THE EFFECT OF GEOGRAPHICAL REGION ON THE TRANSITION TIME OF CMMI-BASED SOFTWARE PROCESS IMPROVEMENT

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ABSTRACT

Software Process Improvement (SPI) is one of the main contributors to the improvement of the software organization process, in terms of achieving targets on time, working within budget, and work quality. Capability Maturity Model Integration (CMMI) is one of the leading SPI models, which is based on the best practices that deal with Organization Maturity. However, despite this, the Software Engineering Institute (SEI) has identified a timeframe for achieving a particular CMMI level. Nevertheless, one of the most frequent reasons given by organizations for their reluctance in adopting CMMI, was time, whilst geographical region was deemed an independent variable that influences the relationship between process improvement and schedule deviation. Therefore, this study aims to identify the factors that affect the transition time of CMMI based SPI, during the CMMI process. It also seeks to identify the effect of Geographical Region on the transition time of CMMI. At the same time, it will propose a reference model that will assist organizations in reducing the effects of these factors, whilst accelerating the CMMI process. Interviews were used to obtain factors from software engineering process group supervisors, consultants, managers, and practitioners, of various software and service firms. A questionnaire survey was then used to identify the factors that affect the transition time of CMMI, between Malaysia and Saudi Arabia. This comparison was done using statistical analysis. Results show that Malaysian firms had different transition time factors, compared to Saudi Arabian firms (chi-square test, $p < 0.05$). In addition, it also shows that geographical region had a significant impact on the transition time factors of CMMI ($p < \alpha$). The study produced a Transition Time Factor Implementation Framework and a Transition Time Factor Reference Model, which was validated by seven CMMI experts, from Malaysia and Saudi Arabia.

DEDICATION

This work is dedicated to my great mother, Ammoushah.

To my family especially my wife, Awatif, and my children: you really played a great role to enable me reach this far. May ALLAH, the Almighty grant more than what you have been requesting him to.

To my brothers and sisters, without your sincere prayers and continuous support, I would not have been able to achieve this work.

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LIST OF ABBREVIATIONS

CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
ISO	International Organization for Standardization
SPI	Software Process Improvement
SPSS	Statistical Package for Social Sciences
TTF	Transition Time Factor
TTFRM	Transition Time Factor Reference Model

CHAPTER ONE - INTRODUCTION

1.1 Background

Software quality has become more critical as software pervades our day-to-day lives (Paulk et al., 1994; Jones and Soule, 2002; Waina, 2004; Niazi, 2006a; Kulpa and Johnson, 2008). Issues associated with software quality are widely diffused to affect the development cost and time (Sommerville 1996, SEI, 2002; SEI, 2004, SEI, 2007). A group of Fellows of the Royal Academy of Engineering and the British Computer Society demonstrated that despite spending 22 billion pounds on Information Technology projects in the UK during 2003/2004, there were still some projects that failed to deliver on time (The Royal Academy of Engineering, 2004). In addition to disappointing execution, some software projects failed in the operational process (e.g. the London Ambulance Service (Finkelstein, 1993), the demise of organizations (e.g. Oxford Health's 'computer glitch' (Khasru, 2001), and One.Tel billing system (Paul, 2002)). The ability to deliver software projects on time is still an obsession with most software organizations (Paulk, 1994; Butler, 1995; Yamamura, 1999; Pitterman, 2000; Zaid, 2004; SEI, 2007, SEI, 2009). However, in order to address the software process management, different techniques and approaches have been developed to improve software processes.

Software Process Improvement (SPI) has received much attention in both fields of academia and industry. SPI has become a common approach for delivering improvements to software quality (Humphrey, 1989). It aims to improve the effectiveness of the software development process within budget and on time (Niazi, 2006a). Software process is defined as a set of processes relating to product, human, and

resources within the current organizational structures and constraints used to develop and serve the required software product (ISO/SPICE, 2008). The potential benefits of SPI may be achieved and classified into six broad categories as shown in Table 1.1.

Table 1.1 Potential benefits of SPI (SEI, 2004; Niazi, 2006a)

No	Benefits	SPI Business goals
1.	Cost	Reducing the cost
2.	Schedule	Reducing the time
3.	Productivity	Increasing the productivity
4.	Quality	Increasing the quality
5.	Customer Satisfaction	Increasing satisfaction
6.	Return on Investment	4:1

The above six benefits namely cost, schedule, productivity, quality, customer satisfaction, and the return on investment (ROI) can be translated to further business goals such as increasing the productivity, reducing the time, reducing the cost, and increasing the quality (SEI, 2004; Gibson et al., 2006; SEI 2007). Therefore, SPI models are used by software development organizations to improve their processes. The most widely used SPI models are the ISO 9000 series (Paulk, 1994), the ISO 15504 (ISO/IEC, 1998), the Capability Maturity Model (CMM) (Paulk et al., 1993; Paulk et al., 1993b), the Capability Maturity Model Integration (CMMI) (SEI, 2007), and the Six Sigma (Pyzdek, 2003). An important point to note is that there is one common objective among all of these models and standards. The ultimate objective of these models and standards is in relation to the quality and process improvement of the software and services industry. Although a community of these models and standards exists, the individual emphasis is different from one to another. For instance the ISO is concerned about a minimum standard for a working quality system. On the other hand the CMMI is more focused on continuous improvement. For this reason a direct comparison between these models and standards

may not be a good approach or judgment (Paulk, 1994; El Emam and Goldenson, 1999b). Therefore, some researchers (Brodman and Johnson, 1994; Johnson, 1994; Herbsleb and Goldenson, 1996; El Emam et al., 1998; El Emam et al., 1999; Hammock, 1999; Dyba, 2000; Stelzer and Mellis, 1998; Wiegers, 1998) have investigated the factors that can affect the success of a software development process. Consequently, some of these studies recognize the demand for further research on implementing the software process improvement as practitioners want more guidance on "how to improve", not just "what to do" (Herbsleb and Goldenson, 1996; Pajerek, 2000). Therefore, studies which provide framework guidelines or practices to explain how to improve the processes are more beneficial and practical for organizations.

1.2 The Urgency to Focus on CMMI

This study selected CMMI as its SPI model because in recent years, more organizations have become interested in SPI, especially the CMMI model. Among the SPI models, CMMI has become a highly accepted model (Jones and Soule, 2002). Therefore, there has been an increase in the number of companies that have applied for CMMI appraisal (Huang et al., 2006).

Kulpa and Johnson (2008) indicated that CMMI includes help, direction, and ideas about software engineering, systems engineering, hardware engineering, and integrated team development, which means that CMMI is not only for software development. One of the primary goals of CMMI is to allow organizations to reduce the cost and confusion incurred from multiple assessments and multiple process improvement programs to cover both their system and software engineering activities (Kulpa and Johnson, 2008). Therefore, CMMI plays the role of linking systems and software into a process improvement structure. As with many other progress and development models, CMMI also provides a structural framework to incorporate new disciplines as new needs emerge in the product life cycle (SEI, 2007).

1.2.1 Definition of CMMI

CMMI can be described as a collection of best practices from previous experiences with the preceding CMM, and other models and standards (SEI, 2007). CMMI defines how an influential process must look like. It offers practitioners with a suitable framework, so that enhancement activities can be defined and organized. It has two representations, a staged representation and a continuous representation which will be discussed further in the literature review chapter.

1.2.2 Benefits of CMMI

CMMI enables the organization to deal with multi-disciplined activities and to easily combine process improvement aims with organizational business goals. It provides a holistic approach towards the vision and mission of a business while accommodating new business developments (Waina, 2004).

The benefits of CMMI are manifold. The visible benefits are in terms of cost, schedule, productivity, quality, customer satisfaction, and return on investment. The performance measurement of 30 different organizations is given in Table 1.2.

Table1.2 Performance results of CMMI (SEI, 2007)

Performance Category	Median Improvement
Cost	34%
Schedule	50%
Productivity	61%
Quality	48%
Customer Satisfaction	14%
Return on Investment	4:1

Therefore, process improvements resulting from the CMMI appraisal can be described in the following Table 1.3 which shows the benefits of CMMI, as highlighted by the Carnegie Mellon University, (SEI, 2007).

Table1.3 CMMI Benefits

No.	**Benefits of CMMI**
1.	Improved deadline meeting
2.	Cycle time reduction
3.	Productivity improvement
4.	Quality improvement
5.	Improved customer satisfaction
6.	Employee morale improvement
7.	Higher return on investment
8.	Cost of quality reduction

In addition, CMMI serves as a standard that many organizations are striving to meet (Niazi and Babar, 2009). These organizations try to reach high levels in the CMMI model in order to be qualified for contract bidding. Therefore, in terms of software process improvement, the company needs to identify the factors that may delay the transition time of the CMMI, as well as to treat various factors within the company through strategic plans, which at the same time helps the organization to improve its processes and to reach a higher level in the CMMI model at a faster rate.

1.2.3 Transition Time of CMMI

Transition time in this study refers to the time taken for a company to move one level upward from a lower level to the next higher level. Therefore, the scope of this study involves looking at the time taken to move to maturity level 3. Maturity Level 3 (ML3), called "Defined," is characterized by "Process Standardization" (SEI, 2007). This is where most of the process areas reside in CMMI. Therefore, ML3 focuses on the maturity of the organization itself. The Software Engineering Institute (SEI) has set a standard transition time for companies to move from one level to another. The SEI has identified the transition time from maturity level 1 to 2 at 4 months. The time taken to move from maturity level 2 to 3 is set at 18 months. The movement to the next level from maturity level 3 to 4 is set at 19 months while the movement from maturity level 4 to 5 is set at 13 months as shown in Table 1.4.

Table1.4 CMMI transition time (SEI, 2009)

Transition From – To	Transition Time
Maturity level 1 to ML 2	4 months.
Maturity level 2 to ML 3	18 months.
Maturity level 3 to ML 4	19 months.
Maturity level 4 to ML 5	13 months.

1.3 Geographical Region

Geographical Region is referred to an area of the earth having natural boundaries, similar culture, topographic terrains, and similar environment. In software engineering, Geographical Region has been one of the most effective issues on SPI (Jung and Goldenson, 2009). Whereas, various geographical regions have a variety of capability levels, the background characteristics of assessed organizations can lead to different analysis results (Jung and Goldenson, 2009). The SEI's Process Maturity Profile (SEI, 2006) explores the classification of the SW-CMM and CMMI maturity levels by geographical regions, which are categorized as US and non US organizations. Therefore, this indicates that the geographical region characteristics might have an influencing role on the capability levels (Paulish and Carleton, 1994).

In this study a comparison was made of two different geographical regions, one in South East Asia and the other in the Middle East. Malaysia is selected to represent a South East Asia region while Saudi Arabia is selected to represent a Middle East region. The similarities and differences between Malaysia and Saudi Arabia are presented in Table 1.5.

Table1.5 Similarities and Differences between the two countries

No	Selection measure	Malaysia	Saudi Arabia
1.	Country status	Developing Country	Developing Country
2.	Geographical Region	South East Asia	Middle East (West of Asia)
3.	Population	27 million people	27million people
4.	Study, similar to this one, has been done	None (to the best of our knowledge)	None (to the best of our knowledge)

	before		
5.	People Literacy Rate	91%	85%
6.	Type of Government	Monarchy	Monarchy
7.	Currency Rate to 1.0 $US	3.20 MYR	3.75 SAR
8.	Number of Software Companies	1500 MSC status companies at MDeC	763 companies are registered at MOCI
9.	SEI Authorized Partner	5 Partners	3 Partners

Both countries are developing countries with an almost equal level of technology application and with a similar number and level of human resources. Apart from these similarities between the two regions, both countries have just about the same population of around 27 million people. The main differences between both countries are their characteristics, such as culture, environment, interest, weather, language, learning system, and political administration. Hence, due to these differences it might be very interesting to find out how these countries differ in terms of the SPI projects implementation.

1.4 Research Motivation

The large and growing body of software development organizations around the world have adopted a Capability Maturity Model Integration (CMMI) (Niazi and Babar, 2009; Huang et al., 2006; SEI, 2007; SEI 2004) to improve their software development processes. Recently, many attempts (Stelzer and Werner, 1999; Goldenson and Herbsleb, 1995; Rainer and Hall, 2002; El-Emam et al., 1999) have been made to study the factors that affect the successful adoption of the CMMI by different organizations. However, the transition time of CMMI is one of the important issues that still need to be addressed efficiently in different organizations. Existing studies (such as Jackelen, 2007; Tufail et al. 2006; Guererro and Eterovic, 2004; Iversen and Ngwenyama, 2006) that handle this important issue and provided some factors that affect the transition time but they did not provide a framework, model, guideline, or roadmap to avoid the effects of this issue. Furthermore, most of the recent studies and researches have used CMMI as case studies which are based on qualitative data. Quantitative studies on the factors that affect the transition time of CMMI are lacking in the literature, although quantitative studies provide a deeper understanding than qualitative studies (Jonson, 1995). CMMI is a highly acceptable approach as a Software Process Improvement (SPI) model in software organizations (Jones and Soule, 2002). However, there is no study which has focused on the transition time of CMMI and provided a guideline to accelerate its applying. Therefore transition time of CMMI requires a special investigation during the implementation process.

The motivation for selecting CMMI as the base of this study is that it is an influential, long-standing, and often-studied standard for the SPI model (Staples & Niazi, 2008).

Moreover, the CMMI-based SPI has led to a quantifiable enhancement in how the processes of software engineering are accomplished (Bollinger and McGowan, 2009).

1.5 Problem Statement

The CMMI model offers considerable benefits in terms of the organizational maturity of organizations as well as financial returns (SEI, 2009; SEI, 2007; SEI, 2004; SEI, 2002). Therefore, the Software Engineering Institute (SEI) has identified a timeframe for achieving each level of CMMI (SEI, 2009; SEI, 2007). However, applying the CMMI consumes more time than expected in most organizations (Guererro and Eterovic, 2004; Iversen and Ngwenyama, 2006; Jackelen, 2007; Zeid, 2004). Consequently, this leads organizations to incur unexpected financial expenses and non-scheduled costs which may be more than the financial returns that come after applying the CMMI. Many organizations have difficulties in accelerating CMMI process (Staples et al., 2007). Therefore there is a need to assist organizations in order to accelerate their SPI project.

Staples et al., (2007) wanted to find out the reasons why firms did not want to implement the CMMI. One of the issues established by Staples et al., (2007) indicated that the organizations had difficulties to allocate time to adopt the CMMI model. In addition, Jung and Goldenson (2009) evaluated the relationship between process improvement and time deviation in software projects. They found that organizational size does not influence the relationship, while geographical region is deemed to be an independent variable affecting the relationship. Hence, this thesis addresses these two issues that deter organizations from adopting the CMMI model for their projects. First, this research investigates which factors can affect the transition time of the CMMI model, and secondly, the effect of geographical region on these factors.

1.6 Research Objectives

The essential aim of this thesis is to increase the understanding on the effect of different geographical region (i.e. South East Asia and Middle East) on the transition time factors of CMMI-based Software Process Improvement (SPI).

In order to fulfil the aim of this study, the following objectives are outlined:

- To identify the factors that affect the transition time of CMMI-based SPI.
- To demonstrate the effect of Geographical Region on the factors that affect the transition time of CMMI-based SPI.
- To produce the reference model that can assist organizations to reduce the effect of these factors.
- To validate the reference model that can be used to reduce the effect of these factors.

These objectives will provide a clear vision for SPI decision makers in designing appropriate strategies to manage and reduce the transition time of CMMI.

1.7 Research Questions

The main purpose of this thesis is to identify the factors that affect the transition time of CMMI-based software process improvement. Consequently, the study tries to explore the impact of geographical region on these factors through applying this study in two different geographical regions (i.e. Malaysia and Saudi Arabia), and how to overcome this influence. The factors that this research examines are (Allocation of Resources, Awareness, Change Management, CMMI Experienced Staff, CMMI Implementation Plan , Communication, Consultation, Cost of Appraising, Financial Motives, Frequency of Process Assessment, Gap Analysis, Group Focus, Imposed Partner, Income Level, Management Commitment, Many Roles to One Person, Metrics and Measurement, Process Documentation, Public Holiday Events, Review, Rewards, Separation of Process and Product Concerns, Staff Involvement, Training, Turnover of Staff, Unscheduled Events). These factors are collected and filtrated from literature review and interview with practitioners. Therefore, the study tried to avoid different factor name with same meaning.

There are five Research Questions (RQ) motivated the work reported in this study:

- ***RQ1***. *What are the factors that affect the transition time of CMMI in the Middle East region?*
- ***RQ2***. *What are the factors that affect the transition time of CMMI in South East Asia region?*
- ***RQ3***. *What are the shared factors that affect the transition time of CMMI in both Middle East and South East Asia regions?*
- ***RQ4***. *How would the geographical regions affect the transition time of CMMI?*
- ***RQ5***. *How to reduce the effect of the factors that affect the transition time of CMMI-based software process improvement?*

1.8 Research Hypotheses

The research questions above led the study to test the main research hypothesis as follows:

***Ho**: There is no significant difference in the factors that affect the transition time of CMMI-based software process improvement from different geographical regions.*

***H1**: There is significant difference in the factors that affect the transition time of CMMI-based software process improvement from different geographical regions.*

Therefore, in order to test this hypothesis, there are a set of sub-hypotheses (26 hypotheses) that are based on the factors that affect the transition time of CMMI. These sub-hypotheses are as follows:

1: There is no significant difference in the Turnover of Staff affecting the transition time of CMMI-based software process improvement from different geographical regions.

2: There is no significant difference in the Cost of Appraising affecting the transition time of CMMI-based software process improvement from different geographical regions.

3: There is no significant difference in Change Management affecting the transition time of CMMI-based software process improvement from different geographical regions.

4: There is no significant difference in the Many Roles to One Person affecting the transition time of CMMI-based software process improvement from different geographical regions.

5: There is no significant difference in Unscheduled Events affecting the transition time of CMMI-based software process improvement from different geographical regions.

6: There is no significant difference in Financial Motives affecting the transition time of CMMI-based software process improvement from different geographical regions.

7: There is no significant difference in Religious Events affecting the transition time of CMMI-based software process improvement from different geographical regions.

8: There is no significant difference in Imposed Partner affecting the transition time of CMMI-based software process improvement from different geographical regions.

9: There is no significant difference in Income Level affecting the transition time of CMMI-based software process improvement from different geographical regions.

10: There is no significant difference in Management Commitment affecting the transition time of CMMI-based software process improvement from different geographical regions.

11: There is no significant difference in Frequency of Process Assessment affecting the transition time of CMMI-based software process improvement from different geographical regions.

12: There is no significant difference in Separation of Process and Product Concerns affecting the transition time of CMMI-based software process improvement from different geographical regions.

13: There is no significant difference in Management & Staff Involvement affecting the transition time of CMMI-based software process improvement from different geographical regions.

14: There is no significant difference in Training affecting the transition time of CMMI-based software process improvement from different geographical regions.

15: There is no significant difference in Review affecting the transition time of CMMI-based software process improvement from different geographical regions.

16: There is no significant difference in Defined SPI Implementation Methodology affecting the transition time of CMMI-based software process improvement from different geographical regions.

17: There is no significant difference in Awareness affecting the transition time of CMMI-based software process improvement from different geographical regions.

18: There is no significant difference in CMMI Experienced Staff affecting the transition time of CMMI-based software process improvement from different geographical regions.

19: There is no significant difference in Communication affecting the transition time of CMMI-based software process improvement from different geographical regions.

20: There is no significant difference in Group Focus affecting the transition time of CMMI-based software process improvement from different geographical regions.

21: There is no significant difference in Process Documentation affecting the transition time of CMMI-based software process improvement from different geographical regions.

22: There is no significant difference in Consultation affecting the transition time of CMMI-based software process improvement from different geographical regions.

23: There is no significant difference in Metrics and Measurement affecting the transition time of CMMI-based software process improvement from different geographical regions.

24: There is no significant difference in Allocation of Resources affecting the transition time of CMMI-based software process improvement from different geographical regions.

25: There is no significant difference in Rewards and Motivation affecting the transition time of CMMI-based software process improvement from different geographical regions.

26: There is no significant difference in Gap Analysis affecting the transition time of CMMI-based software process improvement from different geographical regions.

1.9 Overview of Research Methodology

1.9.1 Research Philosophy

Research philosophy is concerned about the way data should be collected, analyzed and interpreted. The research philosophy must be considered in a given study as this will enable the researcher to develop the best possible design which would produce the most satisfying explanation to the research aims and objectives while answering the research questions and affirming the research hypotheses (Jonson and Clark, 2006). The exclusion of the research philosophy may badly affect the outcome and the quality of the research (Easterby-Smith et al., 2008). Taking this as a fundamental of research, Saunders et al., (2009) proposes that research philosophy enhances the knowledge creation in a given area and further more this is greatly affected by the thinking capability of the researcher him or herself.

The world of research philosophy can be briefly described through the use of a few terms: epistemology, axiology and ontology as discussed extensively in Saunders et al., (2009). On the other hand, these terms are strengthen by another term: doxology which is the belief or opinion of what is the truth (Rosengren, 2008).

- Epistemology has reference to the acceptable knowledge or what is known. (what is known to be true and how we know what we know).
- Doxology has reference to the knowledge of what is believed (opinion) to be true.
- Axiology has reference to the study of the role of the researcher's value in the research undertaken.
- Ontology has reference to the nature of things or reality in another word.

Based on these premises the role of a research is basically to move from the current *doxa* (knowledge of what is believed to be true) to the *episteme* (what is known or accepted knowledge) (Rosengren, 2008).

In line with this philosophy the researcher attempts to establish his beliefs on the independent factors which affect the transition time of CMMI to be an acceptable knowledge upon completing this study.

Two major research paradigms are the positivist and interpretivist (Saunders et al., 2009). These paradigms will be explained in brief below.

i. Positivism

Positivism is defined as an activity to develop knowledge which is valid and general to be used practically. In the act of developing the knowledge and understanding the subject matter, the researcher is detached from the subject matter investigated (Bryman and Bell, 2007). The positivist researchers believe that the reality or a phenomenon can be observed and explained to the world in an objective manner. In this paradigm the researchers themselves are excluded from the observation of the phenomenon (Bryman and Bell, 2007). Positivism attempts to generalize phenomenon which can be applied by the practical world in which the observer and or the researcher is independently cut off from the subject matter being investigated (Creswell, 2007).

ii. Interpretivism

In the interpretivism paradigm the researchers believe to be part of the study and phenomenon investigated. In this way the phenomenon can be fully understand and explained. In the works of Saunders et al. (2009), interpretivism is taken to represent that the researchers are stage actors based on the interpretation of certain roles which are in line with one's belief or set of meanings. Interpretivism is also referred to phenomenology in which the observer and or the researcher are taken to be part of the whole experience in an inclusion manner integrated with the subject matter being investigated (Cope, 2005).

1.9.2 Research Methodology

The research methodologies which are used in this study involves reviewing the literature and then meeting with the related practitioners, who are already involved in the software industry and who have achieved CMMI Level 3, or have achieved CMMI Level 2 and are going on to achieve CMMI Level 3, to extract factors which are having an impact on the transition time of CMMI-based SPI. This is to be followed by designing the research questionnaire and conducting the study in Malaysia which is selected to represent a South East Asia region and Saudi Arabia is selected to represent a Middle East region. Chi square was used to apply SPSS as a tool to analyse the data and then to compare the results. Consequently, in order to validate the effect of geographical region, the study has conducting the questionnaire and collecting data in Indonesia in South East Region and in Jordan which is in Middle East Region, and then comparing findings in Malaysia with Indonesia and Saudi Arabia with Jordan to find out similarities and differences. Therefore, the study compares the findings in Middle East Region with South East Asia Region, to show the effect of different geographical regions on the effective factors of transition time of CMMI. According to findings, the study will suggest a Reference Model for the Transition Time Factors (TTFs) of CMMI. Therefore, in order to validate the Reference Model, the study will use experts review approach for validation process. Figure 1.1 shows an overview of the research methodologies.

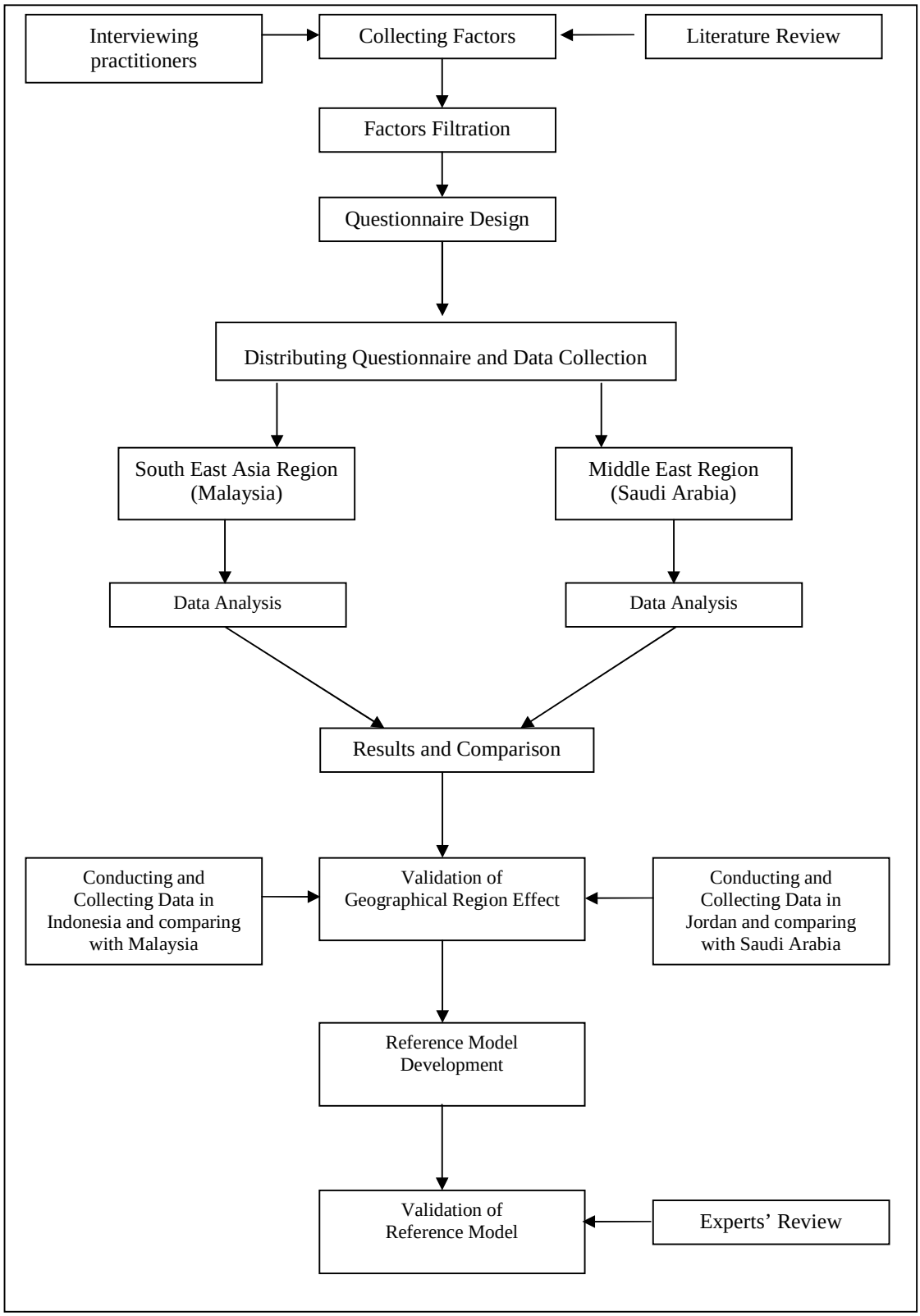

Figure 1.1 Overview of Research Methodology

1.10 Significance of the Study

The significance of the study is classified into the following theoretical and practical perspectives.

1.10.1 Theoretical

Existing CMMI-based SPI (SEI, 2002; SEI, 2004; SEI, 2007; SEI, 2009) to improve the software development process has limited characteristics. Therefore, it is critical for academic and industrial organizations to identify potential factors related to the transition time of the CMMI model, and to find out proper strategies to prevent the delay occurring during the CMMI process.

This study focuses on factors that affect the transition time of CMMI-based software process improvement. Thus, its importance comes from its precedence. This study has suggested a reference model to reduce the transition time of the CMMI and has addressed the geographical region which impacts the factors that affect the transition time of CMMI. Due to the significance of this study, it is expected to contribute considerably to both academic and industrial organizations in the related fields.

1.10.2 Practical

The importance of this study is to provide a comprehensive understanding of the factors that play a major role in delaying the transition time of CMMI, and to present a reference model to reduce the effect of these factors. Therefore, the end product of this study will be a practical reference model, which is designed to assist organizations to overcome and

reduce the effects of those factors that affect the transition time of CMMI. With this reference model it is believed that software organizations will be able to overcome the issue of software development time. In addition, this study may provide suitable advice to SPI decision makers in designing appropriate strategies during the CMMI process.

1.11 Definition of Key Terms

Some of the common terms used in this field of study are compiled here for the benefit of readers. The terms are as follows:

Table1.6 Definition of key terms

No	Terms	Definition
1.	CMMI	A collection of best practices from previous experiences with the preceding CMM, and other SPI models and standards.
2.	Turnover of staff	The employee may leave his job because of some better offers.
3.	Cost of appraising	The company tries to reduce the number of appraisals through the software process improvement because they are expensive.
4.	Change management	The change in the top management, project manager or team leader may affect the transition time as different managers may have different visions
5.	Many roles to one Person	The employee performs many jobs rather that performing a unique job.
6.	Unscheduled Events	The employee or organization may face some unscheduled problems, for example if the employee has health problems or the organization faces economic problems.
7.	Financial Motives	The availability of financial motives in case of project completion.
8.	Public Holiday Events	Public holidays (such as RAMADAN holiday). In some countries the second half of Ramadan is off.
9.	Imposed Partner	This partner is added to the organization because of his/her high social situation.
10.	Income Level	The employee's salary compared to his/her work
11.	Management Commitment	The top management commitment throughout the CMMI process
12.	Frequency of process assessment	The number of informal/formal assessments done before the CMMI appraising.
13.	Separation of process	The software organizations usually focus their efforts on

	and product concerns	delivering software products and put little or no effort into process activities.
14.	Management & staff involvement	The staff and management involvement throughout the CMMI process.
15.	Training	The existence of training related to CMMI in the organization.
16.	Review	The existence of a review group in the organization.
17.	Defined SPI implementation methodology.	The existence of a clear methodology plan in the organization.
18.	Awareness	The level of the staff awareness of CMMI
19.	CMMI Experienced staff	The level of staff experience with CMMI
20.	Communication	The communication between staff in the organization.
21.	Group focus	Enabling small teams to propose and implement improvements.
22.	Process documentation	The adaption level of the process documentation activities before the CMMI process.
23.	Consultation	Working with a consultant throughout the CMMI process.
24.	Metrics and Measurement	The utilization of metrics and measurement activities before the CMMI process in the organization
25.	Allocation of resources	The availability of resources during the CMMI process.
26.	Rewards	The rewards mechanism which the organization has employed throughout the CMMI process
27.	Gap analysis	The utilization of gap analysis in the organization.

1.12 Structure of the Thesis

The thesis is developed in 6 main chapters which are as follows:

Chapter 1 – Introduction

The basis of the study is presented extensively in this chapter. The introduction and background of the study are briefly explained to establish the stage for the study. This is followed by the research problem, aims and objectives, research questions and research hypothesis. The justification and motivation of the study are also included to explain the reason for selecting this topic. The structure of the study is also included for a good follow through of the chapters involved in this study.

Chapter 2 – Literature Review

In this chapter the researcher studies all the relevant literature available to have a good understanding of the selected topic of study. Reviews are conducted on CMMI, SPI, transition time factors, and the geographical region Impact.

Chapter 3 – Research Methodology

Chapter Three is concerned with all the research philosophy, approach and design applied throughout this study. The researcher attempted to cover a wide area of the methodologies to smoothen up the process and procedures applied in this study. The researcher consciously wanted to provide a thorough and systematic step by step path in conducting the study so as to provide a maximum guide to the readers.

Chapter 4 – Data analysis

In this data analysis chapter the researcher presents all the necessary data analysis done in the study. This involves the demographics in the first part and is followed by a detailed analysis of all the factors investigated. The findings of the study are presented in a corresponding manner to the questions and methodologies raised at the beginning of the study.

Chapter 5 – Reference Model Development

In chapter 5 of this study the researcher presents a reference model development for managing the transition time factors of CMMI as part of the objective of this study. The model development involves a complete set of practices. This is presented in tabular format.

Chapter 6 - Conclusion

In the final chapter of this study the researcher presents the summary of the research findings and research contribution to the software engineering community. Research limitations, which the researcher was not able to overcome during the research, are shown. Finally the researcher was able to provide opportunities for future studies.

1.13 Chapter Summary

In this chapter the researcher extensively explains the background of the study together with the research objectives. The research problem statement, research questions and research hypothesis are highlighted for the benefit of the readers. The research method is explained in brief by presenting a diagram. As such, the significance of the study is described from the theoretical and practical perspectives.

In the next chapter, the researcher discusses and presents the extensive literature review conducted prior to the commencement of this study.

CHAPTER TWO – LITERATURE REVIEW

2.1 Introduction

This chapter reviews the relevant literature to this research which mainly relates to the Software Process Improvement (SPI) and its frameworks, the geographical region as one of the important issues that has an effect on the CMMI-based SPI implementation and the transition time of the CMMI-based SPI. The Software Process Improvement (SPI) is defined and explained to observe which factors affect the CMMI-based model. The geographical region is one of the most important issues for the SPI. Different geographical regions have a variety of capability levels and using a different region of assessed organizations leads to different analysis results. The recent studies are discussed in detail with regard to the impact of the geographical region on the CMMI-based SPI. Some recently proposed factors that affect the success of the CMMI-based SPI implementation are also described. The transition time is another important issue for the CMMI-based SPI, and some important factors that affect the transition time of the CMMI-based SPI are discussed.

2.2 Software Process Improvement

A new set of ideas on how to enhance the productivity and quality in software development organizations have emerged over the last decade under the term of Software Process Improvement (SPI) (Aaen et al, 2001). SPI has become highly visible over the past several years. Hence, this topic can only be effectively addressed by blending people, processes, and technology issues (McGuire, 1999). It has provided a rich field for both

conceptual and practical research in industry and academe. Industry practitioners are searching the better models for quality software development. Academic researchers are initiating rigorous streams of process-related field research (Eugene, 1999).

SPI has become the key to the survival of numerous software development organizations who want to deliver their products cheaper, faster, and better. A software process ultimately describes the way that organizations develop their software products and supporting services. Processes define what kind of steps the software development organizations should undertake at each phase of production and provide assistance in making good efforts and scheduling estimates, measuring quality, and developing plans (Gerry and Rory, 2007). Rico (2004) defines the Software Process Improvement as "an approach to designing and defining a new and improved software process to achieve basic business goals and objectives." SPI is simply the act of changing the software process and maintenance activities. The aims are normally to decrease costs, increase efficiency, and also to increase profitability. For instance, SPI could be employed to create a new and enhanced process for software development organizations.

There is a widespread belief that a good software product is the result of mature and repeatable software processes, which have led to a greater focus on SPI to assist software development organizations for potential benefits. Thus, the search for new methodologies, ideas, and innovations to enhance software development continues to be an essential focus for both academic and industrial research. In order to improve software development practices, many attempts (SEI, 2002, SEI 2004, SEI, 2007) have concentrated on defining, measuring, and monitoring development activities in an effort to identify and verify improvement areas. These attempts have led to the emergence of the term Process Model. A Process Model is defined as "a structured collection of practices that describe the

characteristics of effective processes" (SEI, 2007). An organization can define a process improvement priorities and objectives to make its processes capable, stable, and mature with the help of a process model. Moreover, a process model provides a guideline for an organization to monitor its current state, identify relevant improvement activities and how to start these activities (SEI, 2007).

Efforts spent in this area have resulted in several SPI models and standards such as the Team Software Process (TSP) (Humphrey, 1995), the ISO 9000 (Paulk, 1995a), the Six Sigma (Pyzdek, 2003), the Carnegie Mellon Software Engineering Institute's Capability Maturity Model for Software (SW-CMM) (Paulk et al., 1995b), and its most recent version, the Capability Maturity Model Integration (CMMI) (Chrissis et al., 2007).

2.2.1 Benefits of Software Process Improvement (SPI)

Software Process Improvement is significant because it is the primary means by which a new and enhanced software developing process is created. This is done in order to achieve important economic benefits at the least cost. Rico (2004) proposed a well-designed software development process that has a positive impact on the economic performance of software projects. Performance is usually measured in terms of productivity as well as the efficiency of the cost (Rico, 2004). On the other hand, poorly designed software development processes have negative consequences on the economic performance of software projects because a poor software development process results in high operations cost, ineffective use of available resources, and lost opportunities in the market. According to Rico (2004), poorly designed processes result in a lack of quality and reliability, and

poor customer satisfaction. That is why the SPI has emerged as an important paradigm for managing software development (Ravichandran and Ria, 2003).

There are several benefits that can be gained from the adoption of one or more SPI models or standards. As shown in Figure 2.1, Gibson et al., (2006) described the effect of process improvement. The left box illustrates the costs of the process improvement. Some of these might be planned investments for the process improvement; others might be expenses indirectly or directly related to the process improvement. Process capability and organizational maturity are shown in the upper centre box. Organizations enhance their processes in order to achieve other benefits, and they use process capability and organizational maturity to compare and evaluate their results. The box on the right hand side illustrates different categories of benefits that organizations most frequently struggle to attain as a result of their efforts in process improvement. Also a combination of the costs and benefits can be used to calculate the Return on Investment (ROI) or some related measures, as shown in the bottom centre box of Figure 2.1.

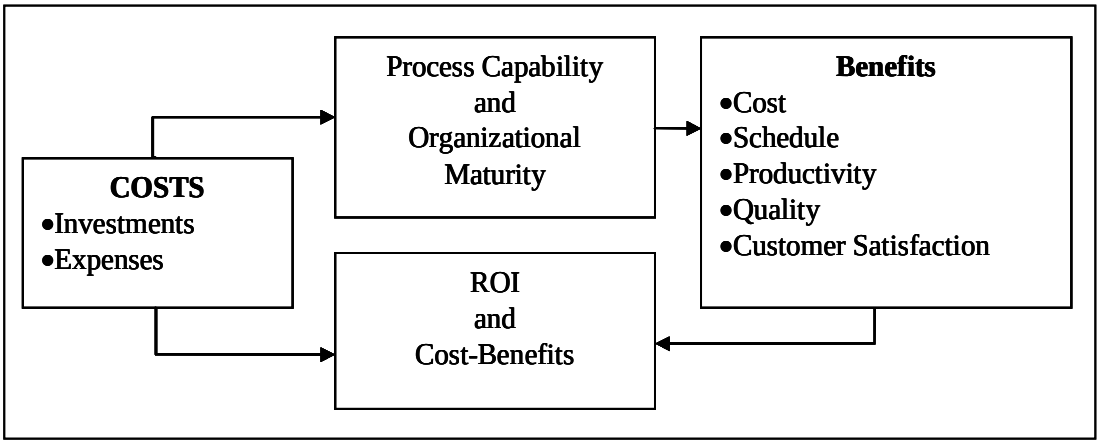

Figure 2.1 High-Level Model of CMMI Impact (Gibson et al., 2006).

As illustrated in Figure 2.1 above, the potential benefits of process improvement may be achieved and classified into six categories such as cost, schedule, productivity, quality, customer satisfaction, and the ROI. According to (Gibson et al., 2006), enhancement in the above six categories can participate to further business goals, such as reduced productivity time, lower cost for products, and higher quality.

Organizations typically seek to adopt some combination of the five basic categories of benefits which are shown in the box on the right hand side of Figure 2.1; any of the five benefits can be refined to include a variety of more particular measures. For example, an organization might be more concerned with decreasing the costs of its services and products while another organization might be interested in having more reliable predictable project costs, effort, or schedules. The above six categories of performance are described in Table 2.1.

Table 2.1 Description of the six performance categories.

Category	Description
Cost	The cost covers instances where the organizations report changes in the cost of final or intermediate work products, changes in the cost of the processes employed to produce the products, and general savings attributed to model-based process improvement. It also includes increased predictability of costs incurred and other measures of variation.
Schedule	This category covers improvements in schedule predictability and reductions in the time required to do the work.
Productivity	Productivity includes various measures based on the amount of work accomplished in a given period of time.
Quality	Improvement in product quality is most frequently measured by reductions in the number of defects.

Customer Satisfaction	This category generally includes changes based on customer surveys. Award fees also are sometimes used as surrogate measures.
Return on Investment	In addition to benefit-to-cost ratios, this category includes companion measures of net present value, internal rate of return, payback periods, and break even points.

2.2.2 Software Process Improvement Frameworks

This section describes the common SPI models such as Capability Maturity Model (CMM), Capability Maturity Model Integration (CMMI), ISO 9000, and Six Sigma.

2.2.2.1 The Capability Maturity Model (CMM)

The Capability Maturity Model is a staged evolutionary model. It categorizes the software process maturity into five levels; Level 1 (Lowest) mentions all levels to Level 5 (Highest), and a set of 18 Key Process Areas (KPA). The organization must demonstrate a capability in a certain number of KPAs assigned to a specific Level in order to be rated at that level. At different maturity levels, key process areas can be used for assessing the capability of existing processes as well as for identifying the areas that need to be strengthened so as to move the process to a higher level of maturity. The five maturity levels of the CMM are Initial, Repeatable, Defined, Managed, and Optimized.

The Capability Maturity Model (CMM) (Paulk et al., 1995a; Paulk et al., 1995b) focuses on the various processes involved in software development. It presents the key elements of an effective software process in describing an evolutionary improvement path for software organizations from ad hoc immature processes to a mature disciplined one (Paulk et al.,

1995b). It was created and developed by attentive observations of best practices in both software and non-software organizations. The framework is thus based on actual practices while reflecting the best of the state of the practice as well as the needs of individuals performing the software process improvement and software process appraisal (Paulk et al., 1995b). The Software Engineering Institute (SEI) at Carnegie Mellon University released the Software Capability Maturity Model (SW-CMM) in 1991 as a model for enhancing an organization's software processes capabilities, and it is widely used by software organizations.

Since the release of the (SW-CMM), it has been applied to a number of areas; therefore, several capability maturity models have been provided. These include the people CMM (P-CMM) (Curtis et al., 1995), the system engineering CMM (SE-CMM) (EPIC, 1996), the software acquisition CMM (SA-CMM) (Cooper and Fisher, 2002), and the integrated product development CMM (IPD-CMM) (EPIC, 1996). As these various models were built by different organizations, there were overlaps in the application's scopes in addition to a lack of consistency in the terminology, assessment approach, and architecture. These problems led to an increase in the time and cost of adopting multiple models. Therefore, the SEI released the Capability Maturity Model Integration (CMMI) in order to integrate all the existing CMM in August 2000. The CMM was replaced by a new process model, which is the Capability Maturity Model Integration (CMMI) (SEI, 2002). The CMMI was created to reduce redundancy, to support product and process improvement, and to eliminate the undesired inconsistency that was being experienced by organizations that were using multiple models. CMMI joined all the relevant process models found in the CMM into one product suite (SEI, 2007).

Table 2.2 CMM Framework (Paulk et al. 1995b).

SW-CMM Levels	Key Process Area
Level 1	None
Level 2 Repeatable	Requirements Management
	Software Project Planning
	Software Project Tracking and Oversight
	Software Subcontract Management
	Software Quality Assurance
	Software Configuration Management
Level 3 Defined	Organization Process Focus
	Organization Process Definition
	Training Program
	Integrated Software Management
	Software Product Engineering
	Intergroup Coordination
	Peer Reviews
Level 4 Managed	Quantitative Process Management
	Software Quality Management
Level 5 Optimizing	Defect Prevention
	Technology Change Management
	Process Change Management

2.2.2.2 Capability Maturity Model Integration (CMMI)

The main focus of this research is on CMMI, with CMMI being discussed in detail in the review more than other Software Process Improvement standards. CMMI can be described as a collection of best practices collected from previous experiences with the preceding CMM, and other models and standards (SEI, 2007; SEI, 2009). CMMI defines how an influential process must look like. It offers practitioners with a suitable framework so that enhancement activities can be defined and organized. Moreover, CMMI enables organizations to deal with multi-disciplined activities and to easily combine process improvement aims with organizational business goals (SEI, 2007).

The CMMI product suite is the complete set of products developed around the CMMI concept. These products include the framework itself, models, appraisal methods, appraisal materials, and various types of training. Its models cover several disciplines, which are System Engineering (SE), Software Engineering (SW), Supplier Sourcing (SS), and Integrated Product and Process Development (IPPD) (Chrissis et al., 2003; SEI, 2004; SEI, 2007; SEI, 2009) which are described as follows:

- System Engineering (SE): It covers the total systems development, which might or might not include software. It concentrates on transferring the needs of the customers, constraints, and expectations into products and trying to support all these products through their life.
- Software Engineering (SW): It covers the development of the software system. Software engineers concentrate on applying quantifiable, systematic, and disciplined approaches to the software operation, maintenance, and development.

- Supplier Sourcing (SS): Due to more complicated work efforts, project managers usually use suppliers to perform some functions to the products that are needed by the project being developed.
- Integrated Product and Process Development (IPPD): This is a systematic approach that performs a timely cooperation of relevant stakeholders through the product's life to satisfy the customer's expectations, needs, and requirements. The processes to support an IPPD approach should be incorporated with other processes in the organization if the IPPD approach is chosen by a project or organization.

These multiple disciplines are due to support a wide process improvement and thus utilize the benefits of such an integrated model. The ultimate benefit of CMMI is to enhance the contractor's capability and to evaluate their ability to perform software development.

A constellation is a subset of the CMMI product suite relevant to improvements in a particular area of interest. Currently, there are several constellations: Development (DEV), Acquisition (ACQ), and Services (SVC) (SEI, 2007; SEI, 2009).

- CMMI-DEV

The CMMI-DEV (SEI, 2007; SEI, 2009) is a process improvement model for the development of products. It contains the best practices that address development and maintenance activities that include the product lifecycle from elicitation through deployment and maintenance.

- CMMI-ACQ

  The CMMI-ACQ (SEI, 2007; SEI, 2009) provides a guideline to acquisition organizations for initiating and managing the acquisition of products and services that match the needs of the customer. The model concentrates on acquirer processes and

integrates bodies of knowledge that are essential for successful acquisitions. The aim of the CMMI-ACQ model is to affect the outcome of the acquisition process, delivering the right capabilities to operational users to avoid over-scheduling and to be at predictable costs through the disciplined application of efficient and effective acquisition processes.

- CMMI-SVC

The CMMI-SVC is a model (SEI, 2007; SEI, 2009) produced to cover the activities needed to manage, establish, and deliver services. The best practices in the model concentrate on activities for producing quality services to customers and end users. The CMMI-SVC constellation produces a guideline for the application of CMMI and integrates bodies of knowledge that are essential for a service provider.

2.2.2.2.1 CMMI Process Areas

The term Key Process Area (KPA) in CMM has been replaced with Process Area (PA) in the CMMI model. PA is "a cluster of related practices in an area that, when implemented collectively, satisfies a set of goals considered important for making significant improvements in that area" (Chrissis et al., 2007).

In CMMI there are 22 process areas, divided into four categories of process management, project management, engineering, and support. Table 2.3 explains these PAs as follows:

Table 2.3 Process areas in CMMI Staged & Continuous representation (Chrissis et al., 2003).

Abbreviation	Process Area	Category
PP	Project planning	Project Management
PMC	Project monitoring and control	
SAM	Supplier agreement management	
IPM	Integrated project management	
RSKM	Risk management	
QPM	Quantitative project management	
OPF	Organizational process focus	Process Management
OPD	Organizational process definition	
OT	Organizational training	
OPP	Organization process performance	
OID	Organization innovation and deployment	
REQM	Requirements management	Engineering
RD	Requirements development	
TS	Technical solution	
PI	Product integration	
VER	Verification	
VAL	Validation	
CM	Configuration management	Support
PPQA	Process and product quality assurance	
MA	Measurement and analysis	
DAR	Decision analysis and resolution	
CAR	Causal analysis and resolution	

2.2.2.2.2 Process Area Components

The components found in each process area are grouped into three categories such as required, expected, and informative, which reflect how to interpret them (SEI, 2007). These categories are described as follows:

- Required components

Required components describe what an organization must achieve to satisfy a process area. This achievement must be visibly implemented in an organization's processes. The required components in CMMI are the specific and generic goals. Goal satisfaction is used in appraisals as the basis for deciding whether a process area has been satisfied (SEI, 2007).

- Expected Components

Expected components describe what an organization may implement to achieve a required component. Expected components guide those who implement improvements or perform appraisals. The expected components in CMMI are the specific and generic practices. Before goals can be considered to be satisfied, either their practices as described, or acceptable alternatives to them, must be present in the planned and implemented processes of the organization (SEI, 2007).

- Informative Components

Informative components provide details that help organizations understand the required and expected components. Sub-practices, typical work products, goal and practice titles, goal and practice notes, examples, and references are examples of informative model components (SEI, 2007).

2.2.2.2.3 Process Area Contents

Each CMMI process area (PA) is described by (Kasse, 2004; SEI, 2007):

- Purpose: describes the purpose of the process area.
- Introductory Notes: describe the major concepts covered in the process area.
- Related Process Area: lists references to related process areas and reflects the high level relationships among the process areas.
- Specific Goals (SGs): apply to one process area and the unique characteristics that describe what must be implemented to satisfy the purpose of the process area.
- Generic Goals (GGs): are called generic because the same goal appears in multiple process areas, which means GGs apply to more than one process area. GGs describe the characteristics that must be present to institutionalize the processes that implement a process area.
- Specific Practices (SPs): describe the activities expected to result in the achievement of the specific goals of a process area.
- Generic Practices (GPs): are activities that ensure that the processes associated with the process area will be effective, repeatable, and lasting. GPs are called generic because the same practice appears in multiple process areas.
- Typical Work Products: are sample outputs of specific practices and is not a complete list.
- Sub-practices: These are detailed descriptions that provide guidance for interpreting and implementing a specific or generic practice.
- Generic Practice Elaborations: These appear after the generic practice to provide guidance on how the generic practice may be applied in the context of a process area.

- Note: This is a text that may provide details, background, or rationale.
- References: These are pointers to additional or more detailed information in related process areas.

2.2.2.2.4 Choosing a Representation

In CMMI, there are two representations (Chrissis et al., 2007; SEI, 2009) that can be selected for implementation by an organization: Staged and Continuous Representation.

1. **Staged Representation**:

The process areas in a staged representation of CMMI are organized into five levels of maturity (Chrissis et al., 2007; SEI, 2009), which are: Initial (Maturity Level 1/ ML1), Managed (Maturity Level 2/ ML2), Defined (Maturity Level 3/ ML3), Quantitatively Managed (Maturity Level 4/ ML4), and Optimizing (Maturity Level 5/ ML5).

According to Chrissis et al. (2007), the staged representation "prescribes the order for implementing each process area according to maturity levels (MLs), which define the improvement path for an organization from the initial level to the optimizing level." Table 2.4 describes the CMMI staged representation and its process areas.

Table 2.4 CMMI Maturity levels (Staged representation) (Chrissis et al., 2007).

Process Area	Description	Maturity Level
OID	A quality managed process that is changed and adapted to meet relevant current and projected business objectives.	ML 5 (Optimizing)
CAR		
OPP	A defined process that is described in more detail and is performed more rigorously than the managed process.	ML 4 (Quantitatively managed)
QPM		
RD	A managed process that is tailored from the organization's set of standard processes according to the organization's tailoring guidelines, has a maintained process description and contributes work products, measures, and other process improvements information to the organizational process needs.	ML 3 (Defined)
TS		
PI		
VER		
VAL		
OPF		
OPD		
OT		
IPM		
RSKM		
DAR		
REQM	A performed process that is planned and executed in accordance with policy.	ML 2 (Managed)
PP		
PMC		

SAM MA PPQA CM		
None of process areas	The process accomplishes the work necessary to produce work products.	ML 1 (Initial)

2. **Continuous Representation**:

The CMMI continuous representation provides the same process areas like the staged representation. However, no process area is allocated to a certain maturity level. The continuous representation grants software firms the flexibility to choose any process area they want to enhance and enable them to choose the order that meets their business objectives or reduces development risk. To measure the achievement of a certain process area for an organization, the continuous representation offers six capability levels, which are: Initial (Capability Level 0/ CL 0), Performed (Capability Level 1/ CL 1), Managed (Capability Level 2/ CL 2), Defined (Capability Level 3/ CL 3), Quantitatively Managed (Capability Level 4/ CL 4), and Optimizing (Capability Level 5/ CL 5).

The continuous representation offers organizations the flexibility to improve various processes at various rates. As an example, the organization may want to achieve CL 2 in a certain process area and CL 4 in another one.

Table 2.5 CMMI Capability levels (Continuous representation) (Chrissis et al., 2007).

Capability Level	Description
CL 5 (Optimizing)	A quality managed process is improved based on an understanding of the common causes of variation inherent in the process.
CL 4 (Quantitatively Managed)	A defined process that is controlled using statistical and other quantitative techniques.
CL 3 (Defined)	A managed process is tailored from the organization's set of standard processes according to the organization's tailoring guidelines and contributes work products, measures, and other process improvements information to the organizational process assets.
CL 2 (Managed)	A performed process has the basic infrastructure in place to support the process.
CL 1 (Performed)	The process satisfies the specific goals of the process area, and supports and enables the work needed to produce the work product.
CL 0 (Incomplete)	The process is either not performed or partially performed.

The term "Maturity Level" belongs to the staged representation and denotes an organization's overall process capability and organizational maturity, whereas the term "Capability Level" belongs to the continuous representation and denotes an organization's process improvement achievement for each process area (Chrissis et al., 2007; SEI, 2009).

- Comparison of continuous representation and staged representation

Table 2.6 compares the six capability levels of continuous representation to the five maturity levels in staged representation. Notice that in both representations, four of the levels have the same names. This is because there is no maturity level 0 for the CMMI staged representation and when the capability level is Performed at level 1, the maturity level is Initial. So, the starting point is not the same for the two representations.

Table 2.6 Comparison of Capability and Maturity Levels (Chrissis et al., 2003).

Staged Representation (MLs)	Continuous Representation (CLs)	Levels
N/A	Incomplete	Level 0
Initial	Performed	Level 1
Managed	Managed	Level 2
Defined	Defined	Level 3
Qualitatively Managed	Qualitatively Managed	Level 4
Optimizing	Optimizing	Level 5

Because the staged representation is focused on the organizational overall maturity of a set of processes, whether an individual process area is incomplete or performed is of little consequence. Therefore, the name "Initial" is given to the starting point of the staged representation (Chrissis et al., 2003; SEI, 2009).

2.2.2.2.5 Benefits of CMMI-based Software Process Improvement

The SEI (2007) reported several benefits of the CMMI-based process improvement, which include:

1. Enhancement of time and budget.
2. Increase in productivity.
3. Enhanced quality of the product.

4. Increase in customer satisfaction.
5. High employee morale.
6. High return on investment.
7. Decrease in proposed cost of quality.

According to Bollinger and McGowan (2009), by adopting CMMI on the software projects mentioned, the results were considerable in a consistent context of schedules, configuration management, requirements traceability, validation and verification, and other related processes. Case studies have also shown the benefits from the CMMI-based Software Process Improvement (El Emam, 2007; Liu, 2007; Sapp et al., 2007; Peter and Sharon, 2007; Garmus and Iwanicki, 2007; McGibbon et al., 2007; Gibson et al., 2006; Huang et al., 2006; Goldenson and Gibson, 2003). Among these case studies, Huang et al. (2006) considered the performance assessment for both tangible and intangible benefits of the CMMI adoption and presented the results of the performance assessment of the CMMI-based Software process improvement based on an empirical study from 18 software firms in Taiwan, which had already obtained CMMI maturity level 2 and 3 certifications. They argued that their empirical study revealed that the CMMI-based software process improvement generally had a positive effect on the six performance dimensions in their investigated software firms.

Goldenson and Gibson (2003) reported some great and credible quantitative evidence that the CMMI-based software process improvement can help an organization to achieve higher quality products and better project performance with lower cost, decreased project schedule, and increased customer satisfaction.

2.2.2.3 International Organization for Standardization (ISO 9000)

The ISO 9000 is a generic standard for quality and can be applied to any production environment. It has been developed by the International Organization for Standardization (ISO) which is located in Geneva, Switzerland. It is used to ensure that suppliers comply with specific requirements during several development stages that include design, development, installation, and servicing. It may include environments that develop technology products and it is expressed at a high level that made it appropriate for the IT industry (Persse, 2006).

2.2.2.4 Six Sigma

Six Sigma is a systematic technique used by different organizations in order to improve productivity, business performance and profitability, enhance customer's satisfaction, and reduce the operational cost of the company (Pyzdek, 2003). Six Sigma is typically designed to be applied in manufacturing or business environments (heavy-transaction). Six Sigma has been applied in technology development shops, but its full range of applications may not be suitable for projects like mid-level software and systems development (Persse, 2006). It may offer greater benefits to IT organizations with stable performance which can be now measured and enhanced.

2.2.2.5 Comparison of Standards for Common SPI Models

Process Improvement Standards are not really suitable choices that are exclusively mutual; they can be applied together (Persse, 2006). Large organizations may operate in the ISO 9000 environment and have their IT section under the umbrella of the CMMI since it may measure the performance of such CMMI programs by using the Six Sigma (Persse, 2006). On the other hand, small new organizations might probably focus on the standard that

appears best suited to their needs. Persse (2006) has made a comprehensive comparison between CMMI, ISO 9000, and Six Sigma which is summarized below:

- CMMI, ISO 9000, and Six Sigma share numerous similar features and characteristics.
- The programs of the three standards can be implemented in tandem with one another or independently.
- ISO 9000 is considered a generic standard for quality that could be used in any production environment.
- ISO 9000 might be best implemented in firms in which the quality system required crosses several different kinds of functional areas.
- CMMI is a model of process improvement which is designed specifically for use in technology environments.
- CMMI may be best implemented in IT firms that are charged with software and systems development.
- Six Sigma is a process improvement approach that is based on some statistical analyses and processes designed to reflect the customer‘s voice.

2.2.2.6 Transition Time of CMM/CMMI based Software Process Improvement

The Software Engineering Institute (SEI) has published reports (SEI, 2004; SEI 2009) which include the time to move from one CMM/CMMI level to another. The SEI (2004) has explained that for organizations which began their CMM-based SPI effort in 1992 or later, that the time to move from:

- Maturity level 1 to 2 is 22 months.
- Maturity level 2 to 3 is 19 months.
- Maturity level 3 to 4 is 25 months.
- Maturity level 4 to 5 is 13 months.

On the other hand, the SEI (2009) and SEI (2007) have illustrated that for organizations that began their CMMI-based SCAMPI effort in 2002 or later, the time to move from:

- Maturity level 1 to 2 is 4 months.
- Maturity level 2 to 3 is 18 months.
- Maturity level 3 to 4 is 19 months.
- Maturity level 4 to 5 is 13 months.

Based on the transition time of the CMM and CMMI models, the study noticed that there is a different time taken in the CMMI model compared to transition time taken in the CMM model. This might be due to the difference in Process Areas and practices which exist in each level of the models.

2.3 Effect of Geographical Region on Software Process Improvement

The Geographical Region has been one of the most effective issues on software process improvement (Jung and Goldenson, 2009). Whereas, various geographical regions have a variety of capability levels, the use of different regions of assessed organizations, can lead to different analysis results (Jung and Goldenson, 2009).

The SEI's Process Maturity Profile (SEI, 2006) explored the classification of the SW-CMM and CMMI maturity levels by geographical regions, which are categorized as US and non US organizations. A case study comparing Siemens companies located in Germany with those in the US states the significant difference of cultural factors in the software process improvement (Paulish and Carleton, 1994), whereas the same software process improvement methods were selected and implemented at case study sites in Germany and US, often using the same training courses and trainers. However, the way that the methods were introduced and the level of acceptance of the methods were very different between the German and US sites. This indicates that the geographical region characteristics have a significant role in the software improvement process (Paulish and Carleton, 1994).

Several researches confirmed the importance of being aware of the differences between the various national, organizational, and geographical region culture levels which affect the SPI (McGuire, 1996; Debou et al., 1999; Rodenbach et al., 2000; Kauppinen and Kujala, 2001; Conradi and Fuggetta, 2002). This means that neither SPI solutions nor programs can be transferred successfully as such. The specific cultural features need to be understood and even the same language needs to be spoken (Debou et al., 1999).

According to a survey of 64 software professionals, McGuire (1996) binds cultural aspects with change management strategies and training, and reasons that if put together these may

have a substantial effect on the percentage of the improvement progress. Kauppinen and Kujala (2001) propose that the SPI calls for a cultural change, and they go on to argue that, basically, cultural change requires that the personnel understand the reason for the change. To alleviate the difficulty of cultural transformation, Conradi and Fuggetta (2002) propose that the SPI should even utilize expertise from social studies. As it is ineluctable that culture differs from organization to organization, and from one geographical region to another, it can be understood that the ready-wrapped solutions are bound to be insufficient and thus also likely to cause opposition.

In multinational corporations, often there are conflicting demands from their business units as the growth and maturity of their operations vary from one geographic region to another (Khandelwal and Ferguson, 1999). A system that performs effortlessly in one geographical region may be a total failure in another because the management in different geographic regions faces different sets of IT cases (Khandelwal and Ferguson, 1999).

Ehn (1992) shows that cultural differences between the US and Scandinavia, in particular on quality management, organizational learning, and the SPI lead to different results. Therefore, in most of cases, this indicates the impact of geographical regions on most of the results of studies that apply in different geographical regions.

2.4 Factors That Affect Successful Implementation of Software Process Improvement

Software quality has become more critical as software permeates our lives (Paulk et al., 1994). The ability to deliver qualified software within budget and schedule remains an obsession with most software organizations (Paulk et al., 1994). There are some technical quality initiatives which have appeared over the last few years, such as CASE tools and organizational initiatives such as the Capability Maturity Model (CMM) (Paulk et al., 1993), and more recently the Capability Maturity Model Integration (CMMI) (SEI, 2002), which were produced to improve software processes. It has been proposed that, irrespective of whether a quality initiative is technical or organizational, the ineffective implementation of these initiatives can significantly influence the success of SPI efforts (Florence, 2001).

A number of empirical studies have investigated the factors that positively or negatively affect the SPI success (e.g. Stelzer and Werner, 1999; Goldenson and Herbsleb, 1995; Rainer and Hall, 2002; El-Emam et al., 1999). These factors are: Senior Management Commitment, Staff Involvement, Training and Mentoring, Staff and Resources, Creating Process Action Teams, Agents and Opinion Leaders, Reviews, Experienced Staff, Clear and Relevant SPI Goals, Assignment of Responsibility for SPI, Reward Schemes, Managing the SPI Project, Providing Enhanced Understanding, Internal Leadership, and Standards and Procedures.

The fifty six software organizations that have either adopted an ISO 9000 quality system or adopted a process improvement initiative based on the CMM defined 10 factors that influence organizational change in the SPI (Stelzer and Werner, 1999).

El-Emam et al. (1999) enhanced the study of Goldenson and Herbsleb (1995) and investigated some success factors and barriers to the SPI. They used data from 14

companies involved in the SPICE (Software Process Improvement and Capability Determination) trials in order to specify the factors that are strongly related to the success of software process improvement efforts and those that have no effect.

A survey of 85 UK organizations by Rainer and Hall (2002) identified the key success factors that can affect the SPI implementation. The results show that the practitioners considered that 4 factors have a major effect on the successful implementation of the SPI. These factors are reviews, standards and procedures, training, mentoring, and experienced staff. The authors also specified another four factors such as internal leadership, inspections, executive support, and internal process ownership that more mature companies considered as having a major effect on the successful implementation of software process improvement.

Goldenson and Herbsleb (1995) conducted a survey on 138 practitioners in 56 software organizations and identified the factors necessary for implementing a successful SPI program. The researchers identified a number of factors related to successful software process improvement programs and factors related to unsuccessful SPI programs without mentioning the impact of the factors on the time. Whereas, these respected studies were interested in the success of SPI implementation and didn’t mention the duration time needed to achieve the SPI program, however this researcher noticed that there is a relationship among SPI successful implementation factors and the transition time factors of CMMI. The researcher attributes that the CMMI is a SPI model, and therefore it is natural that there is a relationship.

2.5 Factors that affect the Transition Time of CMMI based Software Process Improvement.

In the last decade, many studies have been done into the transition time between CMMI levels (Jackelen, 2007; Iversen and Ngwenyama, 2006; Tufail et al., 2006). Jackelen (2007) started a CMMI program to achieve the goal of CMMI Level 2 and satisfaction process areas within five months. The current status of the company was analysed and the top management decided to extend the planned schedule of the program for one month. The case study (Jackelen, 2007) discussed how it was possible to achieve CMMI Level 2 in six months. The factors identified in the study were: Management Commitment, Experienced Staff, Consultant, Training, Awareness, and Quality Environment. However, the study did not provide any technique or strategy to overcome these factors that affected the CMMI transition time.

Tufail et al. (2006) explored how CMMI Level 3 was achieved within 8 months instead of the average time of 22 months according to the SEI data (2009). In that study, the identified factors were: Awareness, Staff Involvement, Management Commitment, Training, Experienced Staff, Quality Environment, Implementation Plan, Consultants, and Reviews. However, the study did not explore how they overcame these factors and what kinds of methods were used by them to accelerate the CMMI implementation process.

Guererro and Eterovic (2004) explored a case study that achieved the movement from CMM Level 1 to CMM Level 2 in 10 months, which would have been achieved in 19 months according to the SEI data (2004). They analysed ten factors that affect the adoption of the CMM. These factors were: Training, Developer's Involvement, Maintaining Momentum, Group Focus, Frequency of Process Assessments, Champions, and Visibility into the SPI process.

Balla et al. (2001); Iversen and Ngwenyama (2006); and Akmenek and Tarhan (2003) have described how the organizations can achieve CMM-Level 3 in 7-months' time which would have been achieved in 19 months according to the SEI (2004) . The identified factors were: Management Commitment, Awareness, Staff Involvement, Training, Experienced Staff, Consultations, and Quality Environment. However, they mentioned that the organizations should address these factors but they did not provide any suggested practices or proposed some activities to reduce the impact of these factors.

Olson and Sachlis (2002) discussed the movement from CMM-Level 1 to CMM-Level 3 in 14 months, which would have been completed in 38 months based on the SEI data (2004). The identified factors were Management Commitment, Staff Involvement, Training, Consultant, Implementation Plan, and Process Documentation. Zeid (2004) has explained how the organization, ITSoft moved from CMM Level 2 to CMM Level 3 in a short time of just two months and from CMM Level 1 to CMM Level 2 in 9 months. The identified factors were: Training, Experienced Staff, Quality Environment, Implementation Plan, Process Documentation, and Metrics and Measurement.

The researcher noticed that from study to study there were different factors and the studies didn't provide any methods, frameworks, or strategies to reduce the effect of these factors on the CMMI transition time during the CMMI implementation process. Moreover, these respected studies did not include the impact of geographical region on the factors and how the results would be if we were to apply the same study in a different geographical region. Therefore, why are there different factors and different transition times of CMMI from one study to another? And how can a reference model be provided which has some of the practices that include the activities that would overcome the effect of these factors?

2.6 Summary

SPI has become highly visible over the past few years. Hence, SPI can only be effectively addressed by blending people, processes, and technology issues. From reviewing the literature on the SPI, CMMI, and the factors that affect the transition time from the geographical region perspective, some conclusive remarks were extracted and listed below:

- Potential benefits of process improvement may be achieved and classified in six categories: cost, schedule, productivity, quality, customer satisfaction, and the return on investment (ROI).
- The above six categories can participate to further business goals, such as, reduced productivity time, lower cost for products, and higher quality.
- According to Persse (2006), the common software process improvement standards that are currently used widely are CMM, CMMI, ISO 900, and Six Sigma.
- The Capability Maturity Model (CMM) focuses on the various processes involved in software development. It is a staged evolutionary model. It categorizes the software process maturity into five levels; Level 1 (Lowest) to Level 5 (Highest), and a set of 18 Key Process Areas (KPA).
- CMMI can be described as a collection of best practices, collected from previous experiences with the preceding CMM, and other models and standards. CMMI defines how an influential process must look like. It offers practitioners with a suitable framework, so that enhancement activities can be defined and organized. It has two representations, a staged representation and a continuous representation. A staged representation is categorized into five levels, with a set of 22 Process Areas (PA).

- CMMI enables the organization to deal with multi-disciplined activities and to easily combine process improvement aims with organizational business goals.
- CMMI models cover several disciplines, which are System Engineering (SE), Software Engineering (SW), Supplier Sourcing (SS), and Integrated Product and Process Development (IPPD).
- ISO 9000 is a generic standard for quality. It is used to ensure that suppliers comply to specific requirements during several development stages, including design, development, installation, and servicing.
- ISO 9000 can be applied to any production environment; it may include environments that develop technology products.
- Six Sigma is a systematic technique used by organizations in order to improve productivity, business performance and profitability, enhance customer satisfaction, and reduce the operational cost of the company.
- Six Sigma is typically designed to be applied in manufacturing or business environments (heavy-transaction).
- Geographical Region has been one of the most effective issues on software process improvement, and there needs to be greater mention regarding its impact on six categories of SPI benefits and its effect on the transition time between CMMI levels.
- There have been numerous prior studies that investigated the factors that affect the success of Software Process Improvement initiatives. Thus, they extracted some factors that affect the software process improvement success in companies that adopted the SPI models, specifically those who adopted ISO 9000 or CMM.

- There have been many studies into the transition time between CMMI levels. However, those respected studies did not mention any framework, reference model, or guideline to overcome and avoid the impact of those factors on the CMMI transition time.

Table 2.7 summarizes the Transition Time Factors in the literature review.

Table 2.7 Transition Time Factors in Literature Review

Factors	Transition Time Factors in Literature Review									
	(Jackelen, 2007)	**Guerrero and Eterovic, 2004)**	**(Tufail et al., 2006)**	**(Balla et al., 2001)**	**(Yasemin, 2009)**	**(Akmenek and Tarhan, 2003)**	**Balla et al., 2001)**	**(Olson and Sachlis , 2002)**	**(Iversen and Ngwenyama, 2006)**	**Zeid, 2004)**
Management Commitment	√	√	√	√	√	√	√	√	√	-
Frequency of process assessment	-	√	-	-	-	-	-	-	-	-
Separation of process and product concerns	-	√	-	-	√	-	-	-	-	-
Management & Staff involvement	-	√	-	√	√	√	√	√	√	-
Training and mentoring	√	√	√	√	√	√	√	√	√	√
Creating process action teams and Reviews	-	-	√	√	√	√	-	-	-	-
Defined SPI implementation methodology	-	-	√	√	√	-	-	√	-	√
Awareness	√	√	-	√	√	√	√	-	√	-
CMMI Experienced staff	√	-	√	√	√	-	√	√	√	√
Communication	-	-	-	-	√	-	-	-	-	-
Group focus	-	√	-	-	√	√	-	-	-	-
Process documentation	-	-	-	-	√	√	-	√	-	√
Consultation	√	-	-	-	√	√	√	√	√	-
Metrics and Measurement	-	-	-	-	√	-	-	-	-	√
Allocation of resources	-	-	√	√	-	-	-	-	-	-
Rewarding & Motivation	-	√	-	-	-	√	-	-	-	-
Parallelism between standards	-	-	-	-	√	-	-	-	-	-
Gap analysis	-	-	-	-	√	-	-	-	-	-
Resistance to change	-	-	√	-	√	-	-	-	-	-
Visibility into the SPI process planning	-	√	√	-	-	-	-	-	-	-

In addressing the knowledge gap that is presented in this chapter, this study will contribute to the software engineering field by providing a novel extension to the efforts that have

been made by respected researchers in the SPI. The next chapter will explain the research methodology.

CHAPTER THREE - RESEARCH METHODOLOGY

3.1 Introduction

The purpose of this study is to identify and investigate the factors that affect the transition time of CMMI-based software process improvement and to what extent the geographical region can affect these factors. The proposed results will be used to produce a reference model (in Chapter Five) to reduce the effects of these factors and consequently to reduce the transition time of CMMI. Therefore, this chapter describes the research methodology that is used in order to achieve the objectives of this study. Section 3.2 explains the theoretical framework. Section 3.3 describes the research design for this study. Section 3.4 describes the research strategy implementation. Section 3.5 describes the interview process. The questionnaire survey is explained in Section 3.6. Section 3.7 defines triangulation. The population and sampling are described in 3.8. Section 3.9 describes the data collection. The data processing is described in section 3.10. Section 3.11 explains the data analysis method. Ethical considerations are considered in section 3.12. Section 3.13 summarizes the research methodology in this study.

3.2 Theoretical Framework

3.2.1 Theoretical Framework Development Process

Preparatory work is carried out at the initial stage of this study. The preparatory work includes conducting an extensive literature review and interviews in order to collect the factors for investigation before proceeding to conduct the questionnaire survey. Upon completion of this step, a research gap has been identified from the recent research problems background, research questions, and hypotheses. Therefore, a theoretical framework development process is used which is shown in a diagrammatic form in Figure 3.1.

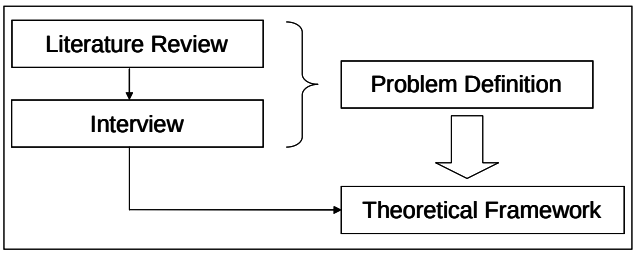

Figure 3.1 Theoretical Framework Development Process

3.2.2 Data Needed

In order to test the hypothesis, quality data are required. Data can be divided into primary data and secondary data. Apart from this classification, data are also usually discussed in terms of quantitative and qualitative data. These are explained as follows.

3.2.2.1 Primary and Secondary Data

The data needed can be either first hand or data that is already available for the researcher, which is known as secondary data. The firsthand data in this study is collected through interviews and the questionnaire survey. This firsthand data is known as primary data (Sekaran, 2008).

The secondary data that are available to researchers are in the form of reports, journals, publications, newspapers, industry reports, and recent researches (Sekaran, 2008).

In this study, both primary and secondary data are used for data analysis. The primary data are from interviews and the questionnaire survey conducted as part of the data collection. The secondary data is compiled from the literature review.

3.2.2.2 Quantitative and Qualitative Data

Data can be either quantitative or qualitative (Winter, 2000). The quantitative data in this study is derived by conducting a questionnaire survey. The quantitative method is used in the questionnaire data collected for hypothesis statistical data analysis. The composition of the questions in the questionnaire was all close-ended questions as prescribed by Jonker and Pennink (2010). This was also confirmed by Saunders et al., (2009) who suggested that in a quantitative study, the data is usually numerical data.

The qualitative data in this study is obtained from the interview. The qualitative method is mainly used in this study for the interview as data collection method and categorizes data analysis. This qualitative data is non-numeric, arising from open-ended questions asked in the interview (Jonker and Pennink, 2010).

For the purpose of this study the researcher used both quantitative and qualitative data for analysis. The quantitative data is obtained from the questionnaire survey and is complemented by the qualitative data obtained from the interviews.

3.2.3 Identification of Variables

In this study, two different types of variables are used. These variables are Independent, which are the factors that affect the transition time of CMMI and Dependent, which is the transition time of CMMI. Figure 3.2 shows the theoretical framework which involves the independent variables and dependent variables.

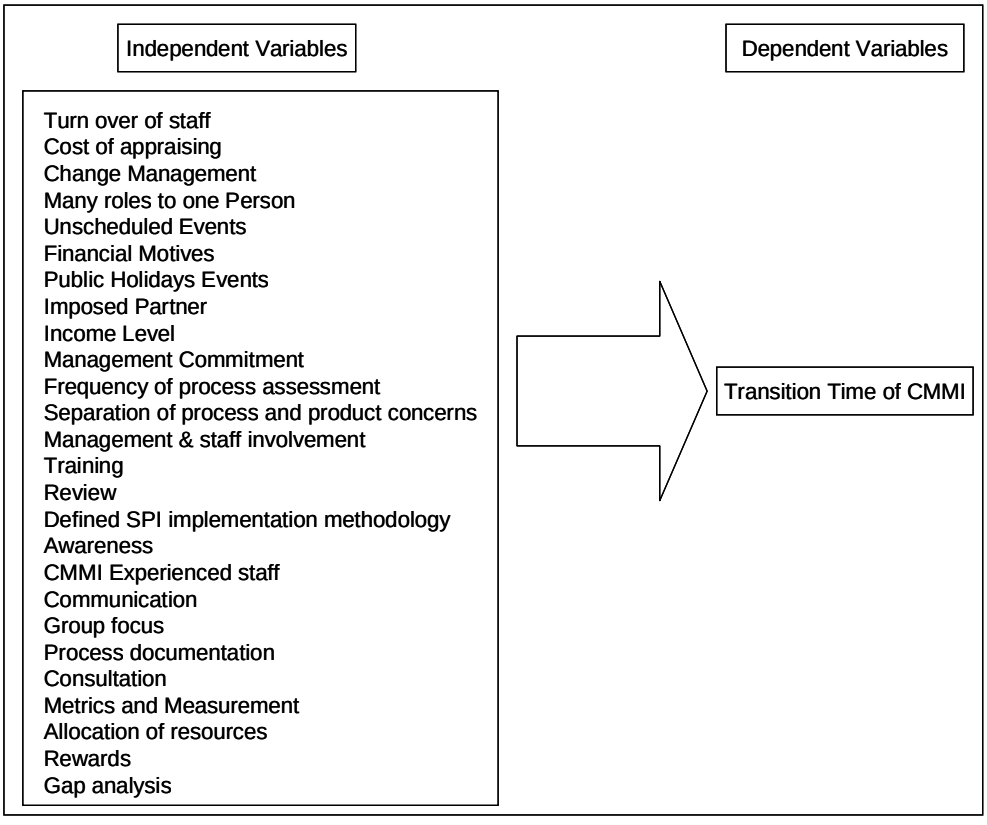

Figure 3.2 Theoretical Framework

3.2.3.1 Independent and Dependent Variables

In this research, twenty-six independent variables have been collected which are used to test the factors that affect the transition time of CMMI, as shown in Table 3.1.

Table 3.1 Independent variable in this study

1.	Allocation of Resources
2.	Awareness
3.	Change Management
4.	CMMI Experienced staff
5.	Communication
6.	Consultation
7.	Cost of appraising
8.	Defined SPI implementation methodology
9.	Financial Motives
10.	Frequency of process assessment
11.	Gap analysis
12.	Group focus
13.	Imposed Partner
14.	Income Level
15.	Management and staff involvement
16.	Management Commitment
17.	Many roles to one Person
18.	Metrics and Measurement
19.	Process documentation
20.	Public Holiday Events
21.	Review
22.	Rewards
23.	Separation of process and product concerns
24.	Training
25.	Turnover of staff
26.	Unscheduled Events

The dependent variable is the Transition Time of CMMI, which is measured by the number of months.

3.2.4 Measurement of Variables

There are different types of measurements which can be used in a given study, as shown in Table 3.2. Therefore, this study uses the list and category type of measurement in the demographics. This is followed by the ranking of the factors by using the interval scale, which is used in conducting the 5 point Likert scale questionnaire.

Table 3.2 Types and measurement of variables (Greener, 2008)

TYPES OF MEASURE	DESCRIPTION
List	Select an answer from a list
Category	Description by category
Ranking	Answers are in an orderly format
Rating	To assign a certain value to the answers
Grid	To provide more than 1 answer using a matrix
Scale	Measure with a scale including: Nominal Ordinal Interval Ratio

3.2.5 Theoretical Framework explained

The dependent variable in this study is the Transition Time of CMMI. This study attempts to understand and explain the reasons behind why some firms take a shorter time while others take a longer time for their transition from one level to the next. This study also tries to identify the relationship between the independent variables to the Transition Time of CMMI.

3.3 Research Design

3.3.1 Study Purpose

Saunders et al. (2009) indicated that the purpose of a study can be exploratory, descriptive or explanatory. The same authors also mentioned that a study could possibly have more than one study purpose. Therefore, this study has two different purposes, namely the exploratory and descriptive purposes based on Saunders et al. (2009).

The purpose of this study can be classified as exploratory in nature at the initial stage when the researcher was preparing for the investigation. This includes the literature review stage and the interviews conducted among the software personnel to identify the potential factors. This was necessary for the researcher to identify and find out the basic details of the phenomenon being investigated (Robson, 2002). The purpose of the study can be classified to include the descriptive when the researcher attempts to classify and describe the findings of the study upon conducting the questionnaire survey. Therefore, descriptive statistics are used to describe the findings of the study.

In this study the researcher deals with the explanatory purpose, which involves the causal and correlational relationship among the variables being investigated. The explanatory purpose is discussed and presented in the study type section of this study in the paragraph below. For the purpose of this study, the hypothesis is also discussed but in the data analysis chapter of this study.

3.3.2 Study Type

A study type can be seen either as a causal or correlation study (Sekaran, 2008). A causal study looks for the cause-and-effect relationship between and among the variables being investigated. The correlational study looks into the factors affecting the outcome being

investigated. In this study the researcher investigates the role of the selected independent variables in affecting the transition time of CMMI organizations. As such, this invariably makes this a correlational study

3.3.3 Involvement in Study

The researcher's involvement in the study can be categorized as minimal, moderate or high interference (Sekaran, 2008). This classification is by no means exhaustive and is only used to show the degree of the researcher's interference in the study environment. In order to be able to conduct a causal study, the researcher needs to manipulate the independent factors being investigated. This will lead to some reasonable interference of the researcher in the normal setting of the work environment.

However, this being a correlational study, there is minimal interference from the researcher in controlling the normal work flow of the subject matter being investigated and also that of the sample personnel involved in the study.

3.3.4 Research Approach

This study is divided into deductive and inductive approaches. The deductive approach is a "top-down" approach whereas the inductive approach is a "bottom-up" approach (Cooper and Emory, 1995). In this study the researcher uses the deductive approach to base the study. This is done through the formation of the theory that the independent factors affect the transition time of CMMI (dependent variable of this study). With that as a basis of this study, the necessary hypothesis is developed to test the relationship between the independent and dependent variables. Data has been collected in order to test the hypothesis. The outcome of this testing will determine whether the hypothesis can be accepted or not.

3.3.5 Research Strategy

There are a number of different strategies available to conduct a study. These are namely experiment, survey, case study, action research, grounded theory, ethnography, and archival research (Saunders et. al., 2009). A survey can be done in a number of ways, namely by observation, structured interviews, and a questionnaire survey.

To achieve the goals and objectives of this study, an interview-based approach is used as a precursor, followed by a questionnaire survey.

3.3.6 Research Choices

The research choice can be one of a mono method, mixed method or a multi-method (Tashakkori and Teddlie, 2003). Therefore, a mixed method, which uses both the qualitative and quantitative methods to complement each other in a given study, is employed. A qualitative method is used alongside with a quantitative method for data collection. A qualitative method, in the form of an interview,is used at the initial exploratory stage to get to know the potential factors affecting the transition time of CMMI. Upon collecting the potential factors, a quantitative method is used, in the form of a questionnaire survey, to establish the correlation between the independent variables and dependent variable at the descriptive stage of the study. This gives the confidence that all factors are important based on the responses of the sample respondents. A similar research approach has been used in (Niazi et al., 2006; Niazi and Babar, 2009).

3.3.7 Study Setting

The study setting can be contrived or non-contrived (Saunders et al., 2009). As this is a correlational study, therefore a non-contrived setting is selected to conduct this research.

The reason for adopting this setting is because this research is interested in investigating the relationship between the independent and dependent variables. This is also in line with the

aim and objective of this study to establish the factors which affect the CMMI transition time.

3.3.8 Study Time Horizon

The time horizon of data collection can be cross-sectional or longitudinal (Saunders et al., 2009). In a given study, the data needed to answer the research questions may be collected just once or more than once. A study in which the data collection is done only once is known as a cross-sectional study, also known as a one shot study. Therefore, a cross-sectional study was conducted as data collection was once only. The design of this study does not require data collection over a period of time and there is no data comparison over a period of time.

3.3.9 Summary of Research Design

The entire research design was discussed in the foregoing paragraphs of this section. As a concluding note for this sub-topic, a brief summary on the whole research design was developed as shown in Table 3.3 below.

Table 3.3 Summary of Research Design

1.	PURPOSE OF STUDY	Exploratory & descriptive
2.	TYPE OF STUDY	Correlational
3.	INVOLVEMENT IN STUDY	None or minimum involvement
4.	STUDY SETTING	Non-contrived
5.	RESEARCH APPROACH	Deductive
6.	RESEARCH STRATEGY	Interview Questionnaire survey
7.	TIME HORIZON	Cross-sectional

3.4 Research Strategy Implementation

In this study, people who are already involved in the software development industry are identified, i.e. Project Manager, Team Leader, Process Engineers, Consultants, Project Directors, and General Managers through a list provided by MfQasia, which is the Software Engineering Institute's (SEI) partner in Malaysia and TechZone, which is the SEI's partner in Saudi Arabia. The purpose of this implementation is to extract the factors that are having an impact on the transition time of the CMMI-based Software Process Improvement. In order to achieve this purpose, the study was conducted based on two stages of research strategy. Stage 1 consisted of the interview and stage 2 involved the questionnaire survey. The research strategies are summarized in Table 3.4 and are explained in detail in sections 3.5 and 3.6 respectively.

Table 3.4 Research Strategy summary

1	I	Face to face interview	Conduct interview with respondents	Interview
	II	Factors filtration	Avoiding redundant/ repeated factors	
2	III	Survey Design	Designing of questionnaire	Questionnaire Survey
	IV	Data collection	Data collected upon distribution of the questionnaire	
	V	Data Analysis	Linear by linear Chi square test	
	VI	Results	Research findings	

3.5 Interview

In the interview stage, the plan is to collect a list of possible factors which affect the transition time of CMMI. Subsequently, a number of factors are selected for further investigation in the questionnaire survey.

3.5.1 Interview Activities

The activities conducted at this stage are as follows:

I. Conducting a face-to-face interview with 18 different interviewees from 15 different software companies in order to extract factors that affect the transition time of CMMI without any interference or input from the researcher. The participants are selected based on the participant's experience which is at least two years experience and above involvement with CMMI. The selected participants are the ones who have direct involvement in his/her companies during the CMMI model implementation. The following steps were followed during the interviews:

1. The researcher explained the objective of the interview to each practitioner.
2. Demographic questions were asked in order to determine the background of the practitioners with regard to his company type, company size (number of employees), and nature of business, etc. as shown in Table 3.5.

Table 3.5 Demographic questions

1.	Interviewee name:
2.	Interviewee job title:
3.	Company name:
4.	E-mail address:
5.	Phone:

6.	Date of interview:
7.	What is the primary business function of your company?
8.	What is the scope of your company?
9.	How long established is your company?
10.	How many employees in your company?
11.	What type of products or services does your company provide?

3. Each practitioner was asked about his/her knowledge and experience of the CMMI based SPI, as shown in Table 3.6.

Table 3.6 Experience of CMMI

1.	YOUR KNOWLEDGE OF SPI IMPLEMENTATION HIGH 5 - - - - - - - - 4 - - - - - - - - 3 - - - - - - - - 2 - - - - - - - - 1 LOW
2.	Has your experience of SPI implementation been positive? Agree 5 - - - - - - - 4 - - - - - - - 3 - - - - - - - 2 - - - - - - - 1 Disagree
3.	Which of the process improvement models does your company use?
4.	Has your company been formally assessed against the process improvement models?
5.	If yes, what were the results?
6.	What do you think are the factors that affect the transition time between CMMI levels?
7.	How can one develop these transition time factors?
8.	Some discussions about the factors identified through the literature.

4. The concept of the factors that affect the transition time of CMMI was described to the interviewee.
5. Each practitioner was asked to provide initial factors that he/she think can play a main role in the transition time of CMMI. These initial factors were mainly collected from the interviewed practitioner.

6. After receiving the initial factors, the researcher showed to each practitioner other factors which have been collected from the other practitioners. This is to get the comments and feedback from the interviewed practitioner.

II. Factors Filtration: to identify and avoid redundancy of those factors having different names with the same meaning among practitioners and the literature.

3.5.2 Conducted Interview

It is possible to have the interviews conducted in a structured, semi-structured or unstructured way (Saunders et. al., 2009). The interviews were conducted in an unstructured way so as to allow the respondents to freely talk on the factors that they believe contributed to the transition time of CMMI. The interview was not constructed in any formal way as it was only an exploratory research whereby the researcher was extracting the different factors that affect the transition time of CMMI.

3.6 Questionnaire Survey

At stage 2, the questionnaire survey is produced as a follow up to the stage 1 interviews. The design of questionnaire was based on Niazi et al. (2006). Therefore, the factors are ranked by respondents in the questionnaire survey using the following steps stated below:

III. Survey Design: In this step a questionnaire is designed in order to collect the data and impact level as ordinal variables (High, Medium, Low, Not Effective and Don't

Know) for each factor from the respondents' perspective to determine the factor's effect on the transition time of CMMI.

IV. Distribution Stage: According to the research objectives, this study is a comparative study. Therefore in order to carry out this task, the questionnaire is distributed in Malaysia and Saudi Arabia.

V. Data Analysis: according to the data which is collected from the respondents, the study has used SPSS by applying the linear by linear association Chi-square test. The linear-by-linear association test is preferred when testing the significant differences between two ordinal variables (Martin, 2000; Niazi and Babar, 2009).

VI. Results and Comparison: In this step, the questionnaire results which have been collected are analysed. The significant differences among the factors are determined, and the common and shared factors between the two data sets are identified.

3.6.1 Data Instrumentation - Questionnaire Design

A questionnaire is used as the main instrument to gather the data needed for this study from the respective companies. However, prior to using the questionnaire survey, an interview is used to compile any additional factors affecting the transition time of CMMI which are not available in the literature.

3.6.2 Demographics

Demographics are an integral part of a questionnaire. Therefore some demographics are included to complete the questionnaire survey in a more acceptable format and standard as

are usually deployed in similar studies. This study applied the demographics by using a sample of companies of varying complexity, size, business nature, and application type. A similar approach has been used by other researchers (Baddoo, 2001; Baddoo and Hall, 2002; Baddoo and Hall, 2002b; Niazi et al., 2006). Appendix A shows the participant companies.

3.6.3 Effective Factors Selection

In this study an effective factor is defined to measure the extent to which a factor has an effect on the transition time between CMMI levels and therefore, whether it adds value to the transition time of CMMI based on the perceptions and experiences of practitioners who have been involved in the area of SPI at their respective organizations. In order to describe the notion of effective factor on the transition time of CMMI, it is essential to decide on the importance of an effective factor. For this purpose, the study has used the following definition:

- If the majority of respondents (≥50%) consider that a factor has a high effect on the transition time of CMMI, thus, the study deals with the factor as an effective factor. A similar approach has been done in the literature (Niazi and Babar, 2009; Niazi et al., 2005; Rainer and Hall, 2002). Rainer and Hall (2002) identified important factors in software process improvement with the criterion that if 50% or more of the participants consider that a factor has a major role in software process improvement efforts then that factor should be considered as having a major effect on software process improvement.

3.6.4 Scale Used

The questionnaire survey is designed using the Likert scale. (Likert, 1932). The researcher decided to use the Likert scale in the questionnaire because the Likert scale questionnaire has been established over a period of time and is regarded to produce a reliable scale. In addition, most respondents are familiar with a questionnaire that uses Likert scale.

The researcher could possibly use a Likert scale with any number of points for this study. The researcher considered the 3-point, 5-point, 7-point and 10-point Likert scale. Upon careful consideration, the researcher thinks that the 3-point scale may have too large a gap between the points. Likewise the researcher also considered the 7-point and 10-point scales provide too close a distinction between the points, which may make it difficult for the respondents to differentiate the fine points between the scales.

Taking into account the too large a gap between the points in a 3-point scale and the too fine a difference between the points in the 7 and 10-point scales, the researcher decided to use a 5-point Likert scale, which may provide the right balance for the respondents' convenience to choose a suitable and relevant point as shown in Table 3.7. This study is to identify the effect on the transition time of CMMI organizations, and therefore the response was necessary in the order of 1 = Don't Know, 2 = Not Effective, 3 = Low, 4 = Medium and 5 = High, as shown in Table 3.7.

Table 3.7 Likert scale used

SCALE	DESCRIPTION	PERCENTAGE
1.	Don't Know	Unknown
2.	Not Effective	0%-25%
3.	Low	26%-50%
4.	Medium	51%-75%

5.	High	76%-100

3.6.5 Testing of Questionnaire

The testing of the questionnaire was done in 2 levels. Level 1 was the pre-test of the questionnaire which was followed by the pilot test of the questionnaire at Level 2. The activities at both the different levels are described in the following subsections.

3.6.5.1 Questionnaire pre-test

The questionnaire was pre-tested by 7 personnel in domestic software companies and 4 graduate students at the researcher's University as shown in Table 3.8.

Table 3.8 Pre-test panel

NO.	NAME	POSITION	ORGANIZATION
1.	Mr Durai	Manager	MFQasia Org.
2.	Mr Sohaimi	SEPG	N2NMalaysia Co.
3.	Mr Nathan	CMMI appraiser	MFQasia Org.
4.	Mr Dom	Consultant	Encoral-solution Co.
5.	Mrs Chua Wen Dee	Consultant	Energized Co.
6.	Mr MohdDaud	SEPG	System-consult.
7.	Ms Kathleen Rimpang	SEPG	MicroLink Co.
8.	Mr Majed	PhD Candidate	University Malaya
9.	Mr Iqbal	Master Candidate	University Malaya
10.	Mr Nassar	Master Candidate	University Malaya
11.	Mr Mohammad	Master Candidate	University Malaya

3.6.5.2 Pilot study

A pilot study is used as a small scale test project before implementing the full scale study. This is done with the view of reducing any bias or risk of running into errors. The pilot study allows the researcher an opportunity to refine and improve the questionnaire, which

also acts as a filter before any major flaws in the actual survey (Zikmund et al., 2009). In this study, a pilot test became necessary as the instrument was developed for the purpose of this study. In an ideal situation a question or questions are used to measure a unique variable. In order to ascertain that the question is suitable to measure a particular variable, the question needs to be tested for validity and reliability, which is discussed in the paragraph below. The questionnaire was put through a pilot study which was conducted among 20 respondents selected at random. This group of respondents were independent respondents who were not part of the actual respondents who participated in the questionnaire survey later.

3.6.5.3 Validity and Reliability

Validity and Reliability are two important requirements in dealing with a measuring instrument like the questionnaire survey used in this study. In establishing the appropriateness of the questionnaire developed to consider the validity and reliability of the instrument used in this study, the suitability of the questions and the particular variables are tested.

- Validity

Validity means the effectiveness or success of an instrument in measuring the specific property which it intends to measure (Krishnaswami and Ranganatham, 2011). Another researcher, at a much earlier time frame, has stated that a measurement procedure is valid to the degree that it measures what it purports to measure (Jahoda, 1958).

- Reliability

Joppe (2000) defines reliability as “The extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and

if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable." Therefore, reliability is the consistency of an instrument producing the same result on a repeated measure. Thus reliability is the ability to perform in the future as it performed in the past (Salkind, 1997). A reliable instrument must be able to produce an accurate and precise measure of what it was intended to measure (Krishnaswami and Ranganatham, 2011).

Therefore, the researcher used Cronbach's alpha as a validity and reliability measurement. Guielford (1965) suggested that the reliabilities of Cronbach's alpha are high if Cronbach's alpha is over 0.70. The items usually have a coefficient variation between 0 – 1. When Cronbach's alpha is closer to 1, then the internal consistency is taken to be stronger among the items in the scale. As a rule, George and Mallery (2003) suggest the following as in Table 3.9:

Table 3.9 Cronbach's Alpha Reliability Description

NO.	CRONBACH'S ALPHA VALUE	DESCRIPTION
1.	lesser than 0.5,	is unacceptable
2.	0.5 to 0.59	is poor,
3.	0.6 to 0.69	is questionable,
4.	0.7 to 0.79	is acceptable,
5.	0.8 to 0.89	is good,
6.	0.9 to 1	is excellent

In order to establish whether a questionnaire survey instrument is valid and reliable, the researcher must calculate the alpha coefficient which is defined as stated below:

Reliability = α

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\sum s_j^2}{s_j^2}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

Where:

n is the number of measurement items,

$\sum s_j^2$ is the sum of the variance of all the measurement items,

s_j^2 is the variance of the total value measurements.

In order to test the reliability of the instrument, a pilot study is conducted among 20 respondents who are not involved in the actual survey.

Table 3.10 Pilot study data

No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q21	Q22	Q23	Q24	Q25	Q26	SUM
R1	1	1	3	1	5	1	4	4			1	1	5	3	4	81
R2	3	1	4	3	5	1	4	4			1	1	5	4	4	86
R3	4	1	4	3	5	1	4	4			1	3	5	4	4	89
R4	4	4	3	4	5	3	4	5			3	3	5	5	4	103
R5	4	4	5	4	5	3	4	5			4	4	3	5	4	107
R6	4	4	5	4	5	3	4	5			4	4	3	5	4	107
R7	5	5	5	4	4	5	4	5			4	4	5	5	4	112
R8	5	5	5	4	4	5	4	5			4	4	5	5	4	115
R9	5	3	5	4	4	5	4	5			4	4	4	4	4	107
R10	5	5	5	5	1	5	5	5			4	4	4	5	5	110
R11	5	4	5	5	1	3	4	5			5	5	4	3	5	105
R12	5	5	5	5	2	4	5	4			5	5	4	3	5	110
R13	4	4	4	3	2	4	4	5			5	4	4	5	5	106
R14	5	5	4	5	2	4	5	5			5	5	4	3	5	115
R15	5	4	5	5	2	4	4	5			5	5	4	5	5	115
R16	5	4	5	5	2	4	5	5			5	5	3	3	5	113
R17	5	5	5	5	2	4	4	3			5	4	3	5	5	110
R18	5	2	5	5	2	4	2	5			5	5	3	5	5	109
R19	5	2	5	5	2	4	5	5			5	5	2	5	5	110
R20	3	5	5	5	2	4	5	5			5	5	2	5	5	111
Mean	4.35	3.65	4.60	4.20	3.10	3.55	4.20	4.70			4.00	4.00	3.85	4.35	4.55	106.05
Var	1.08	2.13	0.46	1.12	2.31	1.63	0.48	0.33			2.00	1.47	0.98	0.77	0.26	28.84
																92.26

Based on the pilot data collected, the data analysis was calculated for validity and reliability of Cronbach's alpha as follows and as shown in Table 3.11:

$$\alpha = \frac{n}{n-1}\left(1-\frac{\sum s_j^2}{s_j^2}\right)$$
$$= \frac{26}{26-1}\left(1-\frac{28.84}{92.26}\right)$$
$$= 0.715$$

Table 3.11 Cronbach's Alpha Test for Pilot Study

NO. OF ITEMS	CRONBACH'S ALPHA	DECISION
26	0.715	Accept / Proceed

The pilot test results of the questionnaire analysis yielded a high average Cronbach's alpha of 0.715. This is an indication that the questionnaire was acceptable and internally consistent. Based on the pilot test results, the questionnaire survey instrument is used to proceed. Pallant (2001) indicates that a coefficient reliability of at least 0.7 is considered good as a general rule.

3.6.6 Cross-Cultural Survey

This study has incorporated a cross-cultural survey involving Malaysia and Saudi Arabia. For the cross-cultural element in this study, the research has carefully considered the following items to remove any possible bias through the cultural differences.

- **Language**: The language used was English in Malaysia. In Saudi Arabia too, the language used was English.
- **Translation**: There was no translation needed in this study. English was the only language used and no other foreign language was used in this study. While developing the questionnaire in English, the researcher paid additional care and was conscious of the different cultures involved between Malaysia and Saudi Arabia. This was necessary so as not to allow the local interpretation through a different culture to make a different interpretation of a given word.
- **Timing**: The questionnaire survey was conducted for 5 months from April 2010 to September 2010. During these five months the questionnaire survey was conducted solely for data collection for this study. The questionnaire survey was conducted simultaneously in both countries as a lapse of time might cause the study to be biased.

3.7 Data Triangulation

Data triangulation is the act of combining data and analysis using both the qualitative and quantitative methods. This is usually done to add credibility and validity to a study (Patton, 2001; McMillan and Schumacher, 2006; Lincoln and Guba, 1985; Seale, 1999; Stenbacka, 2001). Therefore, in this study, one of strategies that increased the validity of the qualitative research was the Multi-method strategy, which allows triangulation in data collection and data analysis.

3.8 Population and Sampling

Population and sampling are important parts of the study design. This is because the researcher would not be able to conduct a survey through interviews or questionnaires due to the large population, making it costly and time consuming. The sampling allows the researcher to arrive at or make a statistical inference based on the representation derived from the sample. This becomes possible because the sample is measured using statistical principles to make a fairly accurate inference on the population based on representations from the sample.

3.8.1 Sampling Process

The steps involved in conducting a sampling process can be presented in a diagrammatic representation as shown in Figure 3.3.

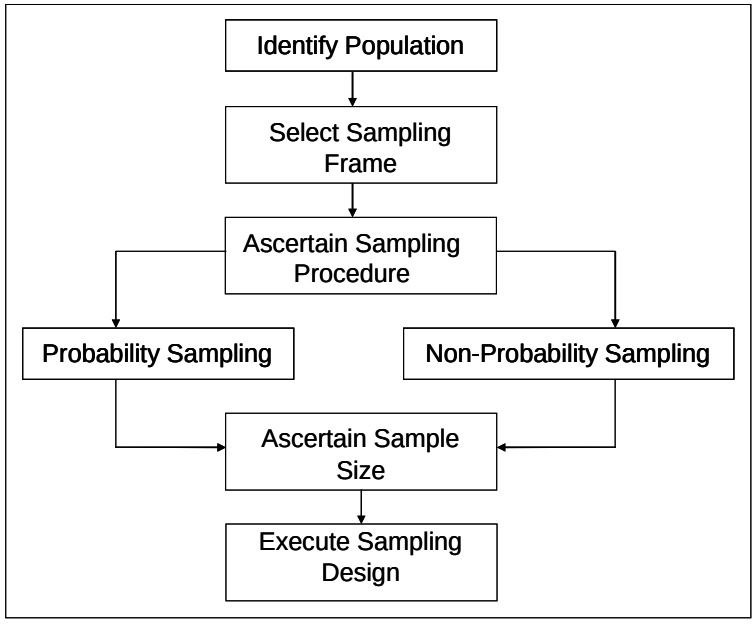

Figure 3.3 Sampling process

The process of sampling is discussed in detail in the following subsections:

3.8.1.1 Identify the Population

At the initial stage the researcher needs to identify the population of the study. This includes the age, gender, industry involved, position and the geographical location of the population of this study. Therefore, software organizations and companies which are using the CMMI model in order to improve their processes are considered as the target of this study. Consequently, this population includes companies from different geographical regions (i.e., Malaysia and Saudi Arabia), which are developing either software or combined software and hardware products or providing services for a wide variety of markets that have already adopted CMMI and achieved CMMI level 3, even those that have achieved CMMI level 2 *AND* are going on to achieve CMMI level 3.

3.8.1.2 Select Sampling Frame

Upon identifying the population, a sampling frame is needed to undertake the study. A sampling frame is usually a list of items or names which are the samples for a given study. The sampling frame usually has to list all the population members from the first to the last. The sample is then selected from the frame using any one of the procedures discussed below. Therefore, in this study the sampling frame is taken from a list of CMMI firms both in Malaysia and Saudi Arabia.

3.8.1.3 Ascertain Sampling Procedure

In order to collect the data from the target sample, a suitable and relevant sampling procedure needs to be selected. The sampling procedure can be classified as Probability or Non-probability sampling and Linear or Non-linear sampling. Probability sampling has an equal chance of being included in the sample, which is at random. The non-probability sampling has an unequal chance of being included in the sample, which is non-random. Probability sampling includes simple random sampling, systematic sampling, stratified

sampling, and cluster sampling (Sekaran, 2008). Non-probability sampling includes convenience sampling, judgment sampling, snowball sampling and quota sampling (Saunders et. al., 2009). In this study it was decided to use a simple random sampling whereby the procedure ensures all members of the population have an equal chance to be included in the sample for participating in the questionnaire survey. Each subject in the population is selected based on random number generator criteria. In the step by step sampling process, the sample size should be determined based on statistical principles so as to introduce credibility to the data assumed to represent the population. Sample size can also be one kind of bias. The larger the sample size, the less likely the chance for sampling bias (Coolican, 1999). Therefore, there are 30 participant companies in the sample of this study. It is significant for the researcher to show that this sample is large enough to minimize the possibility of bias. The resulting sample size for this study is 92 respondents from the software industry both in Malaysia and Saudi Arabia as this concerns both geographical areas.

3.8.1.4 Execute Sampling Design

In the sampling design process, the execution of the sampling design is the final act. At this final stage, the necessary data for the study is collected based on the design established by the researcher complying with the statistical principles discussed. Upon data collection from the sample, the researcher can then proceed to do data analysis and to make the necessary statistical inference.

3.8.1.5 Sampling Profile Summary

For ease of reference and better understanding of the sampling process applied in this study the entire sampling process is compiled into a summary profile of this study as shown in Table 3.12.

Table 3.12 Sampling profile of the study

PROCESS	DESCRIPTION
Population	The software/services firms in Malaysia and Saudi Arabia
Sampling procedure	Simple random sampling
Sampling frame	Software/service companies going for CMMI
Sampling Unit	Individual from the CMMI companies
Sample size	92 respondents in total 46 in Malaysia 46 in Saudi Arabia
Execute Sampling Design	April, 2010 to September 2010.

3.9 Data Collection

Data collection methods significantly affect the data analysis process. Therefore, the data collection method should be carefully selected. Primary data collection is possible in many ways but this study is concerned with the following means of data collection:

i. Interview
ii. Questionnaire

This study has gathered factors that affect the transition time of CMMI using both primary and secondary data. The interviews provided the primary data and the literature review provided the secondary data for compiling the factors.

Subsequently, the questionnaire was used to extract the primary data collection. These methods are selected because they are suited for the nature and type of data analysis of this study (Rockart, 1979), and in order to gather quantitative and qualitative data from a number of respondents (Kitchenham and Pfleeger, 2002).

3.9.1 Data Elicitation Techniques

A survey research method can use one or more data elicitation techniques such as interviews and self-administered questionnaires. Data elicitation techniques are deemed suitable for eliciting both quantitative and qualitative data from respondents (Lethbridge et al., 2005). Therefore, two common methods have been carefully considered to gather survey data, namely face-to-face interviews and an e-mail questionnaire for eliciting the necessary data in this study.

3.9.1.1 Personal interview

The personal interview method used in this study requires the interviewer to ask questions based on a structured questionnaire and to record the answers. This method was selected because of the primary advantage of a high degree of validity of the data (Rockart, 1979; Kan, 2003). This method was appealing to the researcher because the interviewer can note specific reactions and eliminate misunderstandings about the questions being asked. The researcher conducted 18 interviews in 15 different software and services companies in Malaysia and Saudi Arabia. These interviews were deployed to extract the factors affecting the transition time of CMMI. The interviews arranged with the respondents were done with flexible schedules. Therefore, the interviewees could make an appointment at any time suitable for the practitioners (Fowler, 2002). Each interview session conducted in this study lasted about 45 - 60 minutes.

3.9.1.2 E-mail Questionnaire

The e-mail questionnaire method does not require the interviewer's presence and is therefore less expensive. However, these savings are usually at the expense of the response rates. Low response rates can introduce bias to the data. Non-responses can be a problem in any method of surveys, but the e-mail questionnaire method usually has the lowest rate of response (Kan, 2003).

According to the research objectives and available resources, the study has used a survey research method to gather data about the perspective of Malaysian and Saudi practitioners regarding the factors that affect the transition time of CMMI. The study has used the questionnaire as a data collection instrument. Therefore, this study used an e-mail questionnaire as the main approach for collecting the data. The selection of participant was according to the companies that achieved CMMI level 3, or companies that achieved

CMMI level 2 and are on going to achieve CMMI level 3. The study contacted with these companies in order to provide their employees' Emails who willing to participate in the survey. Thereafter, the study has been sent the questionnaire to all the participants via an Email.

3.9.2 Response Rate

According to the aims and objectives of this study and taking into account its scope, 236 questionnaires were sent out to different participants from companies have already achieved CMMI level 3 and also to those companies that are going on to achieve CMMI level 3. Only 92 personnel responded from 30 companies distributed over Malaysia (18 companies) and Saudi Arabia (12 companies).

This means that the response rate was 39%. This is however a reasonable response rate, considering the fact that even a 30% response rate is deemed acceptable in a questionnaire survey (Platek, 1977).

The study, however, has high confidence in the accuracy and validity of the data. Ninety-two practitioners voluntarily participated in this study. It was important to ensure that no particular group was overrepresented (Coolican, 1999).

As mentioned before, a questionnaire was based on factors that affect the transition time of CMMI-based software process improvements. Therefore it was designed to gather the effective factors, where each respondent ranked each factor which is identified as having an effect on the transition time of CMMI-based SPI. Consequently, in order to identify the effective factors, the respondents were asked to rank each factor's impact according to its relative value (i.e., High, Medium, Low, Not Effective or Don't Know). Appendix B shows the questionnaire.

3.10 Data Processing

Data processing is the middle process in the processing and analysis chain of data collection as diagrammatically represented in Figure 3.4

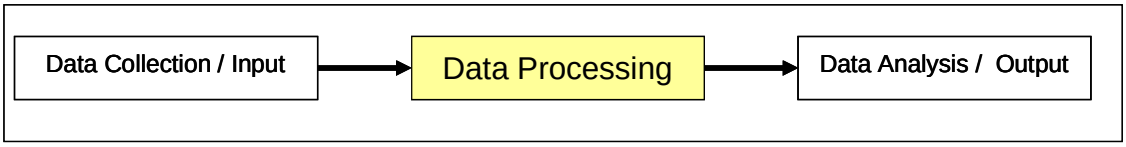

Figure 3.4 Data processing adopted from (Sekaran, 2008; Saunders et. al., 2009)

Data collected from the survey needs to be processed in a practical and academically acceptable way to ascertain the "cleanliness" of the data used for analysis. Data processing involves a number of stages which can be summarized as follows:

- Editing data

  At the editing data stage the researcher needs to check for missing, incorrect or incomplete data. In some cases, the respondents may have been inconsistent in their responses. Some errors in responses are also common in data processing.

  In this study, there were some minor errors in the database used to compile all the responses. The errors were mainly double digit, entered perhaps by way of typographical error. These errors were checked against the original feedback from the respondents and all errors were duly corrected based on the original response from the respondent. This data cleaning was done in order to enable the raw data to be used for analysis.

- Blank responses

  Respondents are also known for leaving questions unanswered for one reason or another. This may be due to an inability to answer, not knowing the answer or even a

case whereby the respondent is not willing to answer a particular question in the questionnaire.

In this study there were some blank responses in the reply mail from 5 respondents. These respondents were asked to resubmit only the missing questions and all 5 duly responded positively enabling the researcher to compile the data comprehensively involving all data fields for the questionnaire.

- Coding data

Coding the responses is helpful for managing large data sets. By coding the responses, confusion is reduced and the increased visibility causes any abnormality in the dataset to be noticed.

- Decoding

Decoding is an important process in data processing to enable the summary data, which is coded, to be interpreted into more meaningful information for readers who are not very interested in figures and statistics.

3.11 Data Analysis Method

Data analysis in this study can be seen at different stages of the investigation. Figure 3.5 shows the data analysis.

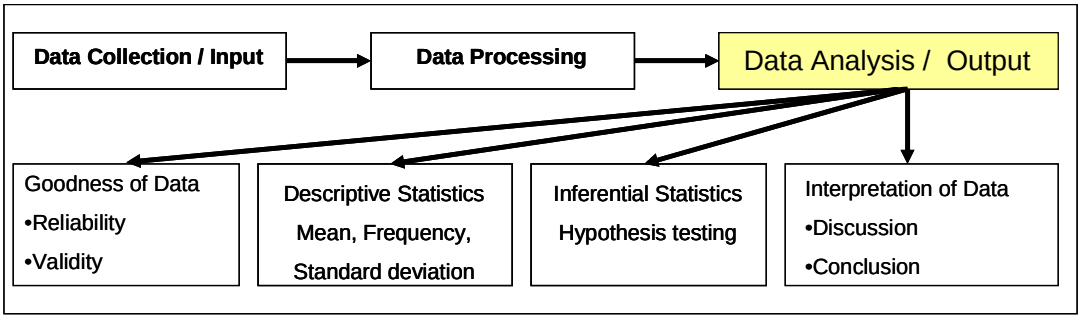

Figure 3.5 Data analysis (Sekaran, 2008; Saunders et. al., 2009)

In this entire study, data analysis was conducted at 4 different stages of the investigation. Initially it was done at the questionnaire setup stage, whereby the researcher had to conduct an analysis to verify that the questionnaire was a suitable instrument to acquire data. This was where Cronbach's alpha was measured. Next the data analysis was used when the researcher used descriptive statistics to describe the findings of the study. The basic statistics of descriptive analysis were used at this stage.

The data analysis was continued up to the hypothesis testing stage towards the end of the data collection, processing, and analysis. After that point, data analysis was used at the interpretation of the output, when the research questions were discussed and concluded at the end of the research.

In order to analyse the perceived value of each factor identified by the respondents, the study identified the perceived value (high, medium, low, not effective, and don't know) for all the factors in the questionnaire. For example, for each factor, the study identified every

impact level with a numerical value in order to process the values, such as High = 5, Medium = 4, Low = 3, Not effective = 2, and Don't know = 1.

Consequently, the chi-square test was applied to the values of all the factors and the *P*-value for each factor was calculated in order to find out the significant difference between the two data sets. A similar approach has been proposed by (Niazi et al., 2006; Niazi et al., 2005b; Staples and Niazi, 2008; Niazi et al., 2010). Therefore, in order to find out the effective factors, the study used the definition of effective factors which is described in section 3.6.3. Thus, the study identified the effective factors in Malaysia only, some other effective factors in Saudi Arabia only, and the shared effective factors in both (i.e. in Malaysia and Saudi Arabia). See Chapter Four for a more detailed description.

3.11.1 Software Used

The Statistical Package for the Social Sciences (SPSS) is a computer program used for statistical analysis and is among the most widely used software for survey analysis.

Consequently, the study used the SPSS V.15 as a tool to calculate the chi-square and P-values.

Apart from the SPSS, which is widely used for data analysis in this study, Microsoft Office was also extensively used. Microsoft WORD was used for word processing of this entire study. Microsoft EXCEL was used for generating simple statistical data analysis. Together with this, the Chart Wizard was used to develop the charts, figures and graphs of this study. Microsoft POWERPOINT was used to present the charts, figures, and graphs in this study.

Thus, according to the results, the study could distinguish the significant difference between two data sets, and based on the results, the study could answer the research questions and hypotheses. Chapter Four explains the results of the study in greater detail.

3.11.2 Descriptive Statistics

Descriptive statistics are generally used for presenting the general findings of a study. Some of the common statistics used in this study are presented in point form in Table 3.13.

Table 3.13 Descriptive statistics

Mean	the average of a given set of numbers
Median	the data point that is in the middle of "low" and "high" values
Standard deviation	the mean deviation from the mean, i.e. how far a typical data point is away from the mean
High and Low value	extremes at both ends
Quartiles	same thing as median for ¼ intervals

3.11.3 Inferential Statistics

3.11.3.1 Applying Chi-Square Test

The chi-square test is used to determine the relationship between values, whether there is a significant difference among the expected frequencies and the observed frequencies in one category or more than one category (Sirkin, 2006).

Chi-Square Test Requirements:

1. Quantitative data.

   For each level (i.e. High, Medium, Low, Not Effective and Don't know) the study determined a numerical value, whereby High = 5, Medium = 4, Low = 3, Not Effective = 2, and Don't know = 1. The study used this approach to extract quantitative data from the qualitative data. A similar approach has been used in previous researches (Niazi et al., 2006; Niazi et al., 2005b; Staples and Niazi, 2008; Niazi et al., 2010).

2. One or more categories.

   The study used more than values as High = 5, Medium = 4, Low = 3, Not effective = 2, and Don't know = 1, with two categories.

3. Independent observations.

   The study applied independent observations on all values in this study.

4. Adequate sample size (at least 10).

   The study used a sample size consisting of 92 participants.

5. Simple random sample.

   The study used a simple random sample in this research when applying the chi-square test.

6. Data in frequency form.

   The study specified and entered the data based on the frequency form.

7. All observations must be used.

   The study used all observations and they are included in the data processing.

The chi-square formula is

$$\chi^2 = \frac{(O-E)^2}{E} \quad \text{..... (3.2)}$$

Where,

O	is the Observed Frequency in each category,
E	is the Expected Frequency in the corresponding category,
χ^2	is Chi Square.

The study used the level of significance (α) at 0.05 (α = 95% as confidence level with a 5% margin of error), which is the standard for most scientific experiments (Sirkin, 2006). The study used the degree of freedom (df), which is the rank of a quadratic form (Sirkin, 2006), as (N-1), where N is the data sets, categories, or values, since in this study, the degree of freedom equals 2-1 based on two data sets (i.e. Malaysia and Saudi Arabia).

3.11.3.2 Testing of Hypothesis

It is necessary to test a hypothesis which is developed at the beginning of a study. Usually a hypothesis is derived from theoretical understanding or is based on previous studies in the field. Hypothesis testing is therefore the testing of an idea through data collection and data analysis. The hypothesis testing theory is to test the hypothesis against the data available from the sample selected for the study. This particular hypothesis is called the null hypothesis and is usually shown as H_0. The test looks to either accept or reject the null hypothesis. The alternative hypothesis differentiates the null hypothesis to another level which indicates the difference from H_0 to the researcher. The alternative hypothesis is

usually shown as H_1. H_0 is clearly identified and is of great interest to the researcher and the study, whereas H_1 specifies the difference moving away from H_0.

Therefore, to find out the significant difference, the study calculated the P-value, which is the probability of getting a test statistic (Sirkin, 2006). Therefore the test applied in this study can be summarized as follows:

- If $p \leq \alpha$ value, then reject the null hypothesis.

- If $p > \alpha$ value, then fail to reject the null hypothesis (i.e. accept the null hypothesis).

3.12 Ethical Considerations

Ethical issues must be considered by all researchers. This study is no exception. In this study the researcher discusses the ethical issues involved from two different perspectives. The first is from the researcher's perspective and the second is from the respondents' perspective, as presented accordingly in the paragraphs below.

3.12.1 For the Researcher

Krishnaswami and Ranganatham (2011) describe that the researcher must report the methods and findings without bias. The researcher must report the guiding principles, methods, data analysis, findings and interpretation in an honest and open manner. The report must also include both the strengths and weaknesses as the findings unfold. In this study, the methods and findings are reported without intervention.

3.12.2 For the Respondents

The ethical principles covering the respondents tend to revolve around the four main areas cited below. However, there seems to be some overlapping between one another but whatever the need for the discussion in this study is, the issues are taken at face value. Diener and Crandall (1978) have identified four major areas of ethical principles which must be observed in a research by the researcher. The areas are:

- The survey cannot be harmful to the respondents/participants.
- The survey must have obtained the informed consent of the respondents to their participation in the survey (Bryman and Bell, 2007).
- The privacy of the respondents must be protected at all times (Robson, 2002).
- The participation cannot be obtained by deception.

In line with the observation of the ethical principles suggested in the above paragraph, the researcher confirms the following:

- The survey was not harmful to the respondents at any time. In ensuring that the questions were not harmful, all questions which might demoralize or embarrass the respondents were removed. All questions were also very strictly related to the transition time of CMMI.
- Each and every one of the respondents was informed that participation is wholly on a voluntary basis. The respondents were informed that they were free to leave from participating in the survey if they were not comfortable at any time during the

survey. Their consent to participate was first obtained before proceeding with the survey,

- The personal details of the respondents were not used in the study as only the aggregated and cumulative responses were derived at and used for reporting. It was further assured that the identity of the respondents would not be disclosed to anyone.
- The participation was not obtained through deception as the respondents were all fully informed of the aims and objectives of the study. The respondents were all made aware that the researcher was conducting this study as part of his PhD programme.

3.13 Chapter Summary

In this chapter, the entire research methodology is extensively described. The purpose of the study is to extract the factors which might have an effect on the transition time of CMMI-based Software Process Improvement. The study used a questionnaire survey as the main instrument to gather the data from main people in companies. The effective factor is defined to measure the extent to which a factor has an effect on the transition time of CMMI. The study used the chi-square test in order to determine the significant difference between two data sets and used the SPSS as a tool to achieve this purpose. All descriptions and numerical representations of the findings produced by the research approach and methodology are described elaborately in the next chapter.

CHAPTER FOUR - DATA ANALYSIS AND DISCUSSION

4.1 Introduction

In this chapter the researcher performed a data analysis based on the questionnaire survey conducted among the respondents in both the countries of Saudi Arabia and Malaysia, where Saudi Arabia is selected to represent the Middle East region and Malaysia is selected to represent the South East region. The findings of this study are analysed, discussed and presented in a number of presentation aids like tables, graphs and figures, and by using descriptive statistics of frequency and percentage.

4.2 Demographics

In this study the researcher studied a number of demographic variables. The variables are as follows:

- Company size
- Gender
- Primary function
- Position
- CMMI level

Company size: The investigation was carried out between large and medium-sized organizations. In Saudi Arabia there were 25 large organizations and 21 medium-sized organizations. These accounted for 54.3% and 45.7% respectively. In Malaysia there were 34 large organizations compared to 12 medium-sized firms. These represented 73.9% and 26.1% accordingly. As a whole between the two countries, large organizations accounted

for 64.1% with 59 large organizations. There were 33 medium organizations in both countries amounting to 35.9% of all organizations participating in this survey.

Gender: In Saudi Arabia there were no female participants in the study. As such all the 46 respondents were males, accounting for 100% of the survey respondents. In Malaysia there were 13 female and 33 male respondents, amounting to 28.3% and 71.7% respectively. On a cumulative analysis there were 13 female and 79 male respondents to the questionnaire survey conducted amounting to 14.1% and 85.9% respectively of the total participants of the study.

Primary Function: In identifying the primary functions of the respondents involved in this study, Saudi Arabia had 1 respondent in the services sector accounting for 2.2%, 29 respondents from the software sector amounting to 63.5%, and 16 respondents from the software/services sector representing 34.8% of the respondents who participated in the survey. The Malaysian respondents were from the software and software/services sectors only. The software sector had 30 respondents accounting for 65.2%, whereas the software/services sector had 16 respondents amounting to 34.8% of the participants from Malaysia. Overall, there was 1 participant from the services sector, 59 from the software sector and 32 from the software/services sector, representing 1.1%, 64.1% and 34.8% respectively.

Position: The researcher also studied the position of the respondents from both countries. Overall the respondents were diversified, coming from 12 different positions. The positions were SEPG, Executive Director, Project Manager, Consultant, Manager, Director, Process

Supervisor, General Manager, Supervisor, Software Director, Software Supervisor and Vice Manager. The details of the respondent numbers and the respective percentages can be seen from the table below. The SEPG had 25 respondents in Saudi Arabia accounting for 54.3%, 28 respondents in Malaysia accounting for 60.9%, and overall 53 respondents from both countries amounting to 57.6%. There were also 10 executive directors and 10 project managers each representing 10.9% respectively from both countries.

CMMI Level: In Saudi Arabia there were 15 respondents from CMMI Level 2 organizations and the remaining 31 respondents from Level 3 organizations. These accounted for 32.6% and 67.4% respectively of the total respondents from Saudi Arabia. In Malaysia there were 12 respondents from organizations in Level 2 and 34 respondents from organizations in Level 3. These were translated into 26.1% and 73.9% accordingly. As a whole, there were 27 respondents from Level 2 amounting to 29.3% and 65 respondents from Level 3 accounting for 70.7%.

All the details of the demographic variables can be seen from Table 4.1. The presentation is shown to reflect the unique situation between Saudi Arabia and Malaysia.

Table 4.1 Demographics

Demographics	Saudi Arabia	%	Malaysia	%	Both	%
Company Size	**46**	**100.0%**	**46**	**100.0%**	**92**	**100.0%**
Large	25	54.3%	34	73.9%	59	64.1%
Medium	21	45.7%	12	26.1%	33	35.9%
Gender	**46**	**100.0%**	**46**	**100.0%**	**92**	**100.0%**
Female	0	0.0%	13	28.3%	13	14.1%
Male	46	100.0%	33	71.7%	79	85.9%
Primary Function	**46**	**100.0%**	**46**	**100.0%**	**92**	**100.0%**

Service	1	2.2%	0	0.0%	1	1.1%
Software	29	63.0%	30	65.2%	59	64.1%
Software/Services	16	34.8%	16	34.8%	32	34.8%
Position	**46**	**100.0%**	**46**	**100.0%**	**92**	**100.0%**
SEPG	25	54.3%	28	60.9%	53	57.6%
Executive Director	9	19.6%	1	2.2%	10	10.9%
Project Manager	4	8.7%	6	13.0%	10	10.9%
Consultant	3	6.5%	5	10.9%	8	8.7%
Manager	1	2.2%	3	6.5%	4	4.3%
Director	1	2.2%	0	0.0%	1	1.1%
Process Supervisor	1	2.2%	0	0.0%	1	1.1%
General Manager	0	0.0%	1	2.2%	1	1.1%
Supervisor	1	2.2%	0	0.0%	1	1.1%
Software Director	0	0.0%	1	2.2%	1	1.1%
Software Supervisor	0	0.0%	1	2.2%	1	1.1%
Vice Manager	1	2.2%	0	0.0%	1	1.1%
CMMI Level	**46**	**100.0%**	**46**	**100.0%**	**92**	**100.0%**
L2	15	32.6%	12	26.1%	27	29.3%
L3	31	67.4%	34	73.9%	65	70.7%

4.3 Presentation of Data Analysis

In this study, a questionnaire survey consisting of 26 questions was sent out for data collection. The data collected for all the 26 questions is provided in a summarized tabular format as shown in Table 4.2.

Table 4.2 Malaysian and Saudi Arabia companies Overall response

MALAYSIA (N=46)							SAUDI ARABIA (N=46)				
DON'T KNOW	NOT EFFECTIVE	LOW	MEDIUM	HIGH	**Factor No.**	**FACTOR NAME**	DON'T KNOW	NOT EFFECTIVE	LOW	MEDIUM	HIGH
1	0	1	11	33	1	Turnover of Staff	0	0	0	8	38
3	0	0	10	33	2	Cost of Appraising	4	3	6	18	15
0	0	1	8	37	3	Change Management	1	1	1	11	32
7	20	2	4	13	4	Many Roles to One Person	2	39	1	1	3
5	3	5	17	16	5	Unscheduled Events	0	3	1	11	31
0	0	0	17	29	6	Financial Motives	3	7	11	17	8
0	0	0	7	39	7	Public Holiday Events	0	20	25	1	0
14	7	2	10	13	8	Imposed Partner	2	0	1	10	33
3	0	1	13	29	9	Income Level	0	0	21	12	13
0	0	0	4	42	10	Management Commitment	0	0	0	7	39
4	2	11	12	17	11	Frequency of Process Assessment	1	0	0	19	26
0	0	1	11	34	12	Separation of Process & Product Concerns	0	0	0	9	37
5	3	1	19	18	13	Management & Staff Involvement	7	0	0	10	29
0	0	0	9	37	14	Training	1	0	0	4	41
0	2	15	7	22	15	Review	0	0	0	8	38
3	9	7	12	15	16	Defined SPI Implementation Methodology	2	0	0	10	34
3	2	8	10	23	17	Awareness	0	1	3	13	29
2	0	7	18	19	18	CMMI Experienced Staff	5	0	1	3	37
0	0	2	5	39	19	Communication	6	0	29	2	9
3	0	10	18	15	20	Group Focus	8	0	0	18	20
5	0	4	13	24	21	Process Documentation	0	0	0	17	29
2	0	7	13	24	22	Consultation	3	0	1	19	23
0	3	8	17	18	23	Metrics and Measurement	0	0	0	20	26
0	0	1	7	38	24	Allocation of Resources	0	0	0	8	38
0	0	0	17	29	25	Rewards	3	7	11	17	8
2	0	0	12	32	26	Gap Analysis	1	0	0	6	39

4.4 Questions

The analyses of the 26 questions in the questionnaire are divided into 4 groups with 7 questions each in the first 3 groups and only 5 questions in the last group. This is to allow good visibility of the questions analysed without overcrowding in a single chart.

The researcher used a stack bar chart to present the perceived level of importance of each of the factors studied. The bar chart is stacked with high, medium, low, not effective and don't know bars to show the frequency of the levels.

4.4.1 Questions 1 – 7

Questions 1-7 tested on the following items:

1. Turnover of Staff
2. Cost of Appraising
3. Change Management
4. Many Roles to One Person
5. Unscheduled Events
6. Financial Motives
7. Public Holiday Events

The findings from the questionnaire survey indicate that Turnover of Staff has a high importance rating (77.17%) from 71 respondents. Therefore this indicates that turnover of staff is one of the factors that plays a main role and has an effect on the transition time of CMMI. The Cost of Appraising got a high rating (52.17%) from 48 respondents while Change Management was voted as being of high importance on 69 occasions (75%) from the respondents. This was followed by Many Roles to One Person which got counted for a

low of 16 times (17.39%). This indicates that it is not an effective factor that affects the transition time of CMMI. Unscheduled Events was suggested 47 times (51%) as an indicator of importance for the transition time. Financial Motives was selected 37 times (40.2%) as an important factor for the CMMI transition time in the study conducted between the two countries. Finally, Public Holiday Events was cited 39 times (42.39%) to show its importance in affecting the transition time of CMMI in two data sets, where it has different importance in two countries.

The details of the questionnaire survey of questions 1 – 7 is displayed graphically in Figure 4.1.

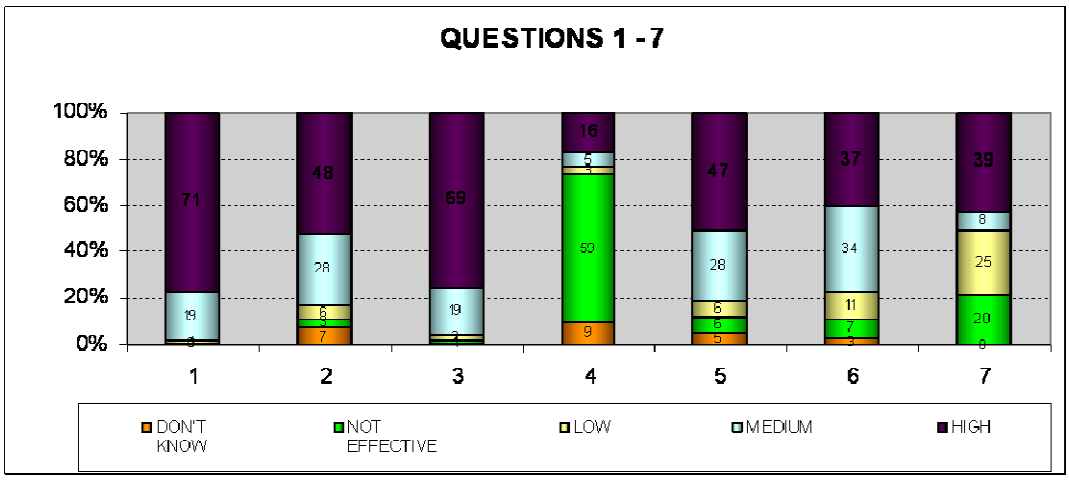

Figure 4.1 **Frequency of the effectiveness of questions 1 – 7.**

4.4.2 Questions 8 – 14

Questions 8-14 tested on the following items:

8 Imposed Partner

9 Income Level

10 Management Commitment

11 Frequency of Process Assessment

12 Separation of Process and Product Concerns

13 Management & Staff Involvement

14 Training

The data analysis indicates that Imposed Partner got selected as being of high importance only 46 times. This shows that for the rest of the 46 times it was not important. Income Level was selected as important 42 times and for 50 times it was not so important. Management Commitment factor was regarded as important by 81 respondents. Frequency of Process Assessment was highly regarded as an important factor affecting the CMMI transition time as there were 43 respondents who clearly said this was important. Separation of Process and Product Concerns got 71 votes as an important factor. Management & Staff Involvement secured the votes of 47 respondents to show that this was an important factor affecting the transition time of CMMI. The final item in this group was Training which got 78 responses to indicate this was important factor affecting transition time.

The details of the questionnaire survey for questions 8 – 14 is displayed graphically in Figure 4.2.

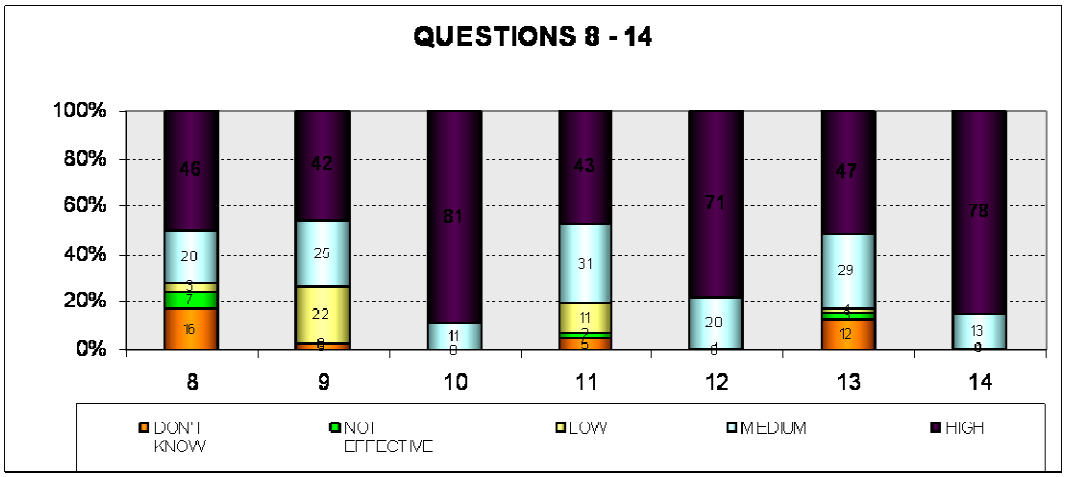

Figure 4.2 Frequency of the effectiveness of questions 8 – 14.

4.4.3 Questions 15 – 21

Questions 15-21 tested on the following items:

15 Review

16 Defined SPI Implementation Methodology

17 Awareness

18 CMMI Experienced Staff

19 Communication

20 Group Focus

21 Process Documentation

The Review factor got voted as a highly important factor affecting the transition time of CMMI by 60 respondents which means that it has 65.22% of importance on the transition time. The Defined SPI Implementation Methodology factor received a convincing 49 responses to show its importance in affecting the transition time. Awareness was also regarded as an important factor as it received the vote from 52 respondents participating in the questionnaire survey. CMMI Experienced Staff was selected as an important factor by 56 respondents, which means that it has approximately 61% of importance. Communication got the approval from 48 respondents while Group Focus obtained 35 confirmations as an important factor. Finally Process Documentation only managed a low of 53 respondents thinking it was an important factor affecting the transition time. It went on to show that 39 other respondents regarded this as not important.

The details of the questionnaire survey for questions 15 – 21 is displayed graphically in Figure 4.3.

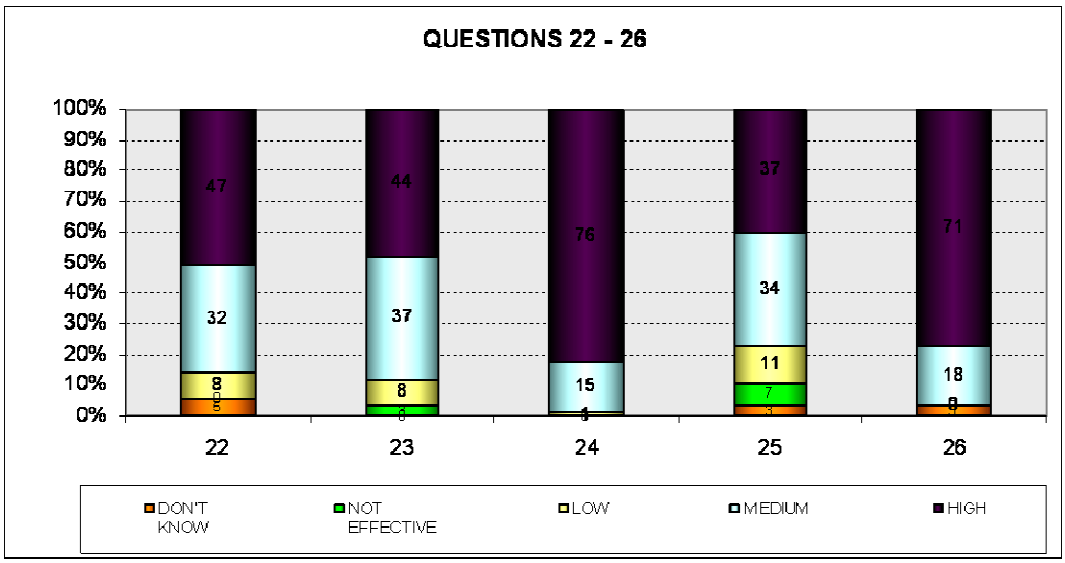

Figure 4.3 Frequency of the effectiveness of questions 15 - 21.

4.4.4 Questions 22 – 26

Questions 22-26 tested on the following items:

22 Consultation

23 Metrics and Measurement

24 Allocation of Resources

25 Rewards

26 Gap Analysis

Consultation received 47 responses saying it was an important factor for the CMMI transition time. Metrics and Measurement got 44 respondents agreeing this was a factor which was affecting the transition time. Allocation of Resources was cited by 76 of the respondents (approximately 83%) who participated in the survey as an important factor affecting the CMMI transition time. Rewards seems to have got the lowest response level from 37 of those who responded in this survey while Gap Analysis seems to have received

a high importance feedback from 71 respondents (77.17%) of both data sets who said that it was an important factor affecting the transition time of CMMI.

The breakdown of the details of questions 22 – 26 given above is shown in Figure 4.4.

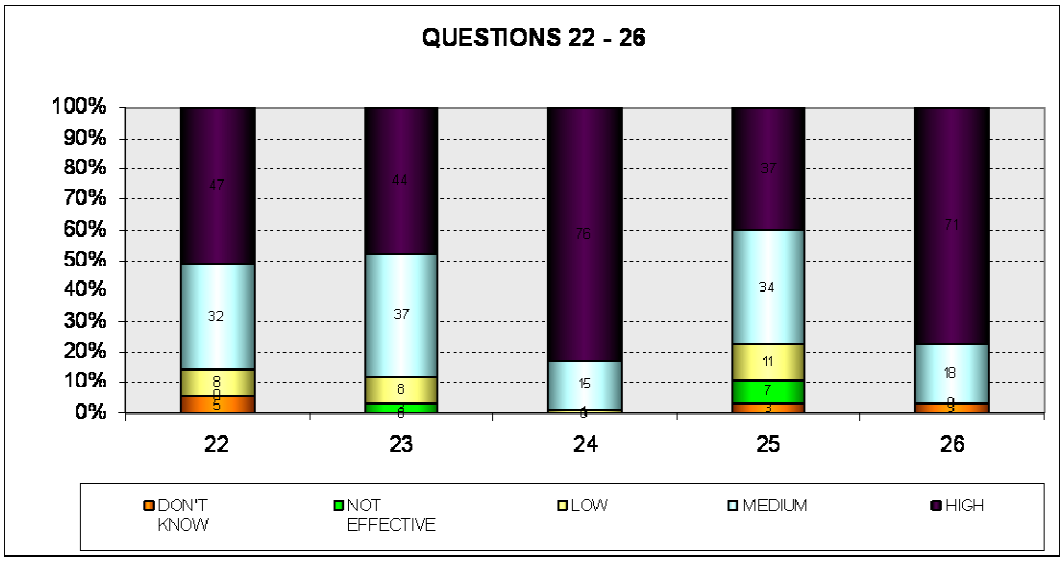

Figure 4.4 Frequency of the effectiveness of questions 22 - 26.

4.5 Factors affecting transition time of CMMI

In this section the researcher organized the data collected in a systematic manner one after another. The data was analysed as follows:

- Effective Factors in Saudi Arabia
- Not Effective Factors in Saudi Arabia
- Effective Factors in Malaysia
- Not Effective Factors in Malaysia
- Effective Factors in both Malaysia and Saudi Arabia
- Not Effective Factors in both Malaysia and Saudi Arabia

The findings for each of the groups are presented and discussed below.

4.5.1 Effective Factors in Saudi Arabia

There are 18 factors affecting the Saudi Arabia organizations. The factors are sorted from the highest to the lowest as reflected in Table 4.3.

Table 4.3 Effective Factors in Saudi Arabia

Factor No.	EFFECTIVE FACTORS IN SAUDI ARABIA	HIGH	PERCENT
14	Training	41	89.1%
10	Management Commitment	39	84.8%
26	Gap Analysis	39	84.8%
1	Turnover of Staff	38	82.6%
15	Review	38	82.6%
24	Allocation of Resources	38	82.6%
12	Separation of Process & Product Concerns	37	80.4%
18	CMMI Experienced Staff	37	80.4%
16	Defined SPI Implementation Methodology	34	73.9%
8	Imposed Partner	33	71.7%
3	Change Management	32	69.6%
5	Unscheduled Events	31	67.4%
13	Management & Staff Involvement	29	63.0%
17	Awareness	29	63.0%
21	Process Documentation	29	63.0%
11	Frequency of Process Assessment	26	56.5%
23	Metrics and Measurement	26	56.5%
22	Consultation	23	50.0%

One of the 18 factors is Training with 41 respondents accounting for 89.1% of Saudi practitioners. Therefore, this reflects that training plays a main role in the transition time of CMMI, and it indicates that the interest in training should be a prime target for companies that want to achieve CMMI Level 3.

Management Commitment and Gap Analysis both received 84.8% with 39 respondents each claiming that it is highly effective on the transition time of CMMI. Therefore, these two factors come in the second place of importance after Training for Saudi practitioners.

This reflects that if the top management is committed to the CMMI process and brings in those who can analyse the processes to identify where the gap is, this would facilitate the CMMI process and reduce the transition time.

Turnover of Staff got 38 respondents representing 82.6% claiming this to be effective. The Review factor received 38 responses acquiring the vote of 82.6% of the total number of respondents, thus suggesting this factor to be highly effective. Allocation of Resources received 38 responses amounting to 82.6%, indicating this factor as highly effective. Separation of Process & Product Concerns received 37 high responses accounting for 80.4%. This was followed by CMMI Experienced Staff as a highly effective factor with 37 respondents accounting for 80.4%. Therefore, it is clear that managers of companies should maintain the employment of those staff members who may be beneficial and effective during the CMMI process and can review the processes and be part of a review group, where the Review factor is effective on the transition time of CMMI. However, these properties are available in CMMI Experienced Staff which is an effective factor affecting the transition time. In addition to that, all the resources that are needed should be provided prior to the CMMI process, and there should not be any separation between the Process and Product Concerns as there are some managers who, when the company gets involved in an urgent project, decide to stop the process improvement until the project is completed, and then continue with the improvement. These managers need to understand that the development process was originally for this purpose and for the project quality itself. Therefore, the Separation of Process and Product Concerns factor is effective on the transition time as it consumes the time for the CMMI process.

Defined SPI Implementation Methodology received 34 responses which was equivalent to 73.9%. Therefore, this indicates that the presence of a clear methodology would affect the transition time of CMMI and reduce it.

Imposed Partner was suggested to be an effective factor by 33 respondents which amount to 71.7%. Therefore, this indicates that adding or imposing any partner to the company during the CMMI process may affect the transition time, especially if this partner has no experience in software process improvement.

Change Management was reflected to be a highly effective factor in CMMI transition time with 32 respondents accounting for 69.6%. Therefore, this indicates that any change in the management during the CMMI process would affect the transition time of CMMI, as each manager has a special vision and a different strategy, and this may alter the CMMI process plan.

Unscheduled Events was reflected to be a highly effective factor in the CMMI transition time with 31 respondents accounting for 67.4%. Therefore, it indicates that the occurrence of any kind of emergency may be time consuming. As such, there should be an alternative resolution and the administration should consider all the possibilities that may happen during the CMMI process.

Management & Staff Involvement was next with 29 respondents, which accounts for 63.0%, claiming it to be highly effective in influencing CMMI transition time. This was followed by Awareness and Process Documentation which also had 29 respondents resulting in 63.0% for both factors respectively. Therefore, this indicates that the staff should be involved with the management in preparing the CMMI process plan, and that raising the level of awareness about CMMI among the staff would be helpful for the

company. Hence, this would be reflected in the importance of the process documentation on the transition time of CMMI during the CMMI process.

Two other factors, Frequency of Process Assessment and Metrics and Measurement accounted for 56.5% each with 26 respondents each claiming these factors were highly effective in influencing the CMMI transition time. Therefore, this indicates that making assessments from time to time would rectify the processes to satisfy all the process areas, thus reducing the transition time. Hence, this cannot happen if no measurement and metrics are made available in the company for achieving that.

Consultation received 23 respondents, accounting for 50.0% of the respondents in the survey who believed this factor was highly effective in influencing the CMMI transition time. Therefore, this indicates the importance of consultation during the CMMI process and its effect on the transition time of CMMI.

Consequently, in order to answer the first research question (*RQ1*) in this study which is: *"What are the factors that affect the transition time of CMMI in the Middle East region?"*, Table 4.3 shows the factors that are effective in Saudi Arabia (in Middle East region) which are: Training, Management Commitment, Gap Analysis, Turnover of Staff, Review, Allocation of Resources, Separation of Process & Product Concerns, CMMI Experienced Staff, Defined SPI Implementation Methodology, Imposed Partner, Change Management, Unscheduled Events, Management & Staff Involvement, Awareness, Process Documentation, Frequency of Process Assessment, Metrics and Measurement, and Consultation.

These factors, together with the number of responses to indicate the "high" responses, are shown in figure 4.5, which is a visual description of the identified effective factors in Saudi

Arabia, with the X-axis representing the percentage and the Y-axis representing the effective factors.

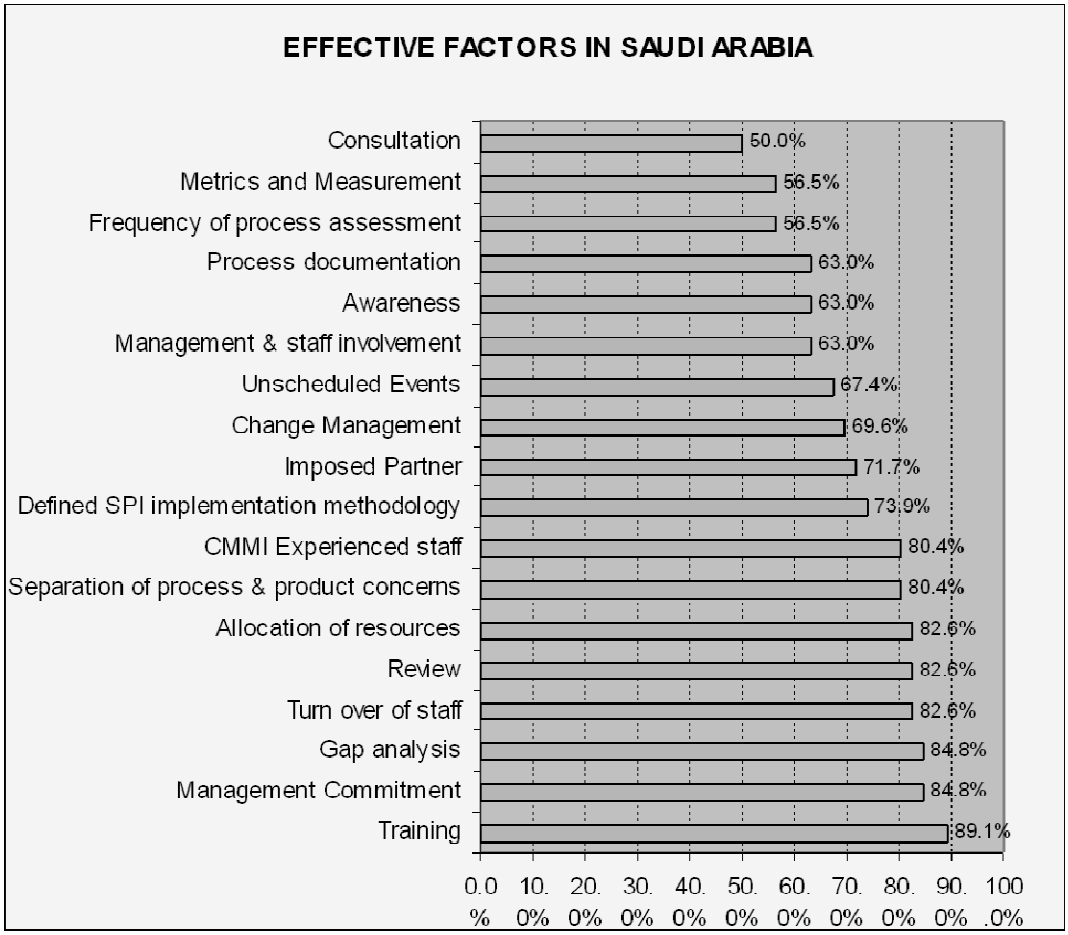

Figure 4.5 Factors affecting Saudi Arabia

4.5.2 Non Effective Factors in Saudi Arabia

According to the effective factor criterion (see 3.6.3), there are 8 factors which are not effective in influencing the CMMI transition time in Saudi Arabia. These factors are highlighted in Table 4.4.

Table 4.4 Non effective Factors in Saudi Arabia

No.	NOT EFFECTIVE FACTORS IN SAUDI ARABIA	HIGH	PERCENT
20	Group Focus	20	43.5%
2	Cost of Appraising	15	32.6%
9	Income Level	13	28.3%
19	Communication	9	19.6%
6	Financial Motives	8	17.4%
25	Rewards	8	17.4%
4	Many Roles to One Person	3	6.5%
7	Public Holiday Events	0	0.0%

Group Focus received 20 respondents with 43.5% of the total respondents in the survey. Cost of Appraising received 15 respondents accounting for 32.6% while Income Level received 13 responses accounting for 28.3% of the total number of respondents. Communication secured the vote of 9 respondents representing 19.6% of the total responses, while Financial Motives and Rewards received 8 respondents each amounting to 17.4% respectively citing this factor as effective. Many roles to One Person had 3 respondents claiming this as effective which amounts to 6.5%, while Public Holiday Events did not attract any high responses in the survey.

The details are highlighted graphically in Figure 4.6, which shows a visual description of factors that are not effective in Saudi Arabia, with the X-axis representing the percentage and the Y-axis representing the factors.

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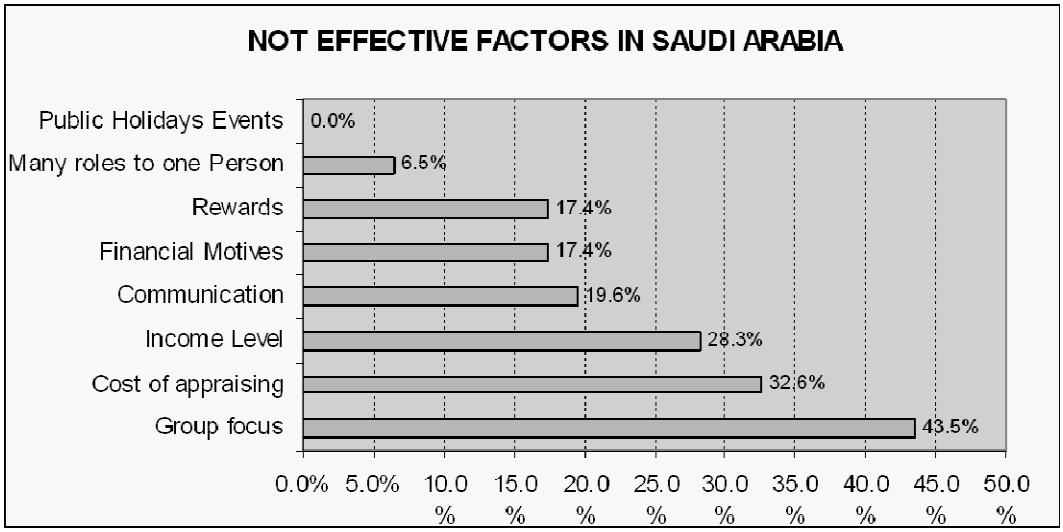

Figure 4.6 Not Effective Factors in Saudi Arabia

4.5.3 Effective Factors in Malaysia

There are 16 factors affecting the transition time of CMMI in Malaysian organizations. These factors are: Management Commitment, Public Holiday Events, Communication, Allocation of Resources, Change Management, Training, Separation of Process & Product Concerns, Turnover of Staff, Cost of Appraising, Gap Analysis, Financial Motives, Income Level, Rewards, Process Documentation, Consultation, and Awareness. Table 4.5 shows these factors.

Table 4.5 Effective Factors in Malaysia

No.	EFFECTIVE FACTORS IN MALAYSIA	HIGH	PERCENT
10	Management Commitment	42	91.3%
7	Public Holiday Events	39	84.8%
19	Communication	39	84.8%
24	Allocation of Resources	38	82.6%
3	Change Management	37	80.4%
14	Training	37	80.4%
12	Separation of Process & Product Concerns	34	73.9%
1	Turnover of Staff	33	71.7%

2	Cost of Appraising	33	71.7%
26	Gap Analysis	32	69.6%
6	Financial Motives	29	63.0%
9	Income Level	29	63.0%
25	Rewards	29	63.0%
21	Process Documentation	24	52.2%
22	Consultation	24	52.2%
17	Awareness	23	50.0%

The most frequently cited factor in Malaysia is Management Commitment, which was regarded as highly effective in influencing the CMMI transition time with 42 respondents accounting for 91.3%. Therefore, this shows that in the opinion of Malaysian practitioners, management commitment can play a vital role to improve the transition time of CMMI.

Public Holiday Events and Communication are two factors which got 39 responses each amounting to 84.8% of the total respondents, thus suggesting that these were highly effective in influencing the CMMI transition time. This indicates that 84.8% of practitioners consider that many days of Malaysian holidays is time consuming, especially as some of these holidays cover 2-3 days. Unless the CMMI process set a specific date to begin and end in order to achieve a particular CMMI level, then the large number of public holidays would mathematically consume a computed time from the CMMI process. Consequently, this is reflected in the final total of the transition time of CMMI. And so, the communication between employees should be more streamlined, and its approaches and methods should be provided and clarified for all employees.

Allocation of Resources was next with 38 respondents accounting for 82.6% thinking this was effective. This was followed by Change Management and Training, with 37 respondents each amounting to 80.4% respectively. Therefore, this finding reflects the importance of providing sufficient resources and adopt suitable change management

strategy to improve the transition time. Thus, there should be training courses and workshops for the staff on the CMMI model and its process areas.

Separation of Process & Product Concerns received feedback from 34 respondents accounting for 73.9% who believe this to be highly effective on the CMMI transition time. Turnover of Staff and Cost of Appraising secured 33 respondents each with 71.7% of the total respondents participating in this survey respectively. Gap Analysis was next with 32 respondents accounting for 69.6% claiming this factor to be highly effective in influencing CMMI transition time. Therefore, the researcher believes that during the CMMI process any kind of staff turnover would affect the transition time because the organization may start seeking to fill up this gap and may succeed in doing so, but this will take time. Malaysian practitioners see that the Gap Analysis and Cost of Appraising factors affect the transition time. So this indicates that by analysing the processes to specify the gap and then to fill it up would reduce the cost of appraising for CMMI as the company will not hesitate to appraise its processes based on CMMI, because the possibility of reappraising processes is very small. Therefore, this is one of the reasons why the CMMI process may delay. Most companies do not appraise their processes officially to make sure that at least most of the processes satisfy the CMMI process areas because the official appraising is very expensive. For example CMMI Level 3 costs between US$160,000 to US$ 200,000, depending on the SEI partner.

Financial Motives, Income Level, and Rewards are three different factors which secured 29 responses or 63.0% of the total responses in the survey respectively. Therefore, this indicates that the financial stability and satisfaction, monthly income of the work force, and rewarding the staff with certificates of appreciation or vacations would motivate them to increase their productivity, thus decreasing the transition time of CMMI.

Process Documentation and Consultation received 24 responses each, which accounted for 52.2% of the total respondents believing these are highly effective factors in determining the CMMI transition time. Meanwhile, the Awareness factor received 23 responses accounting for 50.0%. Therefore, this indicates that by increasing the awareness among employees, the process documentation will be done in the right way. Therefore, the presence of consultation to direct the organization and help it in building a comprehensive plan for the CMMI process will be the best way to abridge the transition time of CMMI.

Consequently, in order to answer the second research question (*RQ2*) which is, "*What are the factors that affect the transition time of CMMI in South East Asia region?*", while Malaysia is selected to represent South East Asia region, Table 4.5 shows these factors which are: Management Commitment, Public Holiday Events, Communication, Allocation of Resources, Change Management, Training, Separation of Process & Product Concerns, Turnover of Staff, Cost of Appraising, Gap Analysis, Financial Motives, Income Level, Rewards, Process Documentation, Consultation, and Awareness.

These factors, together with the number of responses to indicate the "high" responses, are shown in Figure 4.7, which represents a visual descriptionof the factors that are effective in Malaysia, with the X-axis representing the percentage and the Y-axis representing the effective factors.

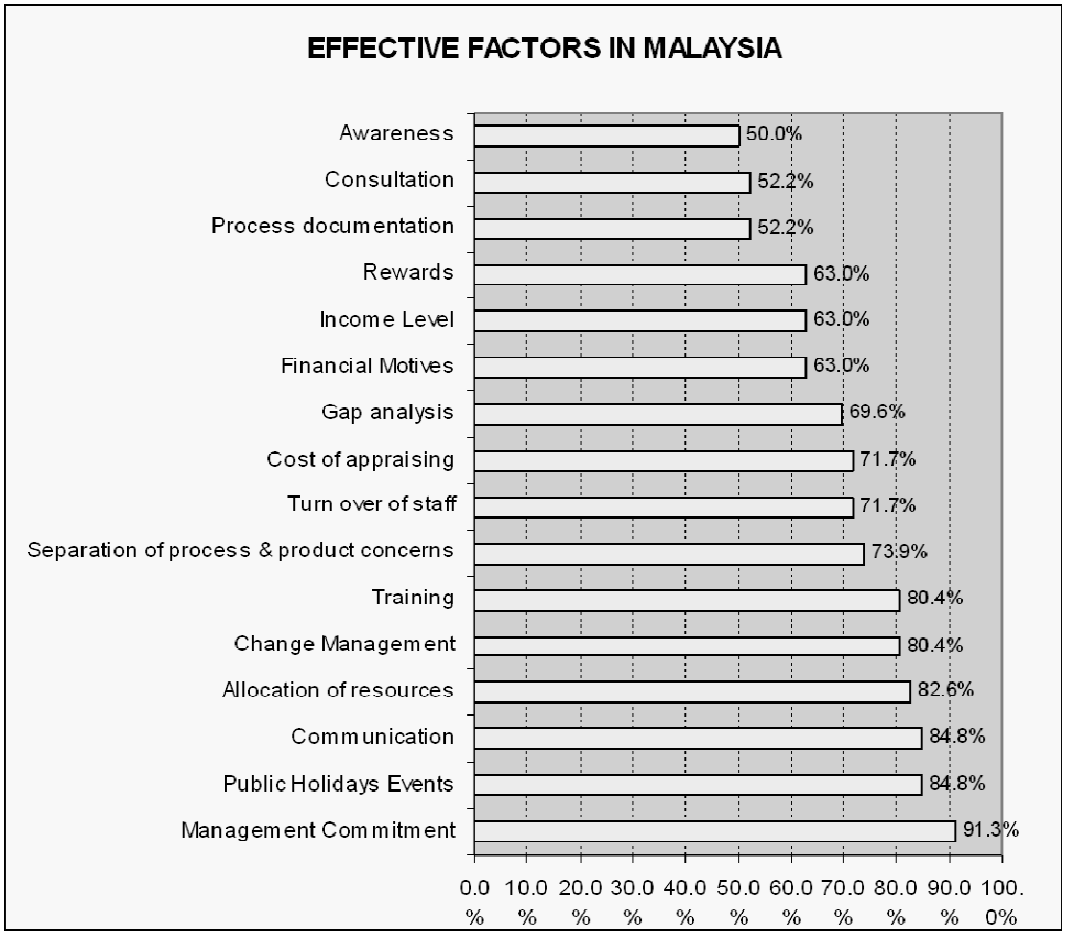

Figure 4.7 Effective Factors in Malaysia

4.5.4 Non Effective Factors in Malaysia

There were 10 factors which were not effective in Malaysia. These factors are shown in Table 4.6.

Table 4.6 Not Effective Factors in Malaysia

No.	NOT EFFECTIVE FACTORS IN MALAYSIA	HIGH	PERCENT
15	Review	22	47.8%
18	CMMI Experienced Staff	19	41.3%
13	Management & Staff Involvement	18	39.1%
23	Metrics and Measurement	18	39.1%
11	Frequency of Process Assessment	17	37.0%

5	Unscheduled Events	16	34.8%
16	Defined SPI Implementation Methodology	15	32.6%
20	Group Focus	15	32.6%
4	Many Roles to One Person	13	28.3%
8	Imposed Partner	13	28.3%

The Review factor received a vote from 22 respondents accounting for 47.8%, followed by CMMI Experienced Staff with 19 responses accounting for 41.3%. Next Management and Staff Involvement together with Metrics and Measurement were 2 different factors securing 18 respondents each representing 39.1% of the respondents respectively. The next factor was Frequency of Process Assessment which had 17 respondents accounting for 37.0% of the respondents. Unscheduled Events received 16 responses to show it was a highly effective factor, accounting for 34.8% of the 46 respondents. Defined SPI Implementation Methodology and Group Focus were 2 different factors which received 15 responses each amounting to 32.6% of the total respondents each. Many roles to One Person and Imposed Partner secured 13 votes representing 28.3% respectively. These factors together with the number of responses to indicate the not effective responses are shown in Figure 4.8.

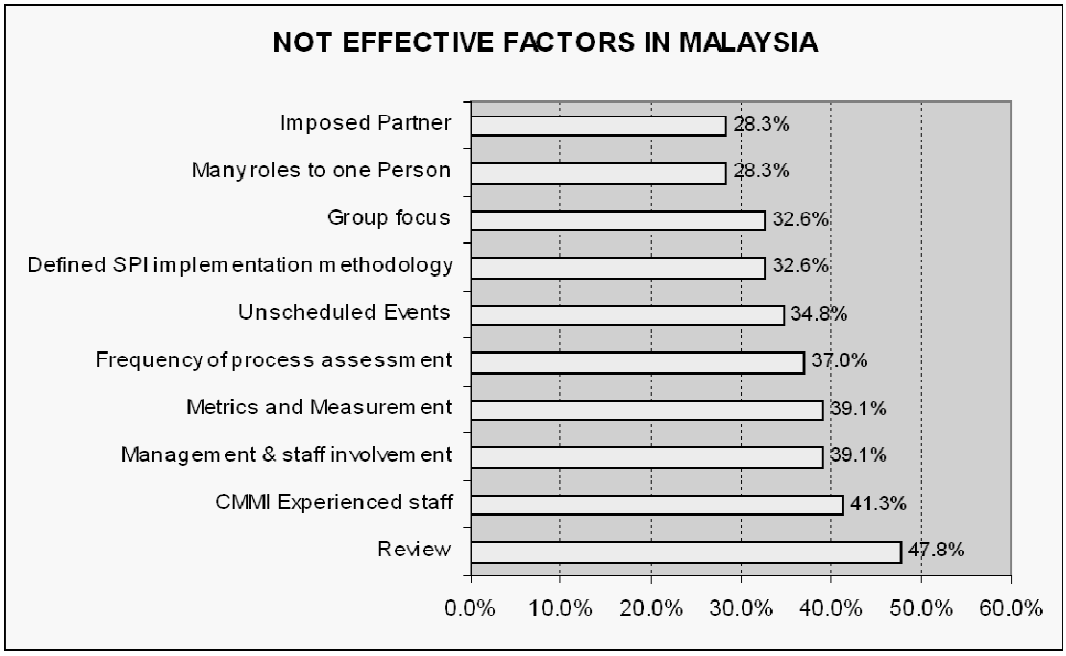

Figure 4.8 Not Effective Factors in Malaysia

4.5.5 Effective Factors in both Data Sets (Malaysia and Saudi Arabia)

There are 10 factors which are effective factors in Malaysia as well as in Saudi Arabia. These factors are: Turnover of Staff, Change Management, Management Commitment, Separation of Process and Product Concerns, Training, Awareness, Process Documentation, Consultation, Allocation of Resources, and Gap Analysis. Therefore, these factors affect the transition time of CMMI.

By these findings, the researcher found that the Training factor has a vital role on the transition time of CMMI, and so this result agrees with (Tufail et al., 2006; Guererro and Eterovic, 2004; Balla et al., 2001; Jacklen, 2007; Oslan and Szchlis, 2002; Zeid, 2004).

Moreover, the findings indicate that Management Commitment plays a considerable role during the CMMI process. Therefore this agrees with (Jacklen, 2007; Balla et al., 2001; Oslan and Szchlis, 2002; Tufail et al., 2006).

The Consultation factor is no less effective on the transition time of CMMI than others. Therefore, this agrees with (Oslan and Szchlis, 2002; Jacklen, 2007; Tufail et al., 2006; Balla et al., 2001).

The Awareness factor is also worth mentioning as it has an effect on the transition time. Therefore, this result agrees with (Balla et al., 2001; Jacklen, 2007; Tufail et al., 2006).

The Process Documentation factor shows the importance of documentation for all processes and the findings indicate that process documentation plays an important role in the transition time of CMMI. Therefore, this result agrees with (Oslan and Szchlis, 2002; Zeid, 2004).

However, the literature and studies investigating the transition time of CMMI is very limited to the best of the researcher's knowledge. Therefore, the researcher found that some factors are not identified in the literature as factors affecting the transition time of CMMI. These factors are: Turnover of Staff, Change Management, Separation of Process and Product Concerns, Allocation of Resources, and Gap Analysis. Consequently, it is possible that some of these factors may have been mentioned as success factors for SPI implementation but, as far as the researcher is concerned, no previous study has focused on the transition time of CMMI or considered time as a main issue in SPI implementation. In addition, it is not necessary for each effective factor on the transition time of CMMI to be a success factor for SPI implementation, for example, the Turnover of Staff factor. The company may consume time to find a substitute for its staff. Therefore this would affect the time of the CMMI process in measuring the time but would not affect the SPI programme in measuring the success, because the company will eventually find a substitute and then continue with the SPI programme until successful, regardless of how long a time it may take.

Consequently, in order to answer the third research question (*RQ3*) in this study, which is: "*What are the shared factors that affect the transition time of CMMI in both Middle East and south East Asia regions?*", the factors are: Turnover of Staff, Change Management, Management Commitment, Separation of Process and Product Concerns, Training, Awareness, Process Documentation, Consultation, Allocation of Resources, and Gap Analysis.

4.5.6 Non Effective Factors in both Data Sets (Malaysia and Saudi Arabia)

In this study, there are only two factors which are not effective in Malaysia as well as in Saudi Arabia. These factors are Many Roles to One Person and Group Focus. This indicates that these factors are not effective factors either in Saudi Arabia or in Malaysia. Therefore, these factors do not have an effect on the transition time of CMMI.

4.6 Overall Factors

An overview of all the factors studied can be summarized as shown in the Venn graph in Figure 4.9. Therefore, overall items: 26 items as following

- Affecting both data sets: 10 items accounting for 38.5% of the total items investigated,
- Affecting Saudi Arabia alone: 8 items amounting to 30.8% of the total items investigated,
- Affecting Malaysia alone: 6 items representing 23.1% of the total items investigated, and
- Not effective in both data sets: 2 items measuring to 7.7% of the total items investigated.

The details are as shown in Figure 4.9.

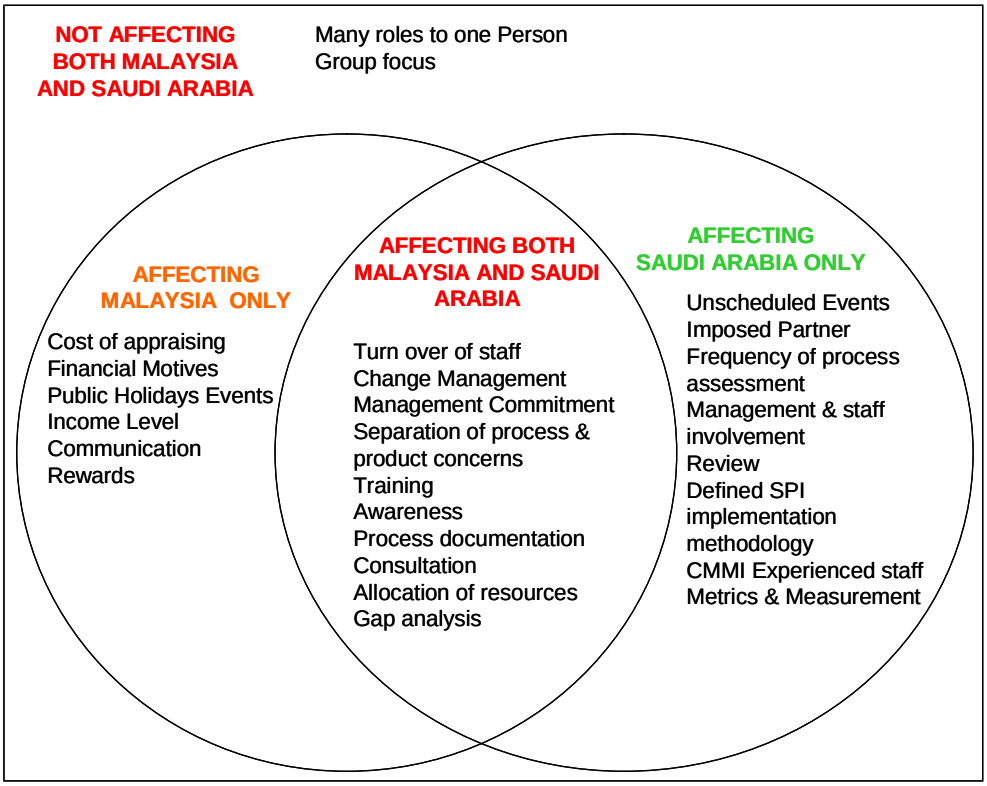

Figure 4.9 Overall factors Venn Graph

The study has divided the factors into three main categories as follows:

1. Organizational Factors, which are related to the management.
2. Human Factors, which are related to employees needs.
3. Project Factors, which are related to CMMI process.

In Saudi's region, the study found that there are four factors which can be categorized into organizational factors which are *Unscheduled Event, Imposed Partner, Management & Staff involvement, and Defined SPI implementation methodology*. And there are four factors which can be categorized into project factors which are *Frequency of process assessment, Review, CMMI Experienced Staff, and Metrics & Measurement*. Therefore, this indicates that 50% of factors that affect that transition time of CMMI in Saudi Arabia are organizational factors and the others are project factors.

While in Malaysian's region there are two factors as project factors which are (Cost of appraising and Communication). And there are four factors as human factors which are (Financial Motives, Public Holidays Event, Income Level, and Rewards). Therefore, this indicates that 67% of identified factors that affect the transition time of CMMI in Malaysia are human factors.

Consequently, the study may indicate that there is a need in Malaysian's firms to focus on employees' needs, while in Saudi's firms there is a need to focus on organizational plan, strategies, and project needs. Hence, this finding indicates that the organizational factors are perceived to be more significant to affect transition time in Middle East Region. While, the human factors are more significant to affect the transition time of CMMI in South East Asia Region.

On other hand, the study found that the two regions shared on 60% of factors which are organizational factors (Turnover of Staff, Change Management, Management Commitment, Training, Awareness, and Consultation). While another factors are project factors. Therefore, it is clear that there is an importance of top management during CMMI process and how the interesting of management interaction will facilitate to achieve the CMMI programme in short time.

4.7 The Effect of Geographical Region

In order to show the effect of geographical region on the transition time of CMMI, the study has preferred to conduct a comparison between two countries in the same region to see whether the effective factors are similar or different. The objective of this comparison is to verify the similarities and differences that exist between the two regions. Hence, Jordan is selected to be studied to establish its similarities and differences with Saudi Arabia, and Indonesia is selected to establish its similarities and differences with Malaysia. Therefore, the study has compared among Saudi Arabia and Jordan in Middle East Region, and among Malaysia and Indonesia in South East Asia Region. Consequently, the study has used the same questionnaire of this study in Jordan and Indonesia, and used same number of practitioners which is 46 practitioners in each country.

4.7.1 Middle East Region

4.7.1.1 Saudi Arabia and Jordan Comparison

The study has used the same questionnaire and the findings were as shown in Table 4.7.

Table 4.7 Saudi Arabia and Jordan Comparison

JORDAN (N=46)							SAUDI ARABIA (N=46)				
DON'T KNOW	NOT EFFECTIVE	LOW	MEDIUM	HIGH	**Factor No.**	**FACTOR NAME**	DON'T KNOW	NOT EFFECTIVE	LOW	MEDIUM	HIGH
0	0	0	10	36	1	Turnover of Staff	0	0	0	8	38
7	0	8	16	15	2	Cost of Appraising	4	3	6	18	15
3	0	0	9	34	3	Change Management	1	1	1	11	32
2	36	2	0	6	4	Many Roles to One Person	2	39	1	1	3
1	2	1	9	33	5	Unscheduled Events	0	3	1	11	31
3	7	11	15	10	6	Financial Motives	3	7	11	17	8
8	15	22	1	0	7	Public Holiday Events	0	20	25	1	0
2	2	1	8	33	8	Imposed Partner	2	0	1	10	33
1	1	17	10	17	9	Income Level	0	0	21	12	13
1	0	0	7	38	10	Management Commitment	0	0	0	7	39
1	1	1	17	26	11	Frequency of Process Assessment	1	0	0	19	26
2	0	0	9	35	12	Separation of Process & Product	0	0	0	9	37

						Concerns					
7	1	1	8	29	13	Management & Staff Involvement	7	0	0	10	29
0	0	0	6	40	14	Training	1	0	0	4	41
2	0	0	6	38	15	Review	0	0	0	8	38
2	1	1	8	34	16	Defined SPI Implementation Methodology	2	0	0	10	34
1	1	1	14	29	17	Awareness	0	1	3	13	29
4	0	2	3	37	18	CMMI Experienced Staff	5	0	1	3	37
9	0	32	3	8	19	Communication	6	0	29	2	9
7	0	1	16	22	20	Group Focus	8	0	0	18	20
2	0	0	15	29	21	Process Documentation	0	0	0	17	29
2	0	1	20	23	22	Consultation	3	0	1	19	23
3	0	2	15	26	23	Metrics and Measurement	0	0	0	20	26
1	0	1	7	37	24	Allocation of Resources	0	0	0	8	38
3	7	6	17	13	25	Rewards	3	7	11	17	8
1	1	1	5	38	26	Gap Analysis	1	0	0	6	39

According to Effective Factor criterion (see 3.6.3), the effective factors were as shown in Table 4.8. Therefore, the effective factors in Saudi Arabia and Jordan are similar. Consequently, the study establishes and verifies that the counties which are in the same geographical region have similar effective factors.

Table 4.8 Saudi Arabia and Jordan effective factors

Factor No.	EFFECTIVE FACTORS	Saudi Arabia (n=46)		Jordan (n=46)	
		HIGH	PERCENT	HIGH	PERCENT
14	Training	41	89.1%	40	87.0%
10	Management Commitment	39	84.8%	38	82.6%
26	Gap Analysis	39	84.8%	38	82.6%
1	Turnover of Staff	38	82.6%	36	78.3%
15	Review	38	82.6%	38	82.6%
24	Allocation of Resources	38	82.6%	37	80.4%
12	Separation of Process & Product Concerns	37	80.4%	35	76.1%
18	CMMI Experienced Staff	37	80.4%	37	80.4%
16	Defined SPI Implementation Methodology	34	73.9%	34	73.9%
8	Imposed Partner	33	71.7%	33	71.7%
3	Change Management	32	69.6%	34	73.9%
5	Unscheduled Events	31	67.4%	33	71.7%
13	Management & Staff Involvement	29	63.0%	29	63.0%
17	Awareness	29	63.0%	29	63.0%
21	Process Documentation	29	63.0%	29	63.0%
11	Frequency of Process Assessment	26	56.5%	26	56.5%

23	Metrics and Measurement	26	56.5%	26	56.5%
22	Consultation	23	50.0%	23	50.0%

4.7.2 South East Asia Region

4.7.2.1 Malaysia and Indonesia Comparison

The study has used the same questionnaire and the findings were as shown in Table 4.9.

Table 4.9 Malaysia and Indonesia Comparison

MALAYSIA (N=46)							INDONESIA (N=46)				
DON'T KNOW	NOT EFFECTIVE	LOW	MEDIUM	HIGH	**Factor No.**	**FACTOR NAME**	DON'T KNOW	NOT EFFECTIVE	LOW	MEDIUM	HIGH
1	0	1	11	33	1	Turnover of Staff	2	0	1	10	33
3	0	0	10	33	2	Cost of Appraising	1	1	1	9	34
0	0	1	8	37	3	Change Management	2	0	1	8	35
7	20	2	4	13	4	Many Roles to One Person	2	18	4	11	11
5	3	5	17	16	5	Unscheduled Events	6	1	6	18	15
0	0	0	17	29	6	Financial Motives	0	0	0	11	35
0	0	0	7	39	7	Public Holiday Events	1	1	1	4	39
14	7	2	10	13	8	Imposed Partner	10	9	6	8	13
3	0	1	13	29	9	Income Level	1	0	0	14	31
0	0	0	4	42	10	Management Commitment	2	0	0	4	40
4	2	11	12	17	11	Frequency of Process Assessment	5	1	10	13	17
0	0	1	11	34	12	Separation of Process & Product Concerns	3	0	1	8	34
5	3	1	19	18	13	Management & Staff Involvement	7	1	1	20	18
0	0	0	9	37	14	Training	0	0	2	7	37
0	2	15	7	22	15	Review	2	2	13	7	21
3	9	7	12	15	16	Defined SPI Implementation Methodology	9	3	6	13	15
3	2	8	10	23	17	Awareness	5	0	7	11	23
2	0	7	18	19	18	CMMI Experienced Staff	1	1	5	20	19
0	0	2	5	39	19	Communication	1	1	2	3	39
3	0	10	18	15	20	Group Focus	5	0	8	15	18
5	0	4	13	24	21	Process Documentation	4	2	3	13	24
2	0	7	13	24	22	Consultation	0	1	6	14	25
0	3	8	17	18	23	Metrics and Measurement	3	3	5	20	15
0	0	1	7	38	24	Allocation of Resources	1	0	1	6	38
0	0	0	17	29	25	Rewards	0	0	0	15	31
2	0	0	12	32	26	Gap Analysis	2	1	1	11	31

According to Effective Factor criterion (see 3.6.3), the effective factors were as shown in

Table 4.10. Therefore, the effective factors in Malaysia and Indonesia are similar. Consequently, the study establishes and verifies that the counties which are in same geographical region have similar effective factors.

Table 4.10 Malaysia and Indonesia Effective Factors

Factor No.	EFFECTIVE FACTORS	Malaysia (n=46)		Indonesia (n=46)	
		HIGH	PERCENT	HIGH	PERCENT
10	Management Commitment	42	91.3%	40	87.0%
7	Public Holiday Events	39	84.8%	39	84.8%
19	Communication	39	84.8%	39	84.8%
24	Allocation of Resources	38	82.6%	38	82.6%
3	Change Management	37	80.4%	35	76.1%
14	Training	37	80.4%	37	80.4%
12	Separation of Process & Product Concerns	34	73.9%	34	73.9%
1	Turnover of Staff	33	71.7%	33	71.7%
2	Cost of Appraising	33	71.7%	34	73.9%
26	Gap Analysis	32	69.6%	31	67.4%
6	Financial Motives	29	63.0%	35	76.1%
9	Income Level	29	63.0%	31	67.4%
25	Rewards	29	63.0%	31	67.4%
21	Process Documentation	24	52.2%	24	52.2%
22	Consultation	24	52.2%	25	54.3%
17	Awareness	23	50.0%	23	50.0%

4.7.3 The Effect of Geographical Region on Transition Time Factors

In order to show the effect of Geographical Region on the transition time of CMMI, and as long as the effective factors in Malaysia is similar to effective factors in Indonesia from South East Asia Region and the effective factors in Saudi Arabia is similar to the effective factors in Jordan from Middle East Region, the study continued the comparison between different countries from different geographical region which are Malaysia to represent a South East Asia Region and Saudi Arabia to represent as Middle East Region.

In two different geographical regions, i.e. Malaysia and Saudi Arabia, the researcher used the same questionnaire. However, it produced different results. Whereas some of the factors were effective in the Malaysian region, they were not effective in the Saudi Arabian region. Table 4.11 shows the effective factors in Malaysia only which are: (Public Holiday Events, Communication, Cost of Appraising, Financial Motives, Income Level, Rewards).

Table 4.12 shows that the effective factors in Saudi Arabia only are: (Review, CMMI Experienced Staff, Defined SPI Implementation Methodology, Imposed Partner, Unscheduled Events, Management and Staff Involvement, Frequency of Process Assessment, and Metrics and Measurement). This indicates that each geographical region has its own impact and unique effect.

Table 4.13 shows the shared factors that are effective in both Malaysia and Saudi Arabia regions. These factors are: (Training, Management Commitment, Gap Analysis, Turnover of Staff, Allocation of Resources, Separation of Process and Product Concerns, Change Management, Awareness, Process Documentation, and Consultation).

Therefore, the researcher found from Table 4.13 that the ratio of the effect based on the shared effective factors in Malaysia is 62.5%, where ratio of the effect in Saudi Arabia

based on these factors is 55.56%. Consequently, the geographical region impact on the transition time in Malaysia is 37.5%, whereas the effect of geographical region on the transition time in Saudi Arabia is 44.44%. This indicates that with different geographical regions there are different effective factors on the transition time of CMMI and different effect ratios. Therefore, these results agree with Paulish and Carleton (1994) who claimed that the geographical region characteristics have a significant impact on software process improvement.

Table 4.11 Effective factors in Malaysia only

Factors	Malaysia	
	High	Percentage
Public Holiday Events	39	85%
Communication	39	85%
Cost of Appraising	33	72%
Financial Motives	29	63%
Income Level	29	63%
Rewards	29	63%

Table 4.12 Effective factors in Saudi Arabia only

Factors	Saudi Arabia	
	High	Percentage
Review	38	83%
CMMI Experienced Staff	37	80%
Defined SPI Implementation Methodology	34	74%
Imposed Partner	33	72%
Unscheduled Events	31	67%
Management & Staff Involvement	29	63%
Frequency of Process Assessment	26	57%
Metrics and Measurement	26	57%

Table 4.13 Shared effective factors in both data sets

Factors	Saudi Arabia (n=46)		Malaysia (n=46)	
	H	%	H	%
Turnover of Staff	38	82.61	33	71.74

Change Management	32	69.57	37	80.43
Management Commitment	39	84.78	42	91.30
Separation of Process and Product Concerns	37	80.43	34	73.91
Training	41	89.13	37	80.43
Awareness	29	63.04	23	50.00
Process Documentation	29	63.04	24	52.17
Consultation	23	50.00	24	52.17
Allocation of Resources	38	82.61	38	82.61
Gap Analysis	39	84.78	32	69.57

4.7.1 Comparison between Malaysia and Saudi Arabia

A comparison of the factors that affect the transition time of CMMI provided evidence that there are similarities and differences between the findings in the two data sets (i.e. Malaysia and Saudi Arabia). Focusing on the factors that affect the transition time across the two data sets may offer CMMI-based SPI practitioners cost-effective opportunities to decrease the time spent throughout the duration of CMMI. This is because there are a number of factors that have a wide effect on the transition time of CMMI which can be treated.

Therefore, from Table 4.13 which has shared effective factors in both data set, the researcher found that the Turnover of Staff factor has an effectiveness of 82.61% in Saudi Arabia and 71.74% effectiveness in Malaysia and this indicates that companies which in Middle East Region have a sufferance from this effective factor more than companies that are in South East Asia Region with 10%, and the study attributes the turnover of staff to abundance of opportunities between competing companies for attracting the distinguished employees, and this verify that even with shared factors that affect the transition time there is an effect of geographical region on these factors.

The Change Management factor has an effectiveness of 69.57% in Saudi Arabia, while in Malaysia the effectiveness is 80.43% and this indicates that this effective factor affect the transition time of CMMI in South East Asia region more than its effect in Middle East Region with 11%, and the study attribute this to frequent change of administrations in Malaysian companies which is due to strategies or culture of the top management in South East Asia Region.

The Management Commitment factor has an effectiveness of 84.78% in Saudi Arabia, while in Malaysia it has an effectiveness of 91.30%, and this indicates that different geographical region has different effect on the transition time factors, and the study attributes the high percentage of the effect to there is a need of companies management in South East Asia Region to show more commitment for CMMI process.

The Separation of Process and Product Concerns factor has an effectiveness of 80.43% in Saudi Arabia, while in Malaysia it has an effectiveness of 73.91%, and this indicates that there is a need in Middle East companies more than companies in South East Asia Region to focus on the processes and don't try to postpone the process improvement.

The Training factor has an effectiveness of 89.13% in Saudi Arabia, while in Malaysia it has an effectiveness of 80.43%, and this indicates that there is a need for training on CMMI model in Middle East Region companies more than companies in South East Asia Region with 9%, and the study attributes that to a lack of SEI Partner in Saudi Arabia (which is only one) while there are 5 SEI Partners in Malaysia . The Awareness factor has an effectiveness of 63.04% in Saudi Arabia, while it has an effectiveness of 50% in Malaysia. The Process Documentation factor has an effectiveness of 63.04% in Saudi Arabia while in Malaysia it has an effectiveness of 52.17%. The Consultation factor has an effectiveness of 50% on the transition time in Saudi Arabia, while in Malaysia it has an effectiveness of

52.17%. The Gap Analysis factor has an effectiveness of 84.78% in Saudi Arabia, while in Malaysia it has an effectiveness of 69.57%, the study attributes that to the companies from different geographical region have different opinions regarding to the effect of effective factors.

Consequently, the researcher attributes this difference in the effectiveness on the transition time of CMMI in Middle East Region and South East Asia Region to the difference in the geographical region due to the culture, strategies, education system, and technology level. Therefore, according to the shared effective factors in Table 4.13, the researcher found that 10 of the 24 effective factors, (as there are 2 factors which are not effective either in the geographical region of Saudi Arabia or in Malaysia), affect the transition time of CMMI. This indicates that these factors play a role with 41.67% effectiveness on the transition time, whilst the geographical region plays role with an effectiveness of 58.33%. Consequently, this answers the fourth research question (*RQ4*) in the study, which is: "*How would the geographical regions affect the transition time of CMMI-based SPI?*" Therefore, the different geographical regions will have an effect on the factors that affect the transition time of CMMI-based SPI with 58.33% of effectiveness.

4.7.2 Hypothesis Test Decision

At the beginning of the study the researcher commenced with 26 different hypotheses that there is no significant difference between two geographical regions. Therefore, for explanation purposes, the hypotheses can be generalized as follows.

Ho There is no significant difference in the factors that affect the transition time of CMMI-based software process improvements in different geographical regions.

Ha There is a significant difference in the factors that affect the transition time of CMMI-based software process improvements in different geographical regions.

Based on these premises, the researcher set the relevant hypothesis to reflect the findings of the study on the 26 factors investigated here. The resulting hypothesis to be tested is as follows:

1 There is no significant difference in Turnover of Staff in affecting the transition time of CMMI-based software process improvement in different geographical regions.

2 There is no significant difference in Cost of Appraising in affecting the transition time of CMMI-based software process improvement in different geographical regions.

3 There is no significant difference in Change Management in affecting the transition time of CMMI-based software process improvement in different geographical regions.

4 There is no significant difference in Many Roles to One Person in affecting the transition time of CMMI-based software process improvement in different geographical regions.

5 There is no significant difference in Unscheduled Events in affecting the transition time of CMMI-based software process improvement in different geographical regions.

6 There is no significant difference in Financial Motives in affecting the transition time of CMMI-based software process improvement in different geographical regions.

7 There is no significant difference in Religious Events in affecting the transition time of CMMI-based software process improvement in different geographical regions.

8 There is no significant difference in Imposed Partner in affecting the transition time of CMMI-based software process improvement in different geographical regions.

9 There is no significant difference in Income Level in affecting the transition time of CMMI-based software process improvement in different geographical regions.

10 There is no significant difference in Management Commitment in affecting the transition time of CMMI-based software process improvement in different geographical regions.

11 There is no significant difference in Frequency of Process Assessment in affecting the transition time of CMMI-based software process improvement in different geographical regions.

12 There is no significant difference in Separation of Process and Product Concerns in affecting the transition time of CMMI-based software process improvement in different geographical regions.

13 There is no significant difference in Management & Staff Involvement in affecting the transition time of CMMI-based software process improvement in different geographical regions.

14 There is no significant difference in Training in affecting the transition time of CMMI-based software process improvement in different geographical regions.

15 There is no significant difference in Review in affecting the transition time of CMMI-based software process improvement in different geographical regions.

16 There is no significant difference in Defined SPI Implementation Methodology in affecting the transition time of CMMI-based software process improvement in different geographical regions.

17 There is no significant difference in Awareness in affecting the transition time of CMMI-based software process improvement in different geographical regions.

18 There is no significant difference in CMMI Experienced Staff in affecting the transition time of CMMI-based software process improvement in different geographical regions.

19 There is no significant difference in Communication in affecting the transition time of CMMI-based software process improvement in different geographical regions.

20 There is no significant difference in Group focus in affecting the transition time of CMMI-based software process improvement in different geographical regions.

21 There is no significant difference in Process Documentation in affecting the transition time of CMMI-based software process improvement in different geographical regions.

22 There is no significant difference in Consultation in affecting the transition time of CMMI-based software process improvement in different geographical regions.

23 There is no significant difference in Metrics and Measurement in affecting the transition time of CMMI-based software process improvement in different geographical regions.

24 There is no significant difference in Allocation of Resources in affecting the transition time of CMMI-based software process improvement in different geographical regions.

25 There is no significant difference in Rewards and Motivation in affecting the transition time of CMMI-based software process improvement in different geographical regions.

26 There is no significant difference in Gap Analysis in affecting the transition time of CMMI-based software process improvement in different geographical regions.

The null hypothesis is that there is no significant difference in the 26 individual factors between Saudi Arabia and Malaysia, while the alternative hypothesis is that there is a significant difference in the 26 different factors between Saudi Arabia and Malaysia.

The relevant test to evaluate before making the statistical decision to accept or reject the hypothesis is based on the Chi-Square test. The statistical decision to either accept or reject the hypothesis is based on the p-value of the Chi-square statistical test.

By calculating the p-value the researcher can decide whether to reject or accept the null hypothesis. The null hypothesis is rejected if the p-value is less than $\alpha = 0.05$. Table 4.14 shows the Chi-square test results between the two data sets.

Table 4.14 Chi-square test results

		Saudi Arabia (n=46)					Malaysia (n=46)					Linear by linear association Chi-square test, α=0.05		
No	Factors	5	4	3	2	1	5	4	3	2	1	$\chi 2$	df	p
1	Turnover of Staff	38	8	0	0	0	33	11	1	0	1	2.5	1	0.115
2	Cost of Appraising	15	18	6	3	4	33	10	0	0	3	8.5	1	0.004
3	Change Management	32	11	1	1	1	37	8	1	0	0	4.8	1	0.029
4	Many Roles to One Person	3	1	1	39	2	13	4	2	20	7	6.9	1	0.009
5	Unscheduled Events	31	11	1	3	0	16	17	5	3	5	9.5	1	0.002
6	Financial Motives	8	17	11	7	3	29	17	0	0	0	29	1	0.000
7	Public Holiday Events	0	1	25	20	0	39	7	0	0	0	78	1	0.000
8	Imposed Partner	33	10	1	0	2	13	10	2	7	14	23	1	0.000
9	Income Level	13	12	21	0	0	29	13	1	0	3	8	1	0.005
10	Management Commitment	39	7	0	0	0	42	4	0	0	0	0.9	1	0.338
11	Frequency of Process Assessment	26	19	0	0	1	17	12	11	2	4	10	1	0.001
12	Separation of Process and Product Concerns	37	9	0	0	0	34	11	1	0	0	0.8	1	0.358
13	Management & Staff Involvement	29	10	0	0	7	18	19	1	3	5	0.8	1	0.357
14	Training	41	4	0	0	1	37	9	0	0	0	0	1	0.845
15	Review	38	8	0	0	0	22	7	15	2	0	19	1	0.000
16	Defined SPI Implementation Methodology	34	10	0	0	2	15	12	7	9	3	16	1	0.000
17	Awareness	29	13	3	1	0	23	10	8	2	3	5.1	1	0.025
18	CMMI Experienced Staff	37	3	1	0	5	19	18	7	0	2	1.9	1	0.172
19	Communication	9	2	29	0	6	39	5	2	0	0	42	1	0.000
20	Group Focus	20	18	0	0	8	15	18	10	0	3	0	1	1.000
21	Process Documentation	29	17	0	0	0	24	13	4	0	5	6.4	1	0.012
22	Consultation	23	19	1	0	3	24	13	7	0	2	0	1	0.837
23	Metrics and Measurement	26	20	0	0	0	18	17	8	3	0	9.6	1	0.002
24	Allocation of Resources	38	8	0	0	0	38	7	1	0	0	0.1	1	0.803
25	Rewards	8	17	11	7	3	29	17	0	0	0	29	1	0.000
26	Gap Analysis	39	6	0	0	1	32	12	0	0	2	1.8	1	0.185

Based on the linear by linear Chi-square test above, the researcher is able to make the statistical decision either to reject or accept the null hypothesis. The null hypothesis is

rejected if the p-value is less than α=0.05. Therefore, the statistical decision is summarized as shown in Table 4.15.

Table 4.15 Statistical test decision

No	Factors	Linear by linear association Chi-square test, α=0.05			Statistical decision
		$\chi 2$	df	*p*	Reject or accept
1	Turnover of Staff	2.49	1	0.115	Accept
2	Cost of Appraising	8.51	1	0.004	Reject
3	Change Management	4.77	1	0.029	Reject
4	Many Roles to One Person	6.91	1	0.009	Reject
5	Unscheduled Events	9.54	1	0.002	Reject
6	Financial Motives	29.1	1	0.000	Reject
7	Public Holiday Events	78.3	1	0.000	Reject
8	Imposed Partner	23	1	0.000	Reject
9	Income Level	8.04	1	0.005	Reject
10	Management Commitment	0.92	1	0.338	Accept
11	Frequency of Process Assessment	10.2	1	0.001	Reject
12	Separation of Process and Product Concerns	0.85	1	0.358	Accept
13	Management & Staff Involvement	0.85	1	0.357	Accept
14	Training	0.04	1	0.845	Accept
15	Review	18.7	1	0.000	Reject
16	Defined SPI Implementation Methodology	16.1	1	0.000	Reject
17	Awareness	5.06	1	0.025	Reject
18	CMMI Experienced Staff	1.87	1	0.172	Accept
19	Communication	41.8	1	0.000	Reject
20	Group Focus	0	1	1.000	Accept
21	Process Documentation	6.37	1	0.012	Reject
22	Consultation	0.04	1	0.837	Accept
23	Metrics and Measurement	9.59	1	0.002	Reject
24	Allocation of Resources	0.06	1	0.803	Accept
25	Rewards	29.1	1	0.000	Reject
26	Gap Analysis	1.76	1	0.185	Accept

Therefore, from the p-value above, the researcher found 16 factors with a significant difference ($p<0.05$), or in other words the researcher can say that these 16 factors are different in both countries. Consequently, this indicates that the geographical region can play a considerable role in the transition time of CMMI, where it has an effect on the factors that affect the transition time of CMMI, because each region has own characteristics in terms of culture, commitment, human resource, employees salaries level, availability of experts, and technology level.

4.8 Chapter Summary

This chapter presented the findings of this study in which the researcher attempted to identify the factors affecting the CMMI transition time. The factors that affect the transition time of CMMI in Saudi Arabia are: Training, Management Commitment, Gap Analysis, Turnover of Staff, Review, Allocation of Resources, Separation of Process & Product Concerns, CMMI Experienced Staff, Defined SPI Implementation Methodology, Imposed Partner, Change Management, Unscheduled Events, Management & Staff Involvement, Awareness, and Process Documentation.

The effective factors in Malaysia are: Management Commitment, Public Holiday Events, Communication, Allocation of Resources, Change Management, Training, Separation of Process & Product Concerns, Turnover of Staff, Cost of Appraising, Gap Analysis, Financial Motives, Income Level, Rewards, Process Documentation, Consultation, and Awareness.

The study mentioned the shared factors that are effective in both data sets which are: Turnover of Staff, Change Management, Management Commitment, Separation of Process and Product Concerns, Training, Awareness, Process Documentation, Consultation, Allocation of Resources, and Gap Analysis.

A questionnaire survey was deployed to achieve the aims and objectives of the study. Therefore, this chapter described the effect of geographical region on the factors that affect the transition time of CMMI by applying the Chi-square linear by linear test to test the research hypothesis and applied a comparison between two data sets, i.e. Malaysia and Saudi Arabia. In order to verify the effect of geographical region, the study has conducted the questionnaire in Indonesia in South East Asia Region and in Jordan in Middle East Region, and then compared the findings between Malaysia and Indonesia to find out the

similarities and differences, and the same thing has been done with Jordan and Saudi Arabia. The study found that the effective factors in Malaysia and Indonesia are almost similar, and the effective factors in Jordan and Saudi Arabia are almost similar, but the effective factors are different in Saudi Arabia and Malaysia. Therefore, the study found that countries which are in the same geographical region have similar effective factors, and countries which are in different geographical region have different effective factors. Therefore, it was clear that the effect of geographical region on the factors that affect the transition time of CMMI with 58.33% of effectiveness.

In the next chapter, the study will deal with the reference model of transition time factors. Hence, the factors that will be used for the development of the proposed framework in the next chapter are *Allocation of Resources, Awareness, Change Management, CMMI Experienced Staff, CMMI Implementation Plan , Communication, Consultation, Cost of Appraising, Financial Motives, Frequency of Process Assessment, Gap Analysis, Group Focus, Imposed Partner, Income Level, Management Commitment, Many Roles to One Person, Metrics and Measurement, Process Documentation, Public Holiday Events, Review, Rewards, Separation of Process and Product Concerns, Staff Involvement, Training, Turnover of Staff, Unscheduled Events*.

CHAPTER FIVE - TRANSITION TIME FACTORS REFERENCE MODEL (TTFRM)

5.1 Introduction

In order to improve software processes there are some organizational initiatives such as CMM (Paulk et al., 1993) and CMMI (SEI, 2002). However, McDermid and Bennet (1999) have mentioned that the human factors to software process improvement have been disregarded and this has damaged the effectiveness of software process improvement programmes. Also, Hall and Wilson (1997, 1998) have indicated that the opinions and experiences of software practitioners affect indirectly on the software quality. Therefore, it is very important to identify the opinions and perceptions of different practitioners on the factors that affect the transition time of CMMI, and to develop a reference model which has set of factors and under each factor there are set of practices that might help to reduce the factor's effect. Section 5.2 describes designing the practices. Section 5.3 explains the expert panel and validating the Reference Model. Section 5.4 shows TTFRM Implementation Framework. The Transition Time Factors Reference Model (TTFRM) is shown in Section 5.5. Section 5.6 describes Chapter Summary.

5.2 Designing the practices.

5.2.1 Sample profile.

Ten software firms were visited, in order to collect the practices that may reduce the factors that affect the transition time of CMMI. All of the firms responded to a request to participate, which was sent by email. The target sample was those software firms that have achieved CMMI Level 3. Sample size can be a source of bias. The larger the sample, the less likely will be the sampling bias (Coolican, 1999). With ten software companies participating in our research sample, it is important to show that this sample is large enough to minimise the possibility of bias (Baddoo, 2001; Baddoo and Hall, 2002; Baddoo and Hall, 2002b; Niazi et al., 2005).

5.2.2 Practices Collection Method.

For each Transition Time Factor (TTF), the study produced a list of practices using literature and interviews. Therefore, the data collection method followed two main approaches:

1. **SPI Literature**

   SPI literature consisted of case studies and experience reports (Niazi et al., 2005; El-Emam et al., 1999; Goldenson and Herbsleb, 1995; Johnson, 1994; Rainer and Hall, 2002; Stelzer and Werner, 1999; Zubrow et al., 1994). Most of these respected studies describe real life experiences of SPI implementation and provide specific guidelines and recommendations for SPI implementation. Therefore, the study followed these literature recommendations by proposing a Reference Model for the Transition Time Factors (TTFRM) of CMMI.

2. **Interview**

The study conducted 17 interviews with practitioners, where the aim of the interview was to answer one main question: “What are the practices that the study should follow to reduce this factor’s effect?” Thus, this question was applied for each factor, respectively. Questioning was open-ended, with investigation to clarify meanings, when required. The interview duration was one hour. Basics skills were applied, such as, explaining the purpose of the interview and length of the interview. At the end of the interview, the study showed the interviewee some of the opinions and practices that had been collected from other practitioners and in the literature for each factor, in order to obtain their opinions on them. The interviewees were also asked to provide their opinions on how these practices can be developed. All interviews were given equal importance regardless of company size or company type. The main reason for this is that the study needed an aggregate list of practices to be used in the TTFRM.

5.3 Expert Panel and Validate the Reference Model.

5.3.1 Expert Panel Demographics.

Twelve experts were approached and the researcher received a positive response from ten. The researcher sent the reference model to them and seven reviewed the model and continued to communicate with the researcher. Table 5.1 shows the demographics of the seven experts.

Table 5.1 Distribution of expertise in the TTFRM expert panel

	Practitioner	Academic	Practitioner and Academic	Total
Saudi Arabia	1	1	1	3
Malaysia	3	1	0	4

5.3.2 Reliability of the Expert Panel – Knowledge

Validation of the TTFRM is dependent on the expert panel's ability to give accurate feedback. Lauesen and Vinter (2001) recommend using experts with different backgrounds to respond to this issue. The study therefore targeted experts with different knowledge who have knowledge in the CMMI process, knowledge in the traceability and modeling, and backgrounds. A similar approach was made by Beecham et al. (2003); Dyba, (2000) ; and Sommerville & Sawyer, (1997).

5.3.3 Reliability of the Expert Panel – Scope

Beecham et al., (2003) mentioned that the larger the sample group, the broader will be the spread of knowledge, leading to more confidence in the results. However, Laueson and Vinter (2001) used only three experts, and were therefore able to insist on them reaching a consensus, rather than only taking an average. Dyba (2000) used 11 experts to conduct his review on Software Process Improvement and he emphasised the importance of each expert's depth of knowledge and experience. Therefore, in this reference model, according to the possibility of finding SPI and CMMI experts that are willing to participate in

reviewing the practices of TTFRM as volunteers, the study used seven experts in order to validate the TTFRM.

5.3.4 Validation Process of the TTFRM.

The validation process of the TTFRM followed several steps, as shown in Figure 5.1. These steps are:

1. Providing the practices of TTFRM to CMMI experts for reviewing and validation process.
2. Collecting the feedback on the reviewed practices from all the CMMI experts.
3. Enhancing and refining the practices according to the experts' feedback.
4. The new version of the TTFRM with its practices was then returned to the CMMI expert for further review process.
5. At this stage, the study repeatedly enhanced the TTFRM according to CMMI experts' feedback, until the researcher receives each expert's approval.

This approach helps to enhance and validate the TTFRM. A similar approach was made by (El Emam and Madhavji, 1996; Dyba, 2000; Beecham et al., 2003).

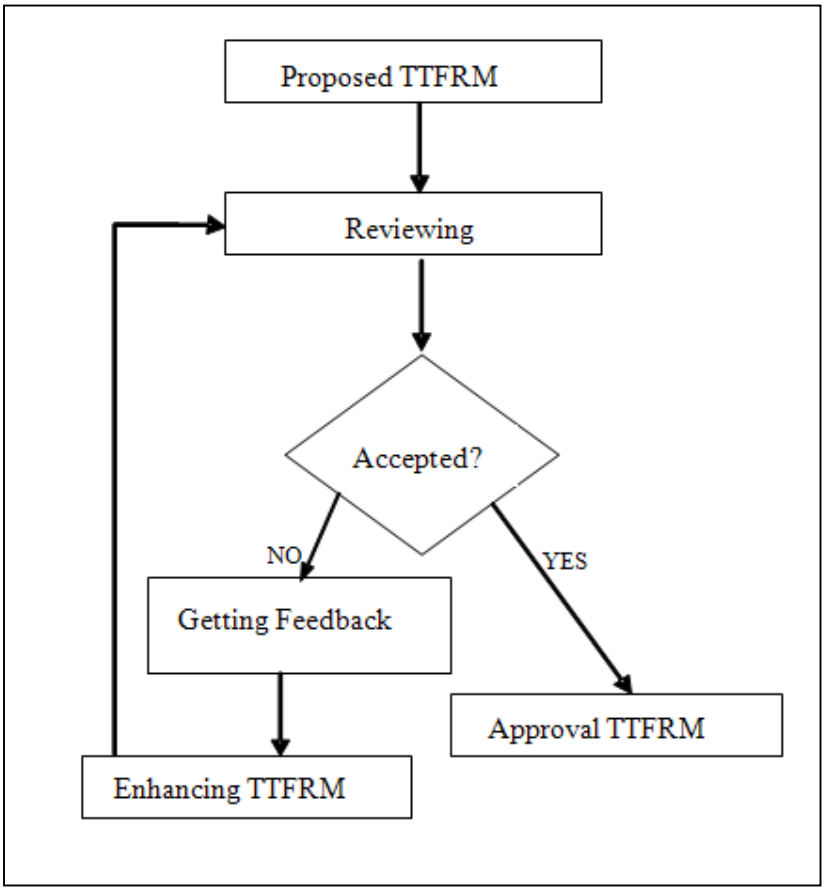

Figure 5.1 Validation Process

5.4 TTFRM Implementation Framework

In order to guide organizations to assess and improve their CMMI implementation processes, the study adapted a Beecham et al., (2003); Niazi et al. (2005), and SEI (2002) perspective, and developed the structure of a TTFRM Implementation Framework for CMMI implementation, as shown in Figure 5.2. This framework shows that companies should address each factor, in order to achieve a certain maturity level (i.e., CMMI Level 3). Under each factor, different practices were designed to describe the activities that guide how to reduce the factor's effect. These practices were reviewed by the CMMI experts that validated the TTFRM.

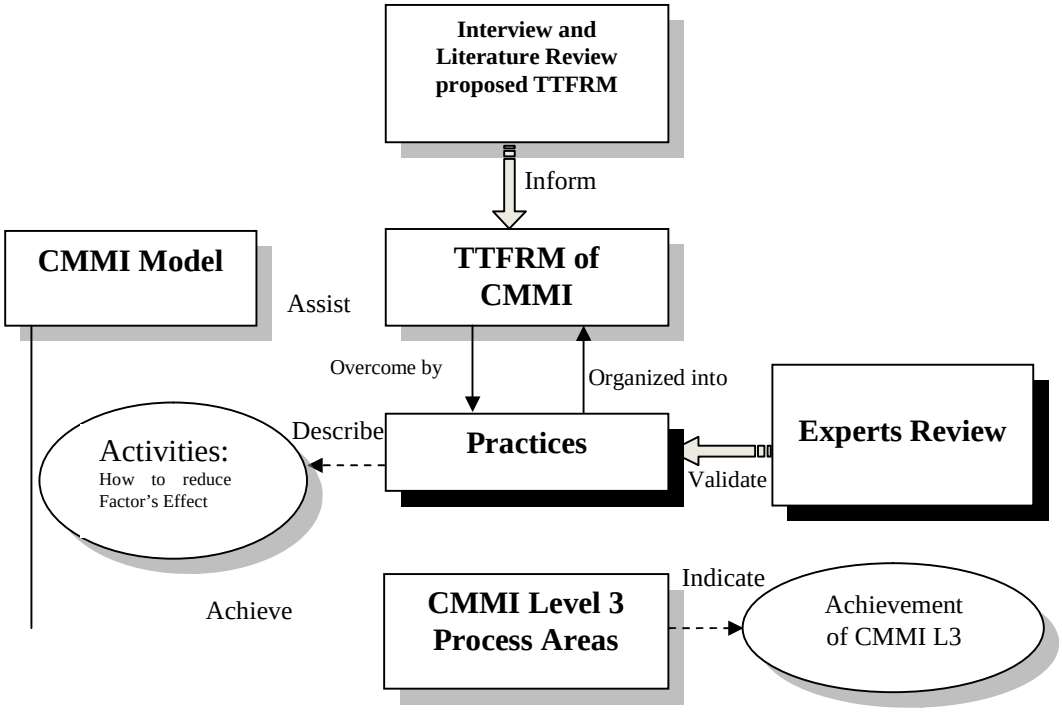

Figure 5.2 TTFRM Implementation Framework

5.5 Transition Time Factors Reference Model (TTFRM).

TTFRM describes a collection of practices that reduce the effects of transition time factors of CMMI. TTFRM contains the TTFs, and for each TTF, there is a set of practices which aim to reduce the factor's effect. The study presented the TTFRM in tabular format which has all factors except 2 factors (Many roles to one Person and Group Focus) which were not effective in both geographical regions (i.e. Saudi Arabia and Malaysia), as shown in Table 5.2.

Table 5.2 TTFRM Model

➢ Allocation of resources The level of resources availability during CMMI journey. Practice (s) • Providing all tools which are requested (e.g. spreadsheet programs, tools for traceability, and tools for testing) • Providing all funds which are required. • Providing employees which are on demand. • Responding to employees needs.
➢ Awareness The level of the CMMI knowledge of SEPG. ☼ Should be known that when the level of SEPG employees' awareness is high the level of employees' commitment would be high as well. Practice (s) • Performing seminars to illustrate the importance of CMMI and clarifying the expected interest of the CMMI. • Applying CMMI workshops (about Process Areas, Gaols, and Practices) for increasing the awareness level of employees. • Providing the employees with CMMI's references.
➢ Change Management Change Management occurs due to the result of dissatisfaction with the present strategies, or to develop a vision of organization for a better alternative. Practice (s)

- Giving employees information about the new management's mission and vision regarding to CMMI adoption.
- Showing a communication strategy that guarantees information to be disseminated efficiently and comprehensively to everyone. This helps to recognise and deal appropriately with the reaction to change.
- Giving individuals occasion to express their concerns and providing reassurances, during the sessions, should give the employees a chance to express their views and support their decision.
- Observing a management practice and should find a time for informal discussion and feedbacks.

➢ CMMI Experienced Staff

The level of Staffs' experience on process improvement and definition in CMMI.

Practice (s)

- Providing an organization with CMMI experts or at least providing employee(s) has/have SPI experience.
- Attracting staffs that have a good experience on process definition.
- Listening to advices of the expert employees.
- Encouragement the CMMI experienced staff in preparing a plan for process improvement from their perspective.
- Involving the CMMI experienced staff in the main plan for accelerating the transition time of CMMI.

➢ Communication

The level of connecting route, understanding, or link between the SPI team.

Practice (s)

- Providing the employees with the ways, methods, and facilities of communication between each other (to know the employees how can communicate in the organization).
- Encouraging bidirectional continuous communications between the workgroups and SEPG during the implementation of CMMI.

➢ Consultation

The level of working with a consultant(s) throughout the CMMI adoption.

☼ Prefer if exist a consultant has an experience with training and CMMI appraisal.

Practice (s)

- Selecting the consultant according to his/her previous experiences in CMMI and Product Integration.
- Applying the consultant recommendations.
- Helping the SEPG in preparing the improvement plan of organization regarding the transition time of CMMI.

- Cost of appraising

Cost of appraising depends on SEI partners prices, there is no a particular value or specified price for CMMI appraising.

☼ Appraisal Cost = Cost of Planning (Preparation) + Execution + Reporting.

☼ Reducing time of appraisal = Reducing cost of appraisal.

Practice (s)

- Specifying appraising team in the organization.
- Training an appraisal team on interpretation of GPs and SPs.
- Using the formal benchmarking for CMMI journey in the organization and following it.
- Making interior-appraising by applying Class C, B, and A appraising respectively before an Official Appraising.
  - ❖ Class C – to settle the processes.
  - ❖ Class B – to implement the process right.
  - ❖ Class A – official appraising (benchmarking).

- Defined SPI implementation Planning

Making a right strategy/methodology for SPI implementing in an Organization.

Practice (s)

- Selecting staffs have SPI experience for the CMMI implementation plan.
- Establishing a high level plan by making experienced staff and consultants involved in the CMMI implementation plan.
- Identifying clear milestones which would use to measure the progress of CMMI implementation.

- Financial Motives

Financial Motives are one of the ways that rise up the productivity of employees and motivate them.

Practice (s)

- Considering this factor through the work plan and financial provisions for CMMI journey in an organization budget.
- Establishing a clear plan that shows who deserves the financial motives in details and understandable points.
- Keeping away from a bias and trying to raise the spirits of employees. In order to produce the maximum possible productivity.

- Frequency of Process Assessment

The number of assessments during CMMI journey before CMMI appraisal.

Practice (s)

- Establishing a process assessment team.

- Monitoring the progress of CMMI Process Areas satisfaction.
- Establishing feedbacks mechanism and encourage SEPG to provide their feedbacks.
- Making sure that the organization is ready before an Official CMMI appraisal by SEI Authorised Partner.

➢ Gap Analysis

Highlights the gaps into processes that exist and need to be filled during CMMI journey.

Practice (s)

- Identifying what is/are required to achieve the objectives.
- Identifying all process areas' case at the present situation.
- Determine the potential barriers/gaps to the process improvements and develop strategies for overcoming these barriers.
- Providing employees by tools that help them to compare the actual processes status with better potential status to improve the processes (e.g. process modelling tools, Ishikawa diagram, and problem-tracking packages).

➢ Imposed Partner

This partner is added to the organization because of his high social situation.

Practice (s)

- Avoiding a bias through CMMI journey, and there should be a clear explanation for effects of this step on CMMI transition time.
- Letting his/her place out of CMMI processing, or keeping him/her as learner without permissions relevant to processes.
- Training him/her through CMMI process on SPI implementation, to benefit of him/her later in an organisation.
- Making sure that his/her hasn't a possible impacts on the CMMI functioning.

➢ Income Level

What is obtained by the employee in an organization at the end of the month.

☼ Normally, a satisfaction of employees has more than dimension. Sense of pleasure, the dealing, sense of presence as part of the development process, and the other side factors would cover a focusing on income level to the employee.
☼ Taking into account that CMMI journey needs to effort.

Practice (s)

- Evaluating employee's effort with his/her income level.
- Establishing a payment strategy for explaining an overtime expenses and making sure that there isn't delay in the overtime payment.

- Management & Staff Involvement

The level of Staffs participation in CMMI planning and implementation.

Practice (s)

- Establishing a conflict resolution plan in the organization.
- Establishing database for a proposed improvement and lessons learned.
- Encouraging the employees to add their experience, comments, and improvement proposals into database.
- Encouraging the employees to provide their feedbacks during the meeting with the management.
- Activating the staff participation role in the CMMI activities.

- Management Commitment

The support level of top management throughout the CMMI journey.

☼ The management should be feel and aware of the real interest that will accrue to the organization when achieving CMMI Level3.

☼ The management commitment towards CMMI would accelerate the transition time of CMMI.

Practice (s)

- Dedicating reasonable time to monitor process improvement activities as appropriate and to be an example to employees by showing real commitment and full respect to the company process especially in the crises times.
- Establishing a measurement approach for performance measurement.
- Evaluating and revising the policy and the plan according to the results.
- Making a meeting with team leaders and managers, listen to them and supporting their ideas.
- Providing the required resources for team members (fund, tools, and people).
- Accelerating the implementation of decisions.
- Providing training courses for team members.
- Eliminating barriers between employees and managers, so that they should work as teams to achieve common objectives (CMMI Level3).

- Metrics and Measurement

The utilization of metrics and measurement during CMMI process.

☼ The employees should realize the benefits of metrics, which would increase their motivation.

Practice (s)

- Measuring what an organization needs.
- Getting on the maximum benefit from what you measure by analyzing the metrics.
- Defining and analyzing the metrics according to the main targets of organization. There should be obvious metrics analysis and it should be meaningful.

- Selecting the metrics that is related to processes.
- Making a plan for automating the metrics process as it is difficult to perform some tasks manually.
- Providing employees with automatic tools, which enable the employees to manage and monitor the processes by collecting and analyzing metrics automatically (e.g. database management systems, system dynamics model, and statistical analysis packages).
- Employing the metrics and measurement results in process implementation.

➢ Process Documentation

The level of process documentation during CMMI process.

☼ It is one of the important references for appraisers.

Practice (s)

- Providing the tools that are needed (e.g. MKS toolkit).
- Training employees for this purpose.
- Specifying particular employees for the process documentation.
- Paralleling with product improvement. There should not be postponement for process documentation.

➢ Public Holidays Events

Normally, for any community there is a Public Holidays and they are different from place to place depending on community's culture and religion.

Practice (s)

- Taking into account this factor in preparing of the annual plan in the organization's budget for CMMI journey.
- Establishing a plan to keep this factor under control (by achieving more work or assigning some employees for working according to CMMI plan's benchmarks to avoid an impact of this factor on CMMI transition time.

➢ Review

Review meeting which is arranging during the CMMI implementation.

Practice (s)

- Arranging review meetings as appropriate for process improvement.
- Specifying meetings to discuss the progress report of processes.
- Performing internal appraisal during the review meetings.
- Providing the management by results and feedbacks of reviews meeting.

- Rewards

The rewarding mechanism that an organization has employed throughout CMMI journey.

☼ Rewards would increase employees' commitment and enjoyment.

Practice (s)

- Establishing a clear mechanism for rewards.
- Giving the rewards based on the performance of the employees.
- Granting the employees some vacations and some plaques, and arranging formal/informal gathering (lunch/dinner).

- Separation of Process and Product Concerns

Some time there is separation in process and product concerns because there are some projects that need to be terminated quickly.

☼ The importance of project delivery is not more than the importance of processes improvement. Whereas, a process improvement will support projects delivery on time, within a budget and high quality.

Practice (s)

- Making stability among project delivery and process improvement.
- Establishing a plan for including all considerations of projects and process improvements.

- Training

An organization has a training plan which is rearranged and updated every year.

Practice (s)

- Establishing a plan for training in the organization.
- Obligating some employees from software department and project managers for attending the related training sessions.
- Providing training courses and references and should be related to CMMI and process improvement.
- Obligating SEPG to attend at least *Introduction to CMMI* training course.
- Making from time to time workshops about CMMI methods, assessment, and implementation.

- Turnover of staff

Employee turnover occurs when employee voluntarily leaves his/her job and must be replaced in the organization.

☼ Realizing that money isn't everything. So that, financial incentives will encourage employees to stay over the short term, but over the long term they need opportunities for growth.

☼ There should be an organization's justice. It is central to understanding a wide range of human attitudes and behaviours in organizations. Therefore it affects staff productivity, but missing an organization's justice may lead them to leave their jobs.

☼ Normally, People are less likely to leave if they feel they're a valued member in the organization.

Practice (s)

- Establishing a solid foundation strategy for growth of employees in the organization. Let employee knows specifically where he/she can go in the organization and what he/she needs to do for getting there (no ambiguity), and praise employees when they've done a good Job.
- Creating a solid work relationship with employees.
- Providing the employees with skills improvement plan in all various sections for those who want to move upward in the organization positions.

➢ Unscheduled Events

Unscheduled Events are a situation that arises from time to time suddenly without a previous warning.

Practice (s)

- Establishing an emergency plan which has alternative ways in case some events are unfeasible.
- Building a team can cover the gap; team leader should be strong enough to settle this factor and should keep on focus (don't lose control).
- Providing the ready substitute.
- Considering team leader's decisions and solutions.

5.6 Chapter Summary

This chapter presented the Transition Time Factors Reference Model (TTFRM). TTFRM implementation framework described how software/services companies should address each factor in order to achieve CMMI level 3. Each factor in this model has set of practices that guide companies to reduce the factor effect during CMMI process. TTFRM has been reviewed and validated by 7 CMMI experts from Saudi Arabia and Malaysia.

CHAPTER SIX – CONCLUSION AND FUTURE WORK

6.1 Introduction

Due to the recent tremendous interest shown by different organizations in CMMI as an SPI model for their projects, this thesis has addressed the effect of geographical region on the factors that affect the transition time of CMMI. The study has explored the impact of geographical region on these factors, through applying a comparative study in two different geographical regions (i.e., Malaysia and Saudi Arabia), and how to overcome this influence. In this chapter, a summary of these contributions and future work directions will be presented. Section 6.2 discusses the conclusion of the research findings. Section 6.3 demonstrates the research implications. Section 6.4 explains some of personal observation during conducting the study. Section 6.5 describes the research contribution to the software engineering community. Research limitations are explained in Section 6.6. And finally, areas for future research are offered in Section 6.7.

6.2 Research Summary and Conclusion

One of the issues of implementing CMMI in organizations is time (Staples et al., 2007). Therefore, the transition time factors of CMMI have highlighted several key areas for the organization's management to focus their attention, in order to achieve the desired results during CMMI process, with the least possible time.

In an attempt to face this issue and as a continuation of previous studies in the software process improvement initiatives field, this research investigates the factors that affect the transition time of CMMI, and the impact of geographical region on these factors. This study

used a questionnaire survey, as its main instrument and approach of interviews, to collect data from organizations. An effective factor criterion was defined; where the majority of respondents (i.e., ≥50%) considered that these factors have a high effect on the transition time of CMMI. Next, the study dealt with measuring which factor was effective, to the extent of affecting the transition time of CMMI. One key hypothesis, with 26 sub-hypotheses, and five related questions, were initially presented and consequently, motivated this research. This study used a chi-square test, to test the main research hypothesis and related sub-hypotheses, in order to determine the significance between the two data sets (i.e., Malaysia and Saudi Arabia). Malaysia was selected to represent South East Asia Region and Saudi Arabia was selected to represent Middle East Region. Therefore, the study used a statistical package (i.e., SPSS programme) to achieve this objective.

The findings indicate that 18 factors (i.e., Training, Management commitment, Gap analysis, Turnover of staff, Review, Allocation of resources, Separation of process & product concerns, CMMI experienced staff, Defined SPI implementation methodology, Imposed partner, Change management, Unscheduled events, Management & staff involvement, Awareness, Process documentation, Frequency of process assessment, Metrics and measurement, and Consultation) have an effect on the transition time of CMMI in Middle East Region. These findings were used in an attempt to answer the first research question. Furthermore, 16 factors (i.e., Management commitment, Public holidays events, Communication, Allocation of resources, Change management, Training, Separation of process & product concerns, Turnover of staff, Cost of appraising, Gap analysis, Financial motives, Income level, Rewards, Process documentation, Consultation, and Awareness) have an effect on the transition time of CMMI in South East Asia Region. These findings were used in an attempt to answer the second research question. The research findings also

indicate that 10 shared factors (i.e., Turnover of staff, Change management, Management commitment, Separation of process and product concerns, Training, Awareness, Process documentation, Consultation, Allocation of resources, and Gap analysis) have an effect on the transition time of CMMI in both geographical regions. These findings were used in an attempt to answer the third research question. The statistical analysis results show that, using the chi-square test to calculate *P*-value (where $\alpha = 0.05$), there were 16 factors with a significant difference ($p<0.05$) between the two data sets (i.e. Saudi Arabia and Malaysia).

In order to reflect the effect of different geographical region on the factors that affect the transition time of CMMI, the study has conducted the same survey questionnaire on two neighboring countries of the same geographical region which are Saudi Arabia and Jordan in Middle East Region and comparing the findings, and then the study has conducted the survey questionnaire on the two other neighboring countries of the same region in different geographical region which are Malaysia and Indonesia in South East Asia Region, and comparing the findings. The findings indicated that the effective factors in two neighboring countries are similar, but they are different in another geographical region. Whereas, the effective factors in Saudi Arabia and Jordan are quite similar which are (Review, CMMI Experienced Staff, Defined SPI Implementation Methodology, Imposed Partner, Unscheduled Events, Management & Staff Involvement, Frequency of Process Assessment, Metrics and Measurement), and the effective factors in Malaysia and Indonesia are quite similar which are (Public Holiday Events, Communication, Cost of Appraising, Financial Motives, Income Level, Rewards). However, the identified effective factors for Middle East Region differ from the identified effective factors for South East Asia Region. Consequently, these findings indicate that geographical region can play a considerable role in the transition time of CMMI, where it affects the factors that affect the transition time of

CMMI with a 58.33% of effectiveness. Based on these findings, the study can establish that there are so many similarities between the countries in the same geographical region. Therefore, these results were used in an attempt to answer the fourth research question; which is related to the main hypothesis of this research. Consequently, our research findings have led us to produce a reference model for the transition time factors of CMMI. This reference model has a set of practices for each factor that tries to reduce the factor's effect on the transition time of CMMI. This reference model (i.e. TTFRM) was used in an attempt to answer the fifth research question.

6.3 Research Implications

1. This research provides an understanding of the transition time factors (TTFs) of CMMI and the impact of the geographical region on these factors. This is important since, to best of our knowledge, there is no empirical research has been conducted on the TTFS of CMMI in Malaysia and Saudi Arabia. Therefore, the findings from this study can be regarded as useful to the Software Engineering community, specifically for researchers in Malaysia and Saudi Arabia.

2. The study shows that each geographical region has different characteristics in terms of strategies, limitations, motivation and effective factors of TTFs. Therefore, this study verified that no specific strategies can be applied to all CMMI processes under all circumstances. In other words, the choice of strategy should depend on contextual aspects of the geographical region.

3. The study demonstrates that 50% of effective factors that affect that transition time of CMMI in Saudi Arabia are organizational factors, while 67% of effective factors that affect the transition time of CMMI in Malaysia are human factors. It can be noticed that both countries have different education systems and different culture which might agree with Harris et al (2004) when they said that “different countries have different culture and work values. The presence of cultural differences across different countries might have led to different working habits and conventions which influence the overall corporate climate”. Therefore, different geographical regions affect working outcome, style, and productivity.

4. This study adopts comparative study set ups as a practical approach. Several researchers recommend the use of comparative study as a research strategy (Berger et al, 2009; Deshpande and Webster, 1999; Redding, 1994). The purpose of comparative study, as a research methodology, is to allow for the ability to compare and control similar factors (Berger et al, 2009). Comparative research is useful in technology researches that investigate similarities, benefits, and effectiveness across a wide variety of industries through different countries.

5. This research provides managers with an insight into various TTFs of CMMI and TTFRM implementation process that contribute to adopt successful CMMI process on time. Hence, it is hoped that managers will use the findings to improve the implementation of CMMI process in their firms.

6. This study confirms that a favourable work climate should be available for all successful CMMI projects. Hence, managements should strive to create a suitable psychological climate, allow more ideas, encourage innovative work and stimulate creativity. This is important to overcome barriers, speed up CMMI process and ensure success in CMMI implementation projects.

7. The study confirms that there should be more focus on minimising behavioural problems during the implementation of CMMI. Moreover, management should provide awareness to all staff through meetings, training, and seminars. Subsequently, firms shell be able to provide required resources and commitment to speed up CMMI process.

8. The study demonstrates that management should pay sufficient attention to the transition time factors (TTFs) of CMMI in order to speed up the CMMI implementation process. These factors varies among geographical regions, however they are shared and effective in these two geographical regions understudy which include the following: Turnover of staff, Change management, Management commitment, Separation of process and product concerns, Training, Awareness, Process documentation, Consultation, Allocation of resources, and Gap analysis. Therefore, the study confirms that these factors must be overcome during CMMI process.

6.4 Beneficial Observation on the Study

The findings presented in this thesis have led the researcher to several learned lessons, which are summarized as follows:

1. Bad practices which might affect the Transition Time of CMMI:

Top management practices may cause an undesired delay in the transition time of CMMI and preventing to get on real benefit of CMMI. These practices include:

- Management who separated certain projects to be in the CMMI programme and some other projects which are urgent to be completed.
- Management would allocate high priority to the urgent project to be delivered rather than the process documentation and improvement.
- There is a limited management role by contracting a consultant and following-up the evaluation without efforts to improve operations.
- Management did not seriously consider workflow reports and makes decisions based on their own impressions, rather than on the facts.
- Management only looks behind the certificate, without obtaining the real value of the CMMI model.

2. Knowledgeable Employee:

Having an employee who is knowledgeable with the program/organization, being evaluated and experienced with CMMI, writing plans, procedures, and checklists, cannot be a small issue. However, a knowledgeable employee can achieve good process documentation and develop well. Therefore, a knowledgeable employee must be retained in an organization.

3. Importance of an Appraiser:

An organization should ensure that the appraiser will work with the organization to understand the environment and to provide help, rather than just provide a list of needed corrective actions. If the appraiser has pre-conceived impressions, about how an organization must operate, the management should ensure that these impressions are corrected; otherwise a compromise should be reached.

4. Refined Database:

Designing a central system requires data and information to include the organization's projects (data bases) as its main repository. Most organizations have this required data and information, but it is not always well documented or organized to provide easy access. Therefore, this system will provide a better capability to share information and data amongst authorized staff, and will save time that is otherwise consumed through the CMMI process.

6.5 Research Contribution

The main contributions of this research are as follows:

- For Research:

This study identifies the effect of geographical region on the factors that affect the transition time of CMMI. In addition, and to the best of our knowledge, this study identifies new factors (i.e., Turnover of staff, Income level, Public holidays events, Cost of appraising, and Imposed partner), which were not included in previous studies, as effective factors on the transition time of CMMI. This study might have explored a new time dimension that might enable more research to be performed on this area and any other area which are related to the time management factors of CMMI implementation.

- For Practitioners:

This study produces a reference model, for the transition time factors of CMMI, as a guideline for reducing the factors' effect during the CMMI process. A Transition Time Factors Reference Model (TTFRM) has the potential to help companies assess and improve their CMMI implementation time. A TTFRM will guide the design of effective implementation strategies for CMMI adoption, in order to achieve CMMI ML3.

Moreover, this study presents an implementation framework for the Transition Time Factors Reference Model (TTFRM) during the CMMI process, in order to guide organizations to improve their CMMI implementation process. The implementation framework explains how organizations should address each factor during the CMMI process, in order to achieve a certain maturity level (i.e., CMMI Level 3).

6.6 Research Limitations

There were a number of limitations in this study. The most notable of which are listed and described briefly as follows:

1. Number of companies that have achieved CMMI Level 3: There are a limited number of companies that have been appraised as CMMI (ML3) in Saudi Arabia and Malaysia. Due to the small number of companies, the data collected was small.

2. Number of respondents: The number of participating respondents in this study was also very limited. With a limited number of respondents, a larger sample size was not possible. Therefore, the results of this study should be treated with caution.

3. This study was limited to Saudi Arabia, Jordan, Malaysian, and Indonesia organizations, which were identified as having implemented a CMMI programme. Employing other developing countries would give more insight on the similarities and differences among them.

4. The study used experts' analysis and review as a validation approach for validating the reference model. By having other validation approach will increase the reliability and accuracy of the reference model and its practices.

6.7 Future Work

Based on this study, a number of opportunities exist for further research. These opportunities can be described as follows:

- The findings of this research provide a possibility to conduct more studies on several organizations at CMMI ML3, using these factors, to measure practically how they would affect transition time, and thus, make detail comparison among them to identify problems in implementing CMMI in organizations. Therefore, a good understanding of the transition time factors of CMMI should help organisations to accelerate moving between CMMI levels. Consequently, the reduction transition time between CMMI levels can lead organisations to achieve more business and commercial benefits (i.e. ROI).

- The findings of this research demonstrate the effect of management commitment on the transition time of CMMI during the CMMI process; thus performing a study to identify better strategies for top management in order to describe the impact of management commitment on the CMMI process and to understand the effect of management commitment on the transition time of CMMI. Furthermore, studying the impact of programmes with well-established processes, on the transition time of CMMI during the CMMI process. Having a program with well-established processes, can speed up the appraisal process; especially if the processes are similar to what the CMMI is looking for. Therefore, this may help to speed up the CMMI process.

- This study only covers CMMI based SPI. However, there are other open research areas, which are related to the factor's effects on SPI based on models other than CMMI, like ISO and Six Sigma. The findings of these researches can be analysed to produce valid approaches for accelerating the SPI process and to investigate the effect of transition time with other SPI models.

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Appendix A: participant companies.

Company	Country	Age (years)	Size	Primary Function	CMMI in Operation (years)
1	Malaysia	5	<100	Software	<5
2	Malaysia	13	>200	Services	>5
3	Malaysia	15	>200	Services	>5
4	Malaysia	13	>200	Services	>5
5	Malaysia	10	<200	Software	>5
6	Malaysia	15	<100	Software/services	<5
7	Malaysia	20	>200	Software/services	>5
8	Malaysia	20	>200	Software	>5
9	Malaysia	25	>200	Software/services	>5
10	Malaysia	6	<100	Services	<5
11	Malaysia	20	>200	Financial services	<5
12	Malaysia	5	<100	Software/services	<4
13	Malaysia	20	>200	Software/hardware/services	>5
14	Malaysia	11	<100	Software/services	<5
15	Malaysia	21	>200	Software/services	<2
16	Malaysia	10	>100	Software/services	>5
17	Malaysia	9	<100	Software	<2
18	Malaysia	10	<100	Software	<5
19	Saudi Arabia	10	<100	Software	<2
20	Saudi Arabia	6	<100	Services	<4
21	Saudi Arabia	5	<100	Software	<2
22	Saudi Arabia	20	>200	Software	>5
23	Saudi Arabia	10	<200	Software	>5
24	Saudi Arabia	20	>200	Software/services	>5
25	Saudi Arabia	10	<100	Services	<2
26	Saudi Arabia	20	>200	Services	>5
27	Saudi Arabia	30	>200	Services	<3
28	Saudi Arabia	15	<200	Software	>5
29	Saudi Arabia	20	>200	Software/hardware	>5

30	Saudi Arabia	12	<100	Software	<3
31	Indonesia	10	<100	Services	<4
32	Indonesia	17	>200	Services	<5
33	Indonesia	13	>200	Services	>5
34	Indonesia	22	>200	Services/Hardware	<3
35	Indonesia	8	<100	Software/Services	<3
36	Indonesia	10	>100	Software/Services	<2
37	Jordan	12	<100	Software	<4
38	Jordan	9	<100	Software	<2
39	Jordan	10	<100	Software/Services	<4
40	Jordan	19	>200	Services/ Finance	<2
41	Jordan	11	<100	Software	<2
42	Jordan	5	<100	Software	<2

Appendix B: Questionnaire

Factors that affect the Transition Time of CMMI-Based Software Process Improvements.

Data Collection Questionnaire

Prepared by

Fahad H. AlShammari

This questionnaire is prepared to be one of the basic supports in the PhD thesis discusses "Factors that affect the Transition Time of CMMI-Based Software Process Improvements". Software Engineering Department, Faculty of Computer Science and Information Technology, University of Malaya.

CMMI: Capability Maturity Model Integration. Software Engineering Institute (SEI), Carnegie Mellon University.

1. Introduction:

This questionnaire is prepared to be one of the basic supports in our research that based on one of the most famous Software Process Improvement (SPI) framework, which is called "CMMI". Such questionnaire is employed to investigate the factors that affect the Transition Time of CMMI.

A fundamental requirement for such research is reliable opinions collected from practitioners who work in CMMI apprised organization. These opinions will be used to test hypotheses and verify our postulation. Your contribution is important to me. I will safeguard your contribution so as not to compromise individual's and company's information.

Hence by your contribution, you play a significant role towards the sound implementation of CMMI model.

For any inquiry about this questionnaire, please contact:
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H/P in Malaysia: 006 012 64 111 64
H/P in Saudi Arabia: 00966 505 15 1334
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2. General Information

2.1 Organization

- **Organization Name:**……..
- **Organization Size: (How many employees work in your Company)**

  ☐ **Less than 50**

  ☐ **51 – 100**

  ☐ **101 – 200**

  ☐ **More than 200**

- **Organization CMMI level: (In which Level of CMMI your company is)**

  ☐ **CMMI Maturity Level 3**

  Started CMMI Program in ……/……/……

  Completion Date in ……../……../……..

  ☐ **CMMI Maturity Level 2**

If your organization has formally started CMMI level 3 Program,

Please state the Start Date of CMMI Program……../……/……

2.2 Participant

Participant Name: ……..

Participant position: ……..

Participant Email: ……..

3. Proposed Factors

The following questions measure your opinion about the effect of particular factors on transition time of CMMI.

Please check the appropriate box according to each factor (1 = Don't Know, 2 = Not Effective, 3 = Low, 4 = Medium and 5 = High).

No.	Question description	1	2	3	4	5
1.	***Turnover of staff:*** This is the measure of the extent to which the employee may leave his job because of some better offers.					
2.	***Cost of appraising:*** This is the measure of the extent to which the company tries to reduce number of appraising through software process improvement because it's expensive.					
3.	***Change Management:*** This is the measure of the extent to which the top management changement, project manager change, or team leader change may affect the transition time as different managers may have different visions.					
4.	***Many roles to one Person:*** This is the measure of the extent to which the employee performs many jobs rather that performing unique job has an effect on transition time.					
5.	***Unscheduled Events:*** This is the measure of the extent to which the employee or organization may face some unscheduled problems for example if employee has health problems or organization faces economic problems.					
6.	***Financial Motives:*** This is the measure of the extent to which the availability of financial motives in case of project completion has an effect on transition time.					
7.	***Public Holiday Events:*** This is the measure of the extent to which the public holiday events would affect the transition time of CMMI.					
8.	***Imposed Partner:*** This is the measure of the extent to which the partner would affect the employee's productivity and therefore affects the transition time. (This partner is added to the organization because of his high social situation).					
9.	***Income Level:*** This is the measure of the extent to which the employee's income is sufficient to meet his living needs has an effect on transition time.					
10.	***Management Commitment***: This is the measure of the extent to which the top management commitment throughout the CMMI application has an effect on transition time.					
11.	***Frequency of process assessment:*** This is the measure of the extent to which the number of the informal/formal assessment done before CMMI appraising has an effect on transition time.					
12.	***Separation of process and product concerns:*** This is the measure of the extent to which the software organizations usually focus their efforts on delivering software products and put little or no effort into process activities has an effect on transition time.					
13.	***Management & staff involvement:*** This is the measure of the extent to which the staff and management involvement throughout CMMI application has an effect on transition time.					
14.	***Training:*** This is the measure of the extent to which the existence of					

	training related to CMMI has an effect on transition time.					
15.	***Review:*** This is the measure of the extent to which the existence of review group has an effect on transition time.					
16.	***Defined SPI implementation methodology***: This is the measure of the extent to which the clear methodology would affect the transition time of CMMI.					
17.	***Awareness***: This is the measure of the extent to which the level of the staff awareness of CMMI has an effect on transition time.					
18.	***CMMI Experienced staff:*** This is the measure of the extent to which the level of staff experience with CMMI has an effect on the transition time.					
19.	***Communication:*** This is the measure of the extent to which the communication between staff has an effect on transition time.					
20.	***Group focus:*** This is the measure of the extent to which the enabling small teams to propose and implement improvements is easier than doing this on an individual basis has an effect on transition time.					
21.	***Process documentation:*** This is the measure of the extent to which the adaption level of the process documentation activities before CMMI application has an effect on transition time.					
22.	***Consultation:*** This is the measure of the extent to which the working with a consultant throughout CMMI application has an effect on transition time.					
23.	***Metrics and Measurement:*** This is the measure of the extent to which the utilization of metrics and measurement activities before CMMI process has an effect upon CMMI applying on transition time.					
24.	***Allocation of resources:*** This is the measure of the extent to which the availability of resources has an effect on transition time.					
25.	***Rewards:*** This is the measure of the extent to which the rewarding mechanism which the organization has employed has an effect on transition time.					
26.	***Gap analysis:*** This is the measure of the extent to which the utilization of gap analysis has an effect on transition time.					

Appendix C: Questionnaire Data

Malaysia

SCALE: 5 = HIGH, 4 = MEDIUM, 3 = LOW, 2 = NOT EFFECTIVE, 1 = DON'T KNOW

No.	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26
1	1	1	3	1	5	1	4	4	5	1	4	1	3	5	4	4	1	5	1	4	5	1	1	5	3	4
2	3	1	4	3	5	1	4	4	5	1	4	1	4	5	4	4	1	5	1	4	5	1	1	5	4	4
3	4	1	4	3	5	1	4	4	5	1	4	1	4	5	4	4	1	5	3	4	5	1	3	5	4	4
4	4	4	4	3	5	1	4	4	5	3	4	1	4	5	4	4	2	5	3	4	5	1	3	5	4	4
5	4	4	4	3	5	1	4	4	5	4	5	2	4	5	4	4	2	5	3	4	5	1	3	5	4	4
6	4	4	5	3	5	2	4	4	4	4	5	2	4	5	4	4	2	5	3	3	5	3	3	5	4	4
7	4	4	5	3	5	2	4	4	4	4	5	3	4	5	4	4	2	5	3	3	5	3	3	5	4	4
8	4	4	5	4	5	2	4	5	4	4	5	3	4	5	4	2	2	5	3	5	5	3	3	5	4	4
9	4	4	5	4	5	3	4	5	4	4	5	3	4	5	4	2	2	5	3	5	5	3	3	5	5	4
10	4	4	5	4	5	3	4	5	3	4	5	3	4	5	5	3	2	5	5	5	5	4	4	5	5	4
11	4	4	5	4	5	3	4	5	3	4	5	3	4	5	5	3	2	5	5	5	5	4	4	5	5	4
12	4	4	5	4	5	3	4	5	3	4	5	3	4	5	5	3	2	5	5	5	5	4	4	5	5	4
13	4	4	5	4	5	3	4	5	3	4	5	3	5	5	5	3	3	5	5	5	5	4	4	5	5	4
14	5	5	5	4	4	5	4	5	3	4	5	3	5	5	5	3	3	5	5	5	5	4	4	5	5	4
15	5	5	5	4	4	5	4	5	3	4	5	3	5	5	5	3	3	5	5	5	5	4	4	5	5	4
16	5	5	5	4	4	5	4	5	3	4	5	3	5	5	5	3	3	5	5	5	1	4	4	5	5	4
17	5	5	5	4	4	5	4	5	3	4	5	3	5	5	5	3	3	5	5	5	1	4	4	5	5	4
18	5	5	5	4	3	5	5	5	3	5	5	4	5	5	5	3	3	5	5	5	1	4	4	5	5	5
19	5	5	5	4	3	5	5	5	3	5	5	4	5	3	5	3	3	5	5	5	3	4	4	4	5	5
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21	5	5	5	5	1	5	5	5	1	5	5	4	5	2	5	3	4	5	5	5	3	4	4	4	5	5
22	5	5	5	5	1	5	5	5	1	5	5	4	5	2	5	3	4	5	5	5	3	4	4	4	5	5
23	5	5	5	5	1	5	5	5	1	5	5	4	5	1	5	3	4	5	5	5	3	5	5	4	5	5
24	5	5	5	5	1	5	5	5	1	5	5	4	5	1	5	3	4	4	5	5	3	5	5	4	5	5
25	5	5	5	5	1	5	5	5	1	5	5	4	5	1	5	5	4	4	5	5	3	5	5	4	5	5
26	5	5	5	5	1	5	5	5	1	5	5	4	5	1	5	5	4	4	5	5	3	5	5	4	5	5
27	5	5	5	5	2	5	5	5	2	5	5	4	5	1	5	5	4	4	5	5	3	5	5	4	5	5
28	5	5	5	5	2	5	5	5	2	5	5	4	5	4	5	5	4	4	5	5	3	5	5	4	5	5
29	5	5	5	5	2	5	5	5	2	5	5	4	5	4	5	5	4	4	4	5	4	5	5	4	5	5
30	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	4	4	4	5	4	5	5	4	5	5
31	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	4	4	4	5	4	5	5	4	5	5
32	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	4	4	5	4	5	5	4	5	5
33	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	4	4	5	4	5	5	4	5	5
34	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	3	4	5	4	5	5	4	5	5
35	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	3	4	5	4	5	5	4	5	5
36	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	3	4	5	4	5	5	3	5	5
37	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	3	4	5	4	5	5	3	5	5
38	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	3	4	5	4	5	5	3	5	5
39	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	3	4	5	4	5	5	3	5	5
40	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	3	4	5	4	5	5	3	5	5
41	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	3	4	5	4	5	5	3	5	5
42	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	2	4	5	4	5	5	3	5	5
43	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	2	4	5	4	5	5	3	5	5
44	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	1	4	5	4	5	5	2	5	5
45	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	1	4	5	4	5	5	2	5	5
46	5	5	5	5	2	4	5	5	2	5	5	5	5	4	5	5	5	1	4	5	4	5	5	2	5	5

Appendix C: Questionnaire Data (cont.)

Saudia Arabia

SCALE: 5 = HIGH, 4 = MEDIUM, 3 = LOW, 2 = NOT EFFECTIVE, 1 = DON'T KNOW

No.	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26
1	5	5	1	3	5	2	1	4	5	5	4	1	4	1	1	4	1	2	1	5	4	4	1	4	4	5
2	5	5	2	2	5	2	1	2	5	5	4	4	4	1	4	4	1	3	1	5	4	4	1	4	4	5
3	5	5	3	1	5	2	1	2	5	5	4	4	4	1	4	4	4	3	1	5	4	4	1	4	4	5
4	5	5	4	4	4	3	2	2	4	5	4	4	4	1	4	4	4	3	1	5	4	4	3	4	4	5
5	5	5	4	4	3	4	2	2	4	5	4	4	4	1	4	4	4	4	1	5	4	4	4	4	4	5
6	5	5	4	4	1	4	2	2	4	5	4	4	4	1	5	4	4	4	3	5	4	4	4	4	4	5
7	5	5	4	4	1	4	2	2	4	5	4	4	4	1	5	4	4	4	4	5	4	4	4	4	4	5
8	5	5	4	4	2	4	2	2	4	5	5	4	4	4	5	4	4	4	4	5	4	4	4	4	4	5
9	5	5	4	4	2	4	2	2	4	5	5	4	4	4	5	5	4	4	4	5	4	4	4	4	5	1
10	5	5	4	4	2	4	2	2	2	5	5	4	5	4	5	5	4	4	5	4	4	4	4	4	5	1
11	5	5	4	4	2	4	3	2	2	5	5	4	5	4	5	5	4	4	5	4	4	4	4	4	5	1
12	5	5	4	4	2	4	3	2	2	5	5	4	5	4	5	5	4	4	5	1	4	4	4	4	5	2
13	5	5	4	4	2	4	3	2	2	5	5	4	5	4	5	5	5	4	5	1	4	4	4	4	5	2
14	5	5	4	4	2	4	3	2	2	4	5	4	5	4	5	5	5	4	5	1	4	4	4	4	5	2
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16	5	4	5	4	2	5	3	2	2	4	5	4	5	4	5	5	5	4	5	1	4	4	4	4	5	2
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19	5	4	5	5	2	5	3	2	2	4	5	4	5	5	5	5	5	5	5	3	1	5	4	4	5	3
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26	5	4	5	5	2	5	5	3	3	3	5	5	5	5	5	5	5	5	5	3	1	5	5	5	5	3
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29	5	4	5	5	2	5	5	3	3	3	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	3
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35	5	3	5	5	2	5	4	3	3	3	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	4
36	5	3	5	5	2	5	4	3	3	3	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	4
37	5	3	5	5	2	5	4	3	3	3	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	4
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39	4	3	5	5	2	5	4	3	3	3	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	4
40	4	2	5	5	2	5	4	3	3	3	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	4
41	4	2	5	5	2	5	4	3	3	3	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	4
42	4	2	5	5	2	5	4	3	3	3	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	4
43	4	1	5	5	2	5	4	3	3	3	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	4
44	4	1	5	5	2	5	4	3	3	3	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	4
45	4	1	5	5	2	5	4	3	3	3	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	4
46	4	1	5	5	2	5	4	3	3	3	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	4

Appendix D: Chi-square Test

Factors	Saudi Arabia (n=46)					Malaysia (n=46)					Linear by linear association Chi-square test, α=0.05		
	H	M	L	Z	N/S	H	M	L	Z	N/S	χ2	df	p
Turn over of staff	38	8	0	0	0	33	11	1	0	1	2.488	1	0.115
Cost of appraising	15	18	6	3	4	33	10	0	0	3	8.511	1	0.004
Change Management	32	11	1	1	1	37	8	1	0	0	4.769	1	0.029
Many roles to one Person	3	1	1	39	2	13	4	2	20	7	6.909	1	0.009
Unscheduled events	31	11	1	3	0	16	17	5	3	5	9.539	1	0.002
Financial motives	8	17	11	7	3	29	17	0	0	0	29.077	1	0.000
Public holiday events	0	1	25	20	0	39	7	0	0	0	78.29	1	0.000
Imposed partner	33	10	1	0	2	13	10	2	7	14	22.97	1	0.000
Income level	13	12	21	0	0	29	13	1	0	3	8.04	1	0.005
Management commitment	39	7	0	0	0	42	4	0	0	0	0.919	1	0.338
Frequency of process assessment	26	19	0	0	1	17	12	11	2	4	10.243	1	0.001
Separation of process and product concerns	37	9	0	0	0	34	11	1	0	0	0.845	1	0.358
Management & staff involvement	29	10	0	0	7	18	19	1	3	5	0.849	1	0.357
Training	41	4	0	0	1	37	9	0	0	0	0.038	1	0.845
Review	38	8	0	0	0	22	7	15	2	0	18.72	1	0.000
Defined SPI implementation methodology	34	10	0	0	2	15	12	7	9	3	16.052	1	0.000
Awareness	29	13	3	1	0	23	10	8	2	3	5.058	1	0.025
CMMI Experienced staff	37	3	1	0	5	19	18	7	0	2	1.869	1	0.172
Communication	9	2	29	0	6	39	5	2	0	0	41.837	1	0.000
Group focus	20	18	0	0	8	15	18	10	0	3	0	1	1.000
Process documentation	29	17	0	0	0	24	13	4	0	5	6.37	1	0.012
Consultation	23	19	1	0	3	24	13	7	0	2	0.042	1	0.837
Metrics and Measurement	26	20	0	0	0	18	17	8	3	0	9.591	1	0.002
Allocation of resources	38	8	0	0	0	38	7	1	0	0	0.062	1	0.803
Rewards	8	17	11	7	3	29	17	0	0	0	29.077	1	0.000
Gap analysis	39	6	0	0	1	32	12	0	0	2	1.759	1	0.185

Appendix E: Malaysian States and National Holidays for Year 2011 and 2012. (It is obtained from the Malaysian government's official portal (2011)).

Holiday	Applies to	2011	2012
New Year's Day	All except Johor, Kedah, Kelantan, Perlis & Terengganu	01 Jan (Sat)	01 Jan (Sun)
Hari Hol Almarhum Sultan Iskandar	Johor	11 Jan (Tue)	TBA
Birthday of Yang DiPertuan Besar of Negeri Sembilan	Negeri Sembilan	14 Jan (Fri)	14 Jan (Sat)
Birthday of the Sultan of Kedah	Kedah	16 Jan (Sun)	15 Jan (Sun)
Thaipusam	Johor, Ng Sembilan, Perak, Penang, Selangor & K. Lumpur	20 Jan (Thu)	07 Feb (Tue)
Federal Territory Day	Federal Territory of Kuala Lumpur, Putrajaya & Labuan	01 Feb (Tue)	01 Feb (Wed)
Chinese New Year	National	03 Feb (Thu)	23 Feb (Thu)
Chinese New Year 2nd Day	All except Kelantan & Terengganu	04 Feb (Fri)	24 Feb (Fri)
Prophet Muhammad's Birthday (Maulidur Rasul)**	National	15 Feb (Tue)	04 Feb** (Sat)
Anniversary of Installation of the Sultan of Terengganu	Terengganu	04 Mac (Fri)	04 Mac (Sun)
Birthday of The Sultan of Kelantan	Kelantan	30 & 31 Mac (Wed & Thu)	30 & 31 Mac (Fri & Sat)
Good Friday	Sabah & Sarawak	22 Apr (Fri)	06 Apr (Fri)
Declaration of Melaka as Historical City	Melaka	15 Apr (Fri)	15 Apr (Sun)
Birthday of The Sultan of Perak	Perak	19 Apr (Tue)	19 Apr (Thu)
Labour Day	National	01 May (Sun)	01 May (Tue)
Hari Hol Negeri Pahang	Pahang	07 May (Sat)	07 May (Mon)
Birthday of The Raja of Perlis	Perlis	17 May (Tue)	17 May (Thu)
Wesak	National	17 May (Tue)	06 May (Sun)
Kaamatan Harvest Festival	Federal Territory of Labuan & Sabah	30 - 31 May	30 - 31 May

		(Mon & Tue)	(Wed & Thu)
Gawai Dayak Festival	Sarawak	01 - 02 June (Wed & Thu)	01 - 02 June (Fri & Sat)
Birthday of S.P.B. Yang di-Pertuan Agong - H M The King	National	04 Jun (Sat)	02 Jun (Sat)
Israk & Mikraj	Kedah, Negeri Sembilan & Perlis	29 Jun (Wed)	16 Jun (Sat)
Declaration of Penang as World Heritage Site	Penang	07 Jul (Thu)	07 Jul (Sat)
Birthday of Yang DiPertua Negeri of Penang	Penang	09 Jul (Sat)	07 Jul (Sat)
Birthday of The Sultan of Terengganu	Terengganu	20 July (Wed)	20 July (Fri)
Awal Ramadan** (Start of Ramadan or the fast month)	Johor, Kedah & Melaka	01 Aug** (Wed)	20 Jul** (Fri)
Nuzul al Qur'an	Kelantan, Terengganu, Pahang, Perak, Perlis, Penang, Selangor &	17 Aug (Wed)	06 Aug (Mon)
National Day/ Independence or Merdeka Day	National	31 Aug (Wed)	31 Aug (Fri)
Hari Raya Puasa*	National	30 & 31 Aug**(Tue & Wed)	19 & 20 Aug**(Sat & Sun)
Birthday of Yang di-Pertua of Sarawak	Sarawak	10 Sep (Sat)	09 Sep (Sat)
Malaysia Day	National	16 Sept (Fri)	16 Sept (Sun)
Birthday of Yang di-Pertua of Sabah	Sabah	01 Oct (Sat)	06 Oct (Sat)
Birthday of Yang di-Pertua of Melaka	Melaka	08 Oct (Sat)	14 Oct (Sat)
Birthday of The Sultan of Pahang	Pahang	24 Oct (Mon)	24 Oct (Wed)
Deepavali	All except Sarawak & Federal Territory of Labuan	26 Oct (Wed)	11 Nov (Wed)
Hari Raya Haji* (Qurban)	National	06 Nov** (Sun)	26 Oct** (Fri)
2nd Day Hari Raya Haji (Qurban)	Kedah & Perlis	07 Nov** (Mon)	27 Oct** (Sat)
Birthday of The Sultan of Johor	Johor	22 Nov (Tue)	22 Nov (Thu)
Awal Muharram*(Islamic New Year) Ma'al Hijrah	National	27 Nov (Sun)	15 Nov (Thu)

Birthday of The Sultan of Selangor	**Selangor**	**11 Dec (Sun)**	**11 Dec (Tue)**
Christmas Day	**National**	**25 Dec (Sun)**	**25 Dec (Tue)**
NOTE: ****Subject to confirmation** ***When a holiday falls on the first day of the weekend then the following working day becomes a public holiday**			

Appendix F: Publications of this thesis

- Alshammari, F.H and Ahmad, R. (2013) Identification of Factors that Affect the Transition Time between CMMI levels from Geographical Region Perspective: An Empirical Study. *International Arab Journal of Information Technology*. (*ISI-Cited Publication*)

- Alshammari, F.H and Ahmad, R. (2013) A Reference Model for Transition Time Factors of Capability maturity Model Integration. *International Arab Journal of Information Technology*. (*ISI-Cited Publication*)

- Alshammari, F.H and Ahmad, R. (2011) An empirical study on factors that affect the transition time between CMMI levels in Saudi Arabia. *African Journal of Business Management*, 5(14):5690-5697. (*ISI-Cited Publication*)

- Alshammari, F.H and Ahmad, R. (2013) The Effective Factors that influence the Duration of CMMI-Based Software Process Improvement in Malaysia: An Empirical Study. *Journal of King Saud University – Computer and Information Science.* (*ISI-Cited Publication*)……UNDER REVIEWING

- Alshammari, F.H and Ahmad, R. (2010) The Effect of Geographical Region on the Duration of CMMI-Based Software Process Improvement Initiatives: An Empirical Study. *Proceeding of 2nd International Conference on software Technology and Engineering ICSTE 2010*, San Juan, Puerto Rico, USA. Oct 3-5, p. V2-97 (*Non-ISI/Non-SCOPUS Cited Publication*)