386	.317	.845

❖ Results for Dependent Variable – Project Performance

		N	%
Cases	Valid	174	100.0
	Excluded[a]	0	.0
	Total	174	100.0

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.808	.811	13

Item Statistics

	Mean	Std. Deviation	N
Item no.1 of the control factor	2.39	.954	174
Item no.2 of the control factor	2.41	.980	174
Item no.3 of the control factor	2.43	.933	174
Item no.1 of the customer satisfaction factor	2.52	.923	174
Item no.2 of the customer satisfaction factor	2.83	1.045	174
Item no.3 of the customer satisfaction factor	2.28	.916	174
Item no.4 of the customer satisfaction factor	2.11	.839	174
Item no.1 of the software product effectiveness factor	2.69	1.100	174
Item no.2 of the software product effectiveness factor	2.44	.940	174
Item no.3 of the software product effectiveness factor	2.35	.911	174
Item no.1 of the staff knowledge factor	2.34	.983	174
Item no.2 of the staff knowledge factor	2.36	.974	174
Item no.3 of the staff knowledge factor	2.38	.946	174

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Item no.1 of the control factor	29.15	40.798	.436	.297	.795
Item no.2 of the control factor	29.13	40.127	.478	.323	.792
Item no.3 of the control factor	29.11	41.143	.419	.290	.797
Item no.1 of the customer satisfaction factor	29.02	39.994	.529	.383	.788
Item no.2 of the customer satisfaction factor	28.71	43.015	.213	.113	.815
Item no.3 of the customer satisfaction factor	29.26	40.782	.462	.302	.793
Item no.4 of the customer satisfaction factor	29.43	41.552	.441	.340	.795
Item no.1 of the software product effectiveness factor	28.85	40.174	.405	.350	.799
Item no.2 of the software product effectiveness factor	29.10	40.308	.489	.316	.791
Item no.3 of the software product effectiveness factor	29.19	40.282	.511	.432	.789
Item no.1 of the staff knowledge factor	29.20	40.609	.435	.324	.796
Item no.2 of the staff knowledge factor	29.18	39.962	.496	.409	.790
Item no.3 of the staff knowledge factor	29.16	40.483	.469	.320	.793

❖ Results for Independent Factor – Project Management Practices

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.618	.621	5

❖ Results for Independent Factor – Software Engineering Standards

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.601	.613	4

❖ Results for Independent Factor – Product Quality

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.616	.618	4

❖ Results for Independent Factor – Process Improvement

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.608	.608	5

Appendix 4 – Pearson Correlation Test

❖ **Pearson correlation between Implementing maturity models variable and project performance variable**

		Implementing Maturity Models Global Variable	Project Performance Global Variable
Implementing Maturity Models Global Variable	Pearson Correlation	1	.719**
	Sig. (2-tailed)		.000
	N	174	174
Project Performance Global Variable	Pearson Correlation	.719**	1
	Sig. (2-tailed)	.000	
	N	174	174

**. Correlation is significant at the 0.01 level (2-tailed).

❖ **Pearson correlation between project management practices factor and project performance variable**

		project management practices factor	Project Performance Global Variable
project management practices factor	Pearson Correlation	1	.608**
	Sig. (2-tailed)		.000
	N	174	174
Project Performance Global Variable	Pearson Correlation	.608**	1
	Sig. (2-tailed)	.000	
	N	174	174

**. Correlation is significant at the 0.01 level (2-tailed).

❖ **Pearson correlation between software engineering standards factor and software product effectiveness factor**

		software engineering standards factor	software product effectiveness factor
software engineering standards factor	Pearson Correlation	1	.457**
	Sig. (2-tailed)		.000
	N	174	174
software product effectiveness factor	Pearson Correlation	.457**	1
	Sig. (2-tailed)	.000	
	N	174	174

**. Correlation is significant at the 0.01 level (2-tailed).

❖ **Pearson correlation between product quality factor and customer satisfaction factor**

		product quality factor	customer satisfaction factor
product quality factor	Pearson Correlation	1	.361**
	Sig. (2-tailed)		.000
	N	174	174
customer satisfaction factor	Pearson Correlation	.361**	1
	Sig. (2-tailed)	.000	
	N	174	174

**. Correlation is significant at the 0.01 level (2-tailed).

❖ **Pearson correlation between process improvement factor and project control factor**

		process improvement factor	control factor
process improvement factor	Pearson Correlation	1	.542**
	Sig. (2-tailed)		.000
	N	174	174
control factor	Pearson Correlation	.542**	1
	Sig. (2-tailed)	.000	
	N	174	174

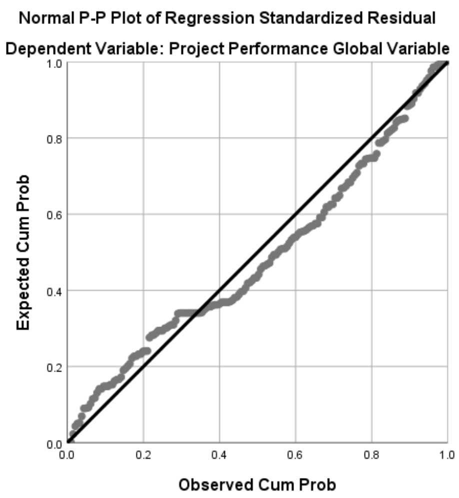
**. Correlation is significant at the 0.01 level (2-tailed).

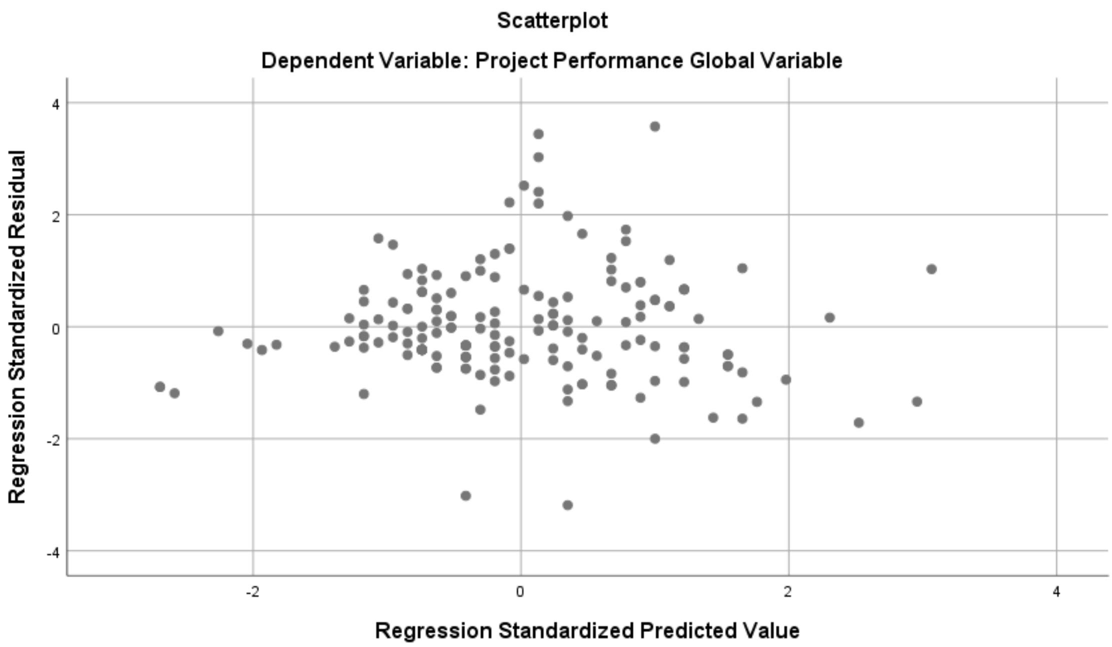
❖ Pearson correlation for factors & global variables

		project management practices factor	software engineering standards factor	product quality factor	process improvement factor	control factor	customer satisfaction factor	software product effectiveness factor	staff knowledge factor	Implementing Maturity Models Global Variable	Project Performance Global Variable
project management practices factor	Pearson Correlation										
	Sig. (2-tailed)										
software engineering standards factor	Pearson Correlation	.532**									
	Sig. (2-tailed)	.000									
product quality factor	Pearson Correlation	.581**	.618**								
	Sig. (2-tailed)	.000	.000								
process improvement factor	Pearson Correlation	.584**	.601**	.589**							
	Sig. (2-tailed)	.000	.000	.000							
control factor	Pearson Correlation	.460**	.515**	.437**	.542**						
	Sig. (2-tailed)	.000	.000	.000	.000						
customer satisfaction factor	Pearson Correlation	.496**	.501**	.361**	.497**	.544**					
	Sig. (2-tailed)	.000	.000	.000	.000	.000					
software product effectiveness factor	Pearson Correlation	.459**	.457**	.483**	.501**	.466**	.524**				
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000				
staff knowledge factor	Pearson Correlation	.508**	.430**	.460**	.434**	.429**	.544**	.490**			
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000			
Implementing Maturity Models Global Variable	Pearson Correlation	.830**	.815**	.830**	.841**	.589**	.562**	.573**	.555**		
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000		
Project Performance Global Variable	Pearson Correlation	.608**	.601**	.549**	.623**	.764**	.833**	.783**	.780**	.719**	
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	

Appendix 5 – Linear Regression (Linearity - Scatter Plot)

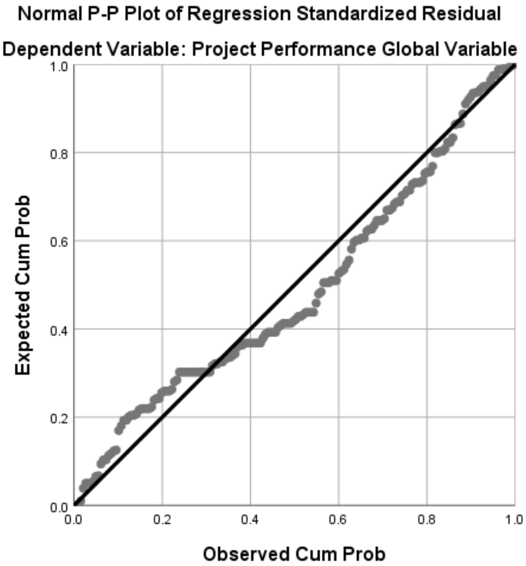
❖ Implementing maturity models variable & Project performance variable

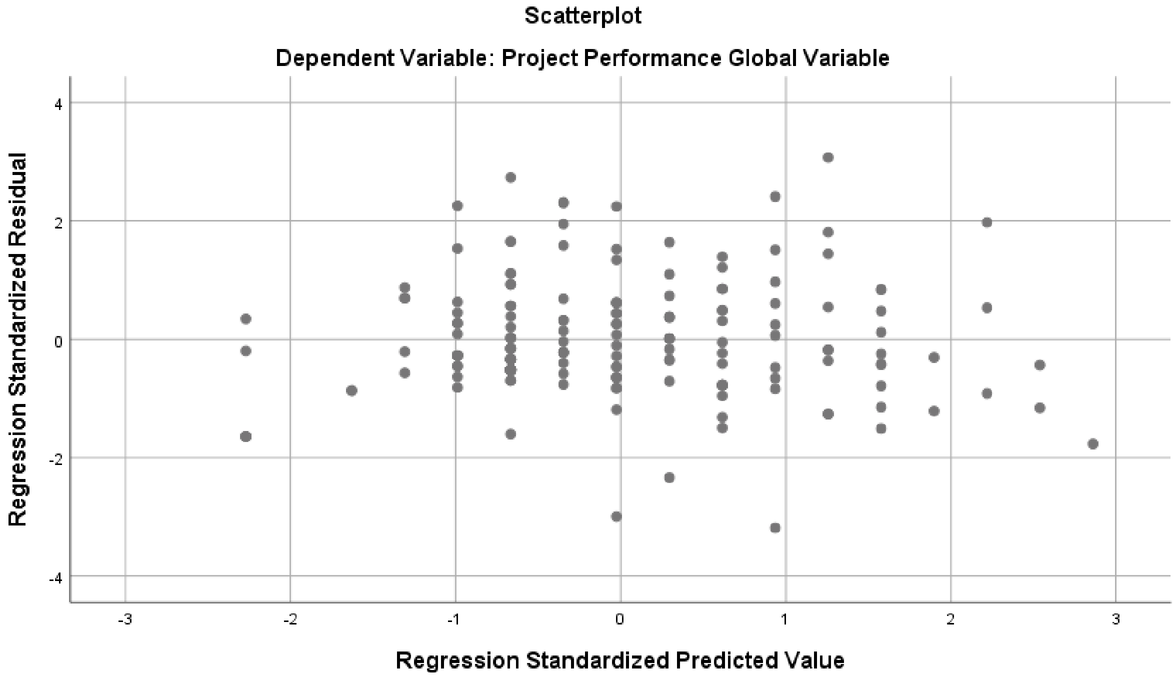




There was linearity as assessed by partial regression plots and a plot of standardized residuals against the predicted values.

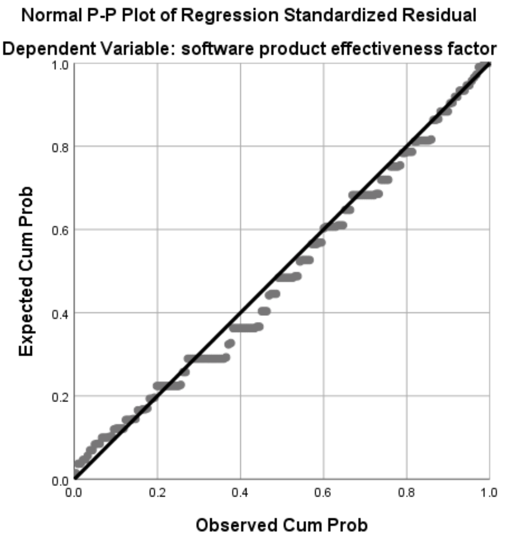
❖ Project management practices factor & Project performance variable

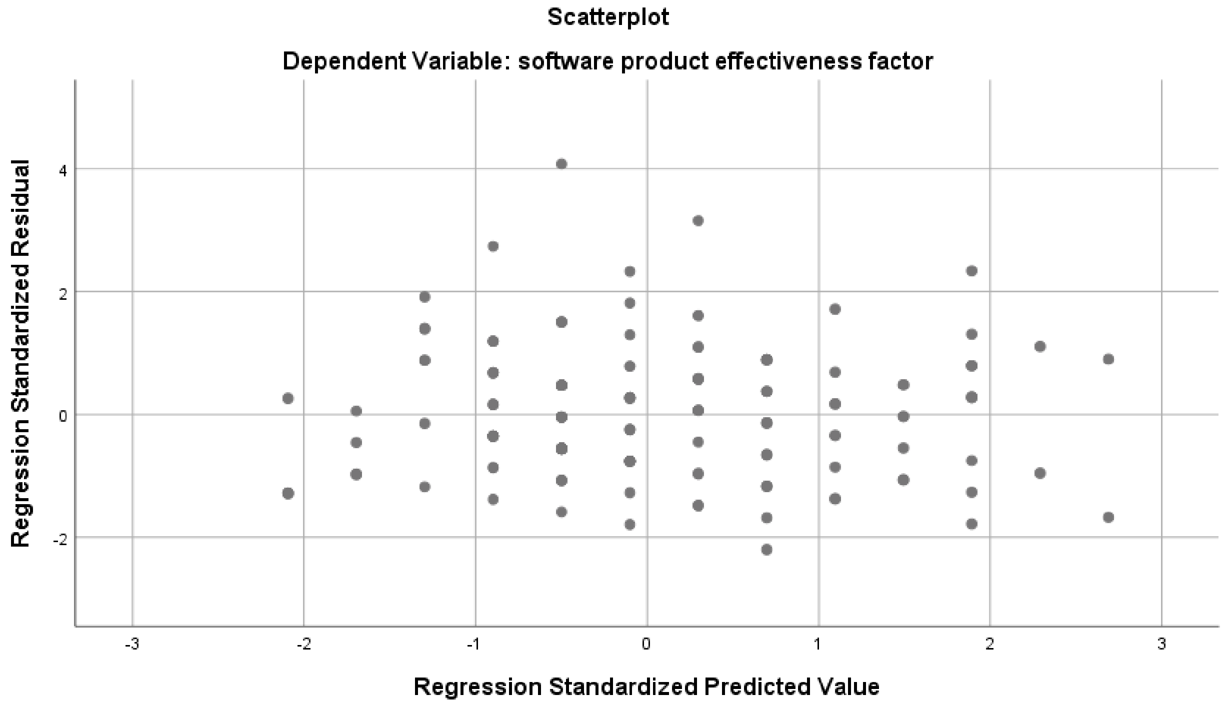




There was linearity as assessed by partial regression plots and a plot of standardized residuals against the predicted values.

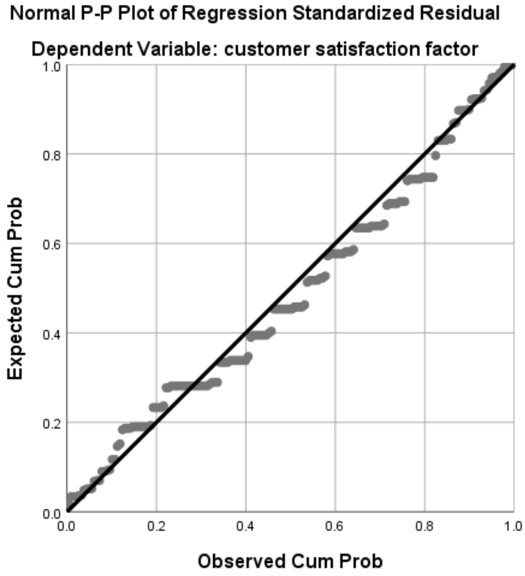
❖ **Software engineering standards factor & Software product effectiveness factor**

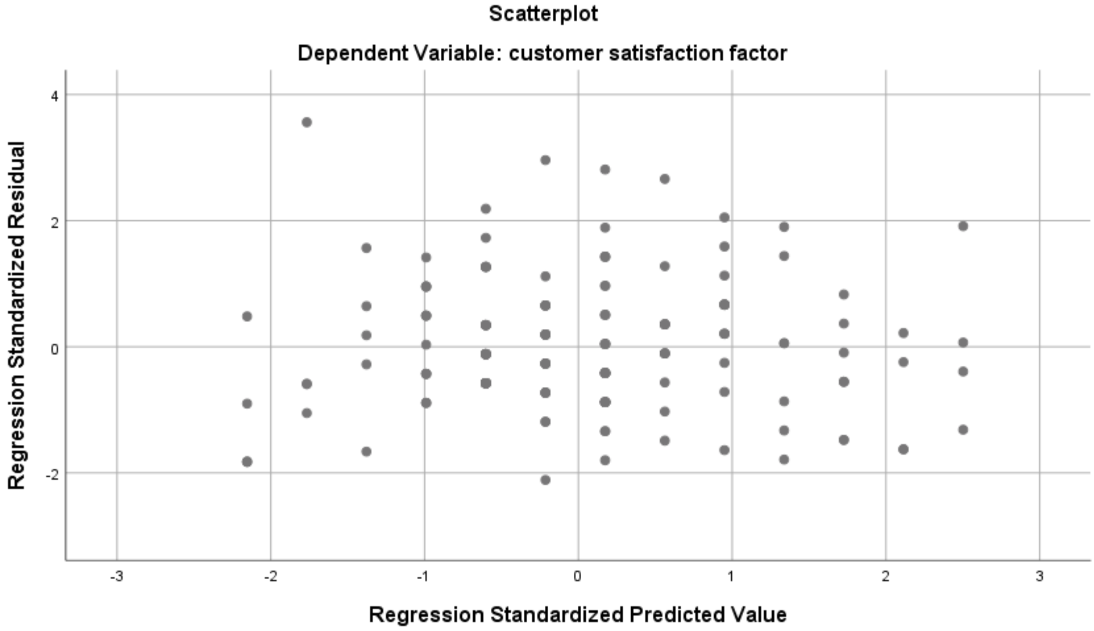




There was linearity as assessed by partial regression plots and a plot of standardized residuals against the predicted values.

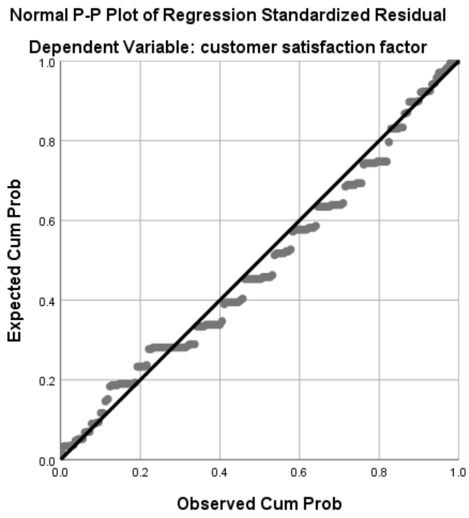
❖ **Product quality factor & Customer satisfaction factor**

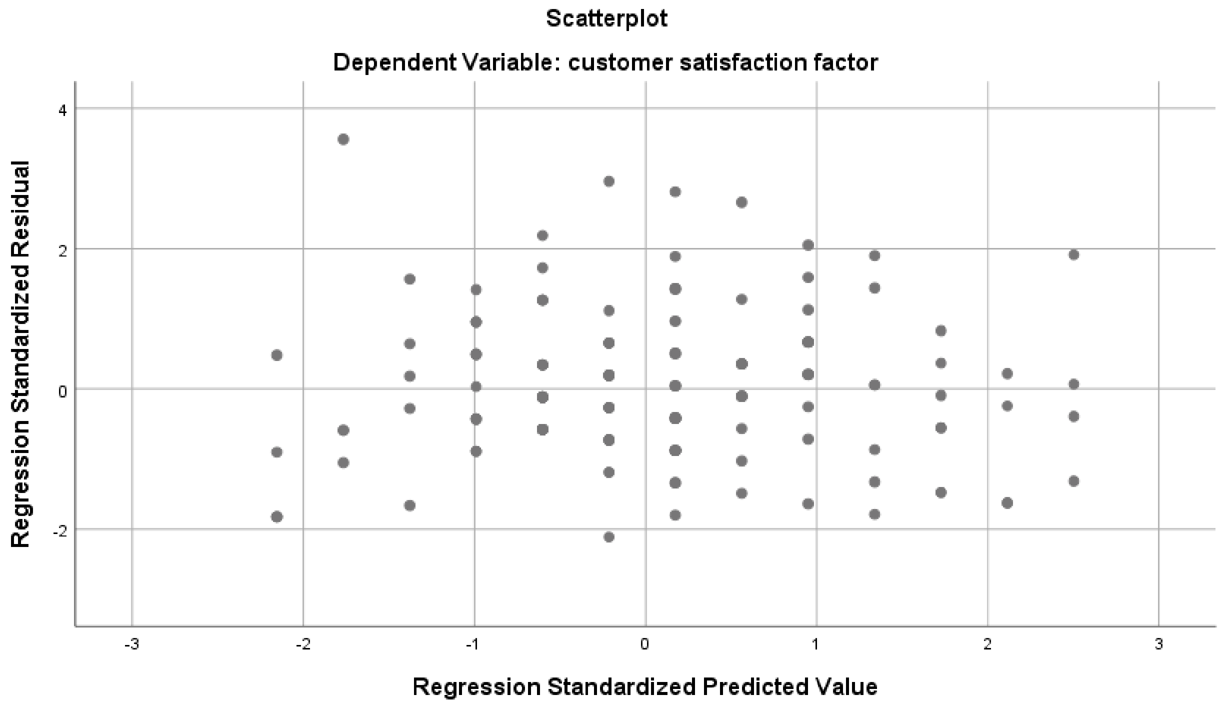




There was linearity as assessed by partial regression plots and a plot of standardized residuals against the predicted values.

❖ **Process improvement factor & Project control factor**

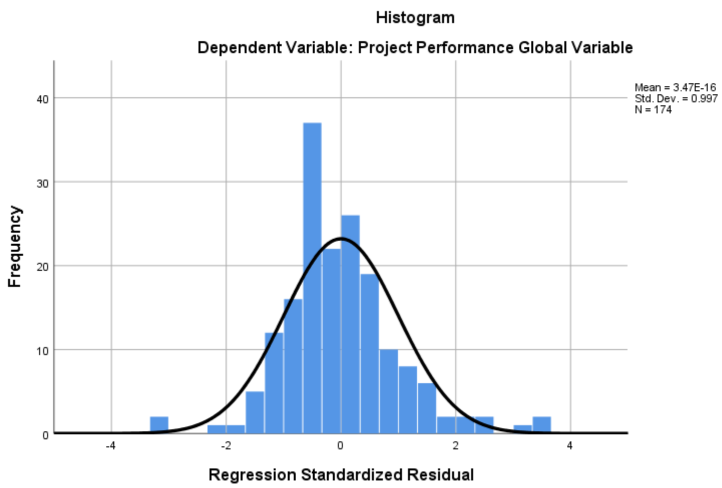




There was linearity as assessed by partial regression plots and a plot of standardized residuals against the predicted values.

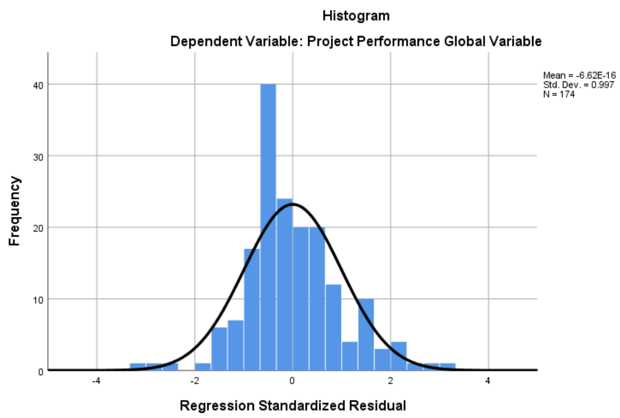
Appendix 6 – Linear Regression (Normality - Histogram)

❖ Implementing maturity models variable & Project performance variable



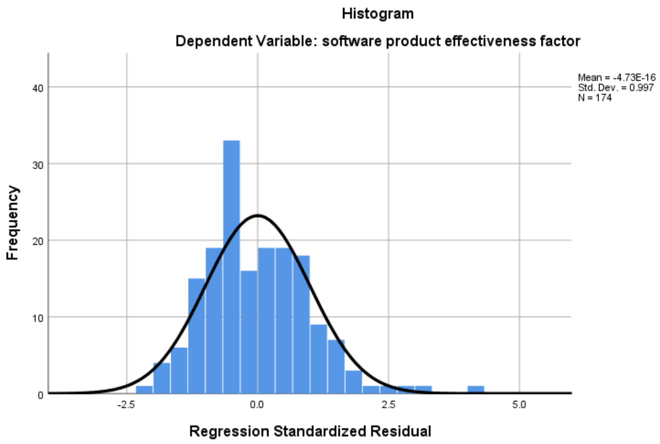
The assumption of normality is met as assessed by a histogram.

❖ Project management practices factor & Project performance variable



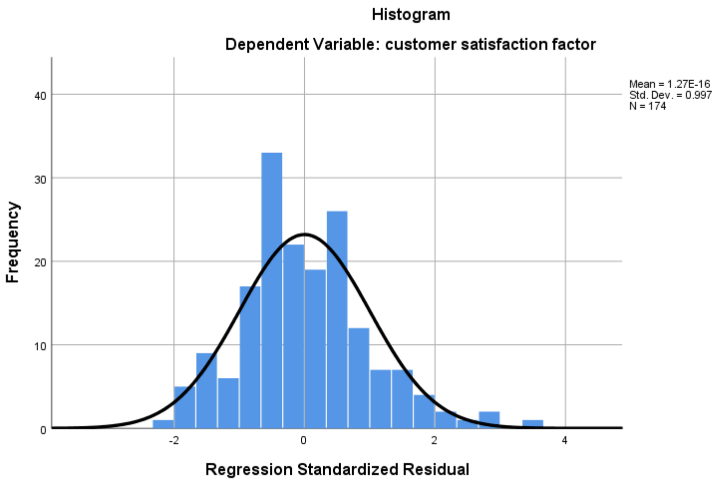
The assumption of normality is met as assessed by a histogram.

❖ **Software engineering standards factor & Software product effectiveness factor**



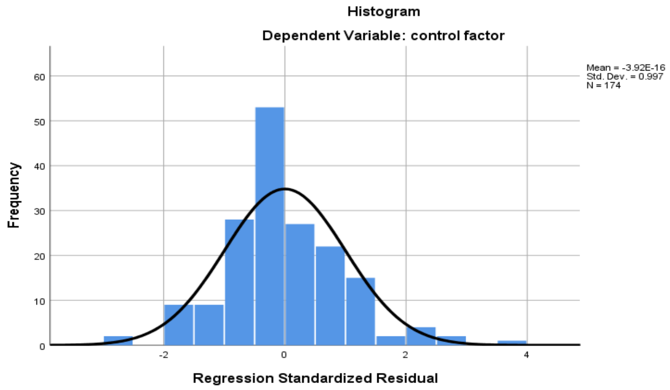
The assumption of normality is met as assessed by a histogram.

❖ **Product quality factor & Customer satisfaction factor**



The assumption of normality is met as assessed by a histogram.

❖ **Process improvement factor & Project control factor**



The assumption of normality is met as assessed by a histogram.

Appendix 7 – Linear Regression Test

❖ **Implementing maturity models variable & Project performance variable**

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Implementing Maturity Models Global Variable[b]	.	Enter

a. Dependent Variable: Project Performance Global Variable

Model Summary[b]

					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.719[a]	.518	.515	4.842	.518	184.496	1	172	.000	1.814

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4326.315	1	4326.315	184.496	.000[b]
	Residual	4033.300	172	23.449		
	Total	8359.615	173			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	8.422	1.752		4.808	.000	4.964	11.879
	Implementing Maturity Models Global Variable	.544	.040	.719	13.583	.000	.465	.623

❖ Project management practices factor & Project performance variable

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	project management practices factor[b]	.	Enter

a. Dependent Variable: Project Performance Global Variable

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.608[a]	.370	.366	5.535	.370	100.865	1	172	.000	1.780

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3090.155	1	3090.155	100.865	.000[b]
	Residual	5269.460	172	30.636		
	Total	8359.615	173			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	15.314	1.683		9.099	.000	11.992	18.636
	project management practices factor	1.355	.135	.608	10.043	.000	1.089	1.621

a. Dependent Variable: Project Performance Global Variable

❖ Software engineering standards factor & Software product effectiveness factor

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	software engineering standards factor[b]	.	Enter

a. Dependent Variable: software product effectiveness factor

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.457[a]	.209	.204	1.943	.209	45.337	1	172	.000	2.036

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	171.164	1	171.164	45.337	.000[b]
	Residual	649.365	172	3.775		
	Total	820.529	173			

a. Dependent Variable: software product effectiveness factor

b. Predictors: (Constant), software engineering standards factor

Coefficients[a]

Model		Unstandardized-Coefficients B	Unstandardized-Coefficients Std. Error	Standardized-Coefficients Beta	t	Sig.	95.0% Confidence Interval for B Lower Bound	95.0% Confidence Interval for B Upper Bound
1	(Constant)	3.906	.564		6.921	.000	2.792	5.020
	software engineering standards factor	.396	.059	.457	6.733	.000	.280	.513

a. Dependent Variable: software product effectiveness factor

❖ Product quality factor & Customer satisfaction factor

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	product quality factor[b]	.	Enter

a. Dependent Variable: customer satisfaction factor

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	Durbin-Watson
1	.361[a]	.130	.125	2.168	.130	25.778	1	172	.000	1.761

a. Predictors: (Constant), product quality factor

b. Dependent Variable: customer satisfaction factor

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	121.195	1	121.195	25.778	.000[b]
	Residual	808.667	172	4.702		
	Total	929.862	173			

a. Dependent Variable: customer satisfaction factor

b. Predictors: (Constant), product quality factor

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.	95.0% Confidence Interval for B Lower Bound	Upper Bound
1	(Constant)	6.657	.633		10.520	.000	5.408	7.905
	product quality factor	.325	.064	.361	5.077	.000	.199	.451

a. Dependent Variable: customer satisfaction factor

❖ Process improvement factor & Project control factor

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	process improvement factor[b]	.	Enter

a. Dependent Variable: control factor

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	Durbin-Watson
1	.542[a]	.294	.290	1.760	.294	71.627	1	172	.000	1.583

a. Predictors: (Constant), process improvement factor

b. Dependent Variable: control factor

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	221.755	1	221.755	71.627	.000[b]
	Residual	532.504	172	3.096		
	Total	754.259	173			

a. Dependent Variable: control factor

b. Predictors: (Constant), process improvement factor

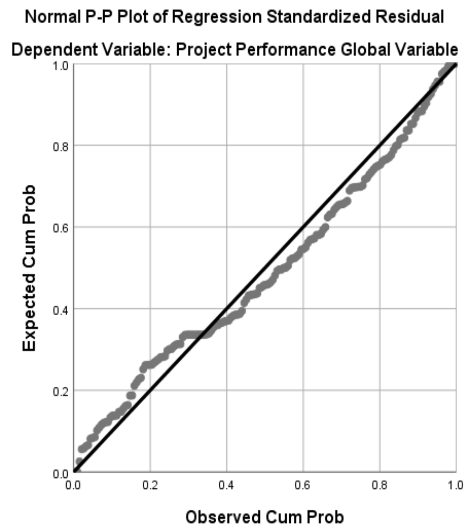
Coefficients[a]

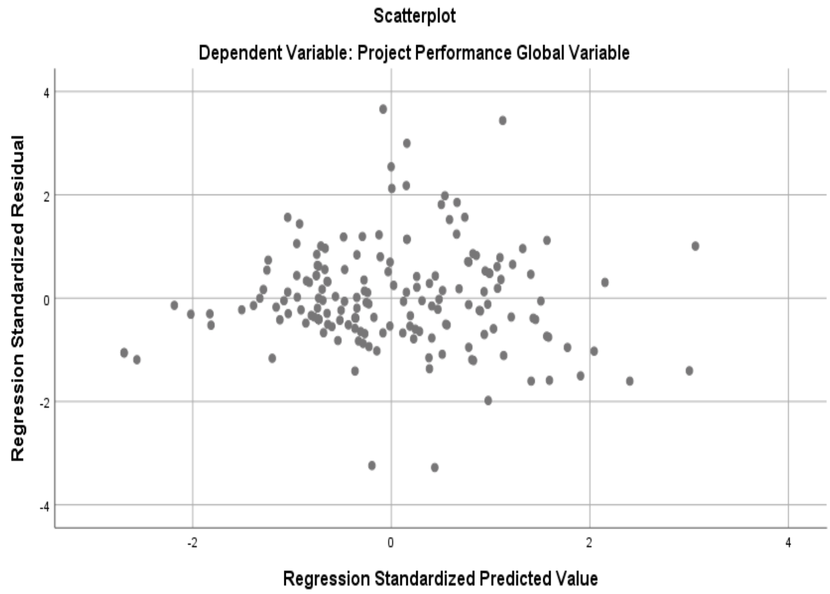
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	2.555	.568		4.502	.000	1.435	3.676
	process improvement factor	.392	.046	.542	8.463	.000	.301	.484

a. Dependent Variable: control factor

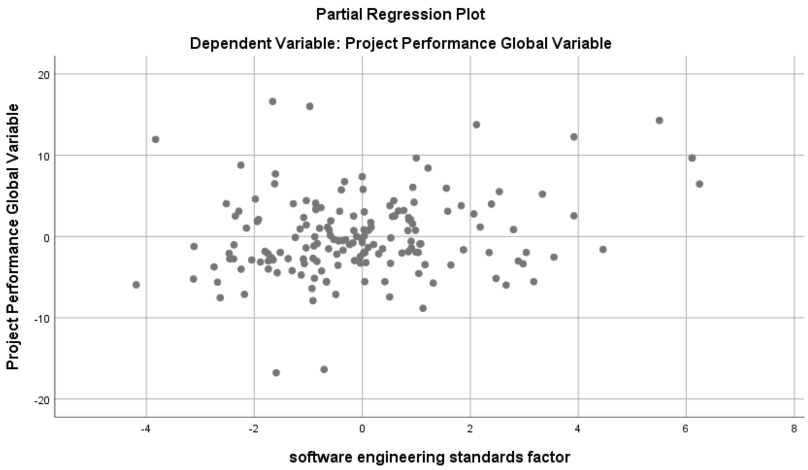
Appendix 8 - Multiple Regression Assumptions Tests

- **Linearity (Scatter Plot & Partial Regression Plots)**

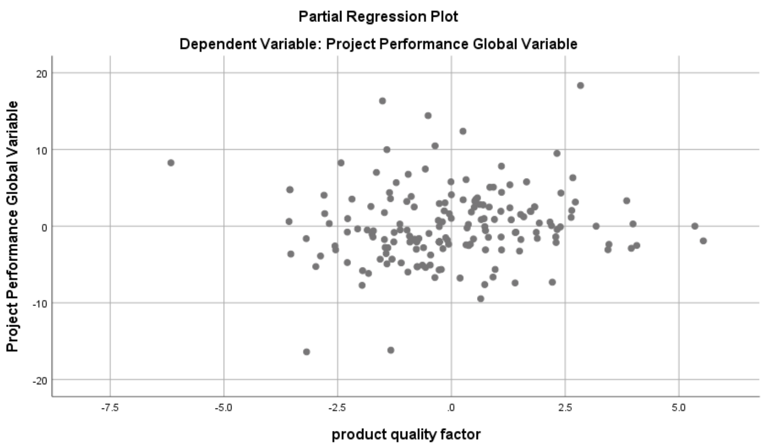




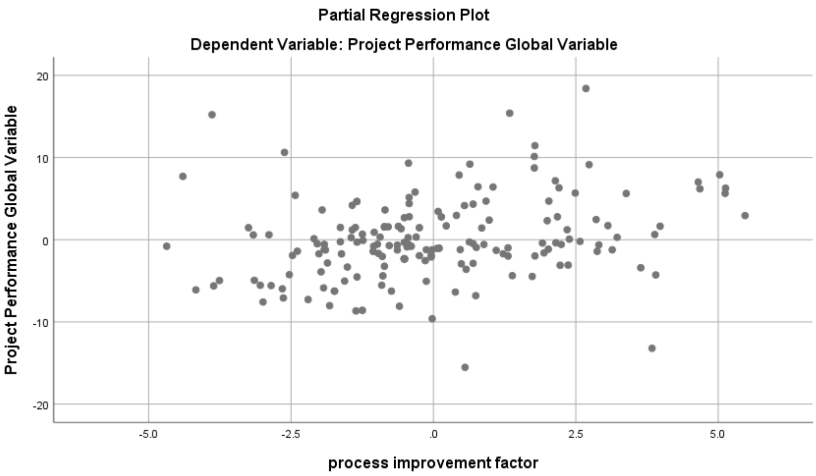
<u>Software Engineering Standards Factor & Project Performance Variable</u>



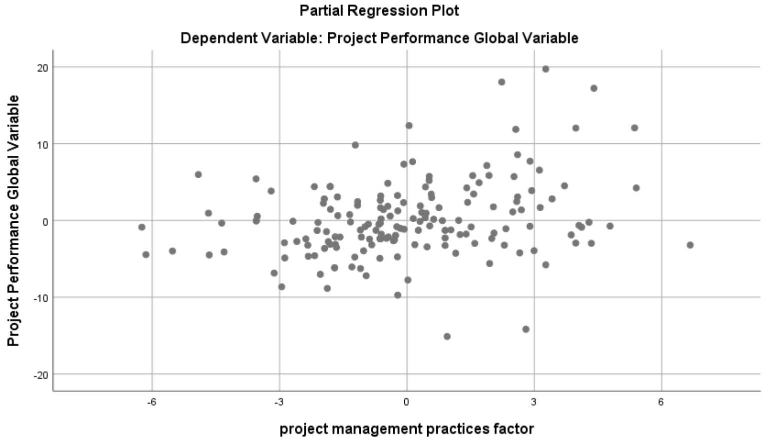
Product Quality Factor & Project Performance Variable



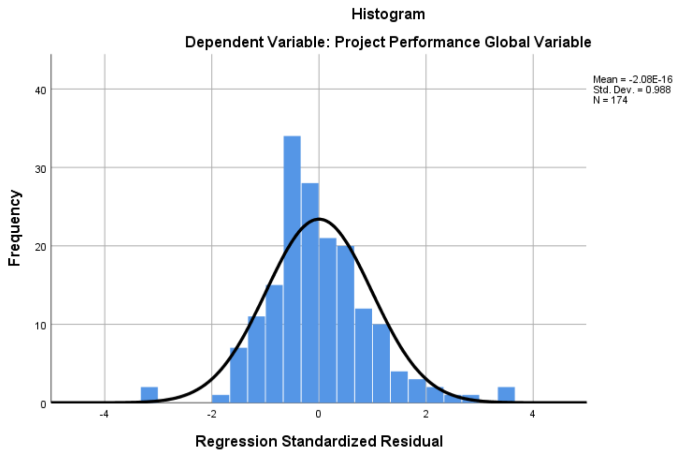
Process Improvement Factor & Project Performance Variable



Project Management Practices Factor & Project Performance Variable



❖ **Normality - Histogram**



❖ **Independence of Residuals (Durbin-Watson)**

Model Summary[b]

					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.725[a]	.525	.514	4.846	.525	46.748	4	169	.000	1.854

a. Predictors: (Constant), process improvement factor, project management practices factor, software engineering standards factor, product quality factor

b. Dependent Variable: Project Performance Global Variable

❖ Multicollinearity Test

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	8.257	1.760		4.691	.000					
	project management practices factor	.612	.158	.275	3.875	.000	.608	.286	.205	.560	1.787
	software engineering standards factor	.676	.204	.244	3.316	.001	.601	.247	.176	.520	1.925
	product quality factor	.216	.202	.080	1.072	.285	.549	.082	.057	.501	1.995
	process improvement factor	.648	.178	.269	3.636	.000	.623	.269	.193	.512	1.951

a. Dependent Variable: Project Performance Global Variable

Appendix 9 - Multiple Regression Test (Stepwise Method)

Descriptive Statistics

	Mean	Std. Deviation	N
Project Performance Global Variable	31.68	6.951	174
project management practices factor	12.08	3.119	174
software engineering standards factor	9.25	2.509	174
product quality factor	9.55	2.577	174
process improvement factor	11.91	2.888	174

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	process improvement factor	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	project management practices factor	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	software engineering standards factor	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Project Performance Global Variable

Model Summary[d]

					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.623[a]	.388	.385	5.452	.388	109.189	1	172	.000	
2	.692[b]	.479	.473	5.048	.091	29.703	1	171	.000	
3	.723[c]	.522	.514	4.848	.043	15.368	1	170	.000	1.877

a. Predictors: (Constant), process improvement factor

b. Predictors: (Constant), process improvement factor, project management practices factor

c. Predictors: (Constant), process improvement factor, project management practices factor, software engineering standards factor

d. Dependent Variable: Project Performance Global Variable

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3246.138	1	3246.138	109.189	.000[b]
	Residual	5113.477	172	29.730		
	Total	8359.615	173			
2	Regression	4002.902	2	2001.451	78.556	.000[c]
	Residual	4356.713	171	25.478		
	Total	8359.615	173			
3	Regression	4364.098	3	1454.699	61.894	.000[d]
	Residual	3995.517	170	23.503		
	Total	8359.615	173			

a. Dependent Variable: Project Performance Global Variable

b. Predictors: (Constant), process improvement factor

c. Predictors: (Constant), process improvement factor, project management practices factor

d. Predictors: (Constant), process improvement factor, project management practices factor, software engineering standards factor

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	13.821	1.759		7.858	.000					
	process improvement	1.500	.144	.623	10.449	.000	.623	.623	.623	1.000	1.000
2	(Constant)	10.043	1.770		5.676	.000					
	process improvement	.980	.164	.407	5.985	.000	.623	.416	.330	.659	1.516
	project manage. practices	.826	.152	.371	5.450	.000	.608	.385	.301	.659	1.516
3	(Constant)	8.525	1.743		4.890	.000					
	process improvement	.693	.173	.288	3.994	.000	.623	.293	.212	.542	1.845
	project manage. practices	.660	.152	.296	4.351	.000	.608	.317	.231	.608	1.645
	software eng. standards	.750	.191	.271	3.920	.000	.601	.288	.208	.589	1.698

a. Dependent Variable: Project Performance Global Variable

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	project management practices factor	.371[b]	5.450	.000	.385	.659	1.516	.659
	software engineering standards factor	.355[b]	5.091	.000	.363	.639	1.565	.639
	product quality factor	.278[b]	3.926	.000	.288	.654	1.530	.654
2	software engineering standards factor	.271[c]	3.920	.000	.288	.589	1.698	.542
	product quality factor	.165[c]	2.287	.023	.173	.568	1.760	.565
3	product quality factor	.080[d]	1.072	.285	.082	.501	1.995	.501

a. Dependent Variable: Project Performance Global Variable

b. Predictors in the Model: (Constant), process improvement factor

c. Predictors in the Model: (Constant), process improvement factor, project management practices factor

d. Predictors in the Model: (Constant), process improvement factor, project management practices factor, software engineering standards factor

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	process improvement factor	project management practices factor	software engineering standards factor
1	1	1.972	1.000	.01	.01		
	2	.028	8.391	.99	.99		
2	1	2.944	1.000	.01	.00	.00	
	2	.032	9.575	.91	.05	.43	
	3	.024	11.087	.09	.95	.57	
3	1	3.913	1.000	.00	.00	.00	.00
	2	.035	10.576	.79	.01	.00	.41
	3	.030	11.465	.15	.00	.81	.35
	4	.022	13.251	.06	.98	.19	.23

a. Dependent Variable: Project Performance Global Variable