Full Length Research Paper

An empirical study on factors that affect the transition time between capability maturity model integration (CMMI) levels in Saudi Arabia

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During recent years, software process improvement (SPI) has been more concerned by a software industry. Numerous studies have been made in development of SPI standards and models, or to identify factors that affect SPI success. However, these studies did not provide answers to questions about the factors that affect the transition time between capability maturity model integration (CMMI) levels, and why there are obvious differences in the organizations' transition time between CMMI levels. The objective of this research is to identify the factors that can affect the transition time between CMMI levels. The study conducted 10 interviews in 7 different Saudi's software companies to extract the factors and compare these factors with what are in the literature to avoid redundancy, based on that, the study designed a questionnaire. It sent out 117 requests to participants, of which 46 responded from 12 companies. The study asked the participants to rank each factor on a five-point scale (high, medium, low, zero and not sure) to determine the effect of each factor. It identified 21 factors that are considered effective factors on the transition time between CMMI levels. Also, the study identified two new factors (turnover of staff and imposed partner) which were not identified in the literature.

Key words: Software process improvement, capability maturity model integration (CMMI), factors, transition time, empirical study.

INTRODUCTION

During recent years, Issues associated with software quality are widely diffused to affect the development cost and time (Sommerville, 1996; Okay and Semiz, 2010). The software industry has been more concerned about Software Process Improvement (SPI). Software quality has become more critical as software pervades our day-to-day lives (Paulk et al., 1994). The decrease of transition time between CMMI levels can lead organisations to business benefits. A group of Fellows of the Royal Academy of Engineering and British Computer Society demonstrated that despite spending 22 billion pounds on Information Technology projects in the UK during 2003/2004, there are still some projects that failed to deliver on time (The Royal Academy of Engineering, 2004). Therefore, in general, time is still a main issue

which affect an organization's business benefits. SPI has some models and Capability Maturity Model Integration (CMMI) is one of the reference models, concerned with organizations quality. CMMI can be described as a collection of best practices gathered from the experiences with software-capability maturity model (SW-CMM), and other standards and models (SEI, 2007). However, there are obviously different times, in the organizations' transition time, in order to move from one level to another. Despite Software Engineering Institute (SEI) has specified an average transition time between CMMI levels, there is still an obvious deviation in various software organizations in terms of their transition time between CMMI levels. The effort put into these models and standards can assist in producing high quality software, reducing cost and time, and increasing productivity (Butler, 1995; Pitterman, 2000; Yamamura, 1999). However, little attention has been paid to the effective implementation of these models and standards

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(Goldenson and Herbsleb, 1995). Therefore, the transition time between CMMI levels still needs more investigation. Thus, the main objective of this study is to investigate the factors that affect the transition time between CMMI levels in Saudi Arabia, and in light of that, applying the factors in an empirical study over Saudi's companies. This paper presents the results of an empirical study aimed at identifying and investigating the factors which has an effect (positively or negatively) on transition time between CMMI levels based on the perceptions and experiences of practitioners in developing country, that is, Saudi Arabia. The research was limited to the companies which already achieved CMMI level 3 or companies which have a CMMI level 2 and already started ways to achieve CMMI level 3. The investigation has several interesting findings which enabled the study to identify and explain the relative factors which affect the transition time between CMMI levels in Saudi Arabia. The study has analyzed the experiences, opinions and views of practitioners in the literature (that is, case studies, reports and journal papers, etc.). The study has also conducted a study on factors that have an impact on the transition time between CMMI, and critically analyzing and discussing each factor which affects the duration/transition time between CMMI levels. Our results may provide feasible and timely advice to SPI decision makers in designing appropriate strategies to accelerate the transition time between CMMI levels.

LITERATURE REVIEW

In the last decade, numerous studies have been done into the transition time between CMMI levels. Jackelen (2007) started a CMMI program with the goal of achieving the CMMI Level 2 and satisfaction process areas within five months. After the analysis of the current status of the company, the top management decided to extend the plan's schedule of the program for one month. The paper discussed how it was possible to achieve CMMI Level 2 in six months. The factors identified in this study were: Management Commitment, Experienced Staff, Consultant, Training, Awareness, and Quality Environment. Guererro and Eterovic (2004) explored a case study that achieved the moving from CMM Level 1 to CMM Level 2 in 10 months which would have been achieved in 19 months on the average time according to SEI data (2004). They analyzed ten factors that affect the adoption of 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 an achieving of CMM-Level 3 in 7-months time which would have been achieved in 19 months according to SEI (2004). Identified factors were: Management Commitment, Awareness,

Staff Involvement, Training, Experienced Staff,

Consultations, and Quality Environment. Olson and Sachlis (2002) discussed the moving from CMM-Level 1 to CMM-Level 3 in 14 months which would have been completed in 38 months based on the time average according to SEI data (2004). 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 (two months) and from CMM Level 1 to CMM Level 2 in 9 months. Identified factors were: Training, Experienced Staff, Quality Environment, Implementation Plan, Process Documentation, and Metrics and Measurement. It is important to conduct empirical research in order to provide more certainty that explores these factors that affect the transition time between CMMI levels, since an empirical research enables rigorous experimentation by encouraging multiple analysis from multiple perspectives using different approaches, and helps to compare what was believed to what was observed (Harrison et al., 1999; Perry et al., 2000). Therefore, empirical research helps researchers move towards well-founded decisions (Perry et al., 2000). An empirical investigation of SPI implementation factors will provide SPI practitioners with valuable insights through planning of SPI strategies (Niazi et al., 2006). A good understanding of the transition time factors of CMMI should help organisations accelerate in moving between CMMI levels. The decrease of transition time between CMMI levels can lead organisations to business benefits.

RESEARCH DESIGN

Research approach

In this study, people who are already involved in software development industry were identified, to extract factors which are having a high impact on transition time between CMMI levels. For this purpose, the study has done the following:

i. Conducting a face to face meeting, to extract the factors that affect the transition time between CMMI levels without any suggestions from the researchers.
ii. Factors filtration, to identify and avoid redundancy of factors which have different name with the same meaning between practitioners and literature review.
iii. Survey design, designing a questionnaire in favor of this study in order to collect the data from respondents.
iv. Distribution stage, to distribute and apply the questionnaire into Saudi Arabia.
v. Data analysis, according to data, which are collected from respondents.
vi. Results, to find out the findings and to determine the effective factors from the data set.

Study scope

In this research, the study scope would be on the companies which already adopted CMMI and achieved CMMI level 3 or companies which have CMMI level 2 and have started procedures to achieve CMMI level 3.

Population and sample profile

Software organizations and companies are considered as the target population for this study. This population includes companies that develop either software or combined software and hardware products for a wide variety of markets. According to the study and the scope, it had sent out 117 requests to participants, of which, only 46 responded from 12 companies distributed over Saudi Arabia. This means the response rate was (39.32%).

However, we have high confidence in the accuracy and validity of the data. Forty-six practitioners voluntarily participated in this study. It was important to ensure that no particular practitioner was over-represented (Coolican, 1999).

This research addressed the issue of over-representation by using a sample of companies of varying complexity, size, business nature, application type, etc. A similar approach has been used by other researchers (Baddoo, 2001; Baddoo and Hall, 2002, 2003; Niazi et al., 2006).

Data instrumentation

In this study, a questionnaire as a main instrument to gather survey data from companies was used. A survey research method can use one or more data elicitation techniques such as interviews and self administered questionnaires (Lethbridge, 2005). It is deemed suitable for eliciting quantitative and qualitative data from respondents (Lethbridge, 2005). A questionnaire was pre-tested by 7 SPI personnel in domestic software companies and 4 graduate students at the University of Malaya.

Guielford (1965) suggested that reliabilities of Cronbach's α is high if Cronbach's α is over 0.70. Therefore, in our analysis, the pre-test of the expert questionnaire appeared as a high average Cronbach α of 0.799; this indicated that the questionnaire was acceptable and internally consistent.

The study used e-mail, telephone calling and face to face meeting sessions. Because of the possibility of illustrating the objectives of the research and different terms used in the questionnaire, and clarifying the purpose of different questions included in the questionnaire, and also ensuring data validation before the end of each survey session, the survey session duration was about 45 min.

Effective factor

This study defined effective factor as a measure of the extent to which the factor has an effect on the transition time between CMMI levels and 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 organisations. In order to describe the notion of effective factor on transition time of CMMI, it is essential to decide on the importance of an effective factor. For this purpose, the study has used the definition: If the majority of respondents (≥ 50%) consider that factor has a high effect on transition time of CMMI then it treats that 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 SPI with the criterion that if 50% or more participants consider that a factor has a major role in SPI efforts then that factor should be considered as having a major impact on SPI.

Data collection

According to the research objectives and available resources,

although, depending on what has been suggested by Alam (2011), the study has used a survey research method to gather data on Saudis practitioners' perspective of the factors that affect the transition time between CMMI levels. A survey of data collection is considered suitable for gathering quantitative and qualitative data from a number of respondents (Kitchenham and Pfleeger, 2002). A survey of data collection can use one or more data elicitation techniques such as interviews and questionnaires (Lethbridge, 2005). The study has used a closed format questionnaire as a data collection approach in conjunction with face-to-face meetings during some stages of data collection. In order to make sure of clarifying the research objectives, the terms used in the questionnaire, and ensuring data were validated before completing each survey session. The study has conducted 10 interviews in 7 different software companies in Saudi Arabia, with flexible schedules so that interviewees could make an appointment at any time suitable for them (Fowler, 2002). We sent 117 questionnaires by email to those included in our scope. A questionnaire was based on factors that affect the transition time between CMMI levels. The study has designed a questionnaire to gather the effective factors where each respondent ranked each factor identified as factor which has an effect on transition time between CMMI levels. In order to identify the effective factors, the respondents were asked to note each factor's relative value (that is, High, Medium, Low, Zero, or Not sure).

FINDINGS

Factors that affect the transition time between CMMI levels in Saudi Arabia

Table 1 shows the list of impacting factors that affect the transition time between CMMI levels. According to the scope of this study, Table 2 identifies the high frequency and percentage of each factor that affect the transition time between CMMI levels in Saudi Arabia. Table 3 shows the effective factors in the transition time between CMMI are, training (89%), management commitment and gap analysis, 85% to each. This indicates that, in the Saudi practitioners' opinion, training can play quite a vital role in the transition time between CMMI levels. Therefore, this result almost agrees with Olson and Sachlis (2002), Balla et al. (2001) Iversen and Ngwenyama (2003) and Akmenek and Tarhan (2003). Other frequently effective factors in Saudi Arabia are turnover of staff, review, allocation of resources, resistance to change, separation of process and product concerns, CMMI experienced staff, defined SPI implementation methodology, visibility into the SPI process planning, imposed partner, management of changement, unscheduled events, investments of a company, management and staff involvement, awareness, process documenttation, frequency of process assessment, metrics and measurement, and consultation. Table 4 shows the non effective factors on the transition time between CMMI which are having less impact. From the empirical study in Saudi Arabia, the study has noted that the factors; turnover of staff and imposed partner, are new effective factors, whereas, the study did not find in literature and previous studies, to best of our knowledge that, these new factors have been identified or have been taken

Table 1. Factors that affect the transition time between CMMI levels.

Factor	Saudi Arabia (n = 46)				
	H	**M**	**L**	**Z**	**N/S**
Self-Motivation power	22	8	2	4	10
Turnover of staff	38	8	0	0	0
Market conditions changes	4	3	32	6	1
Cost of appraising	15	18	6	3	4
Management of changement	32	11	1	1	1
Investments of a company	29	14	1	1	1
Many roles to one person	3	1	1	39	2
Unscheduled events	31	11	1	3	0
Financial motives	8	17	11	7	3
Public holiday events	0	1	25	20	0
Imposed partner	33	10	1	0	2
Job respecting	3	6	21	16	0
Income level	13	12	21	0	0
Management commitment	39	7	0	0	0
Frequency of process assessment	26	19	0	0	1
Separation of process and product concerns	37	9	0	0	0
Management and staff involvement	29	10	0	0	7
Training	41	4	0	0	1
Review	38	8	0	0	0
Defined SPI implementation methodology	34	10	0	0	2
Awareness	29	13	3	1	0
CMMI Experienced staff	37	3	1	0	5
Communication	9	2	29	0	6
Group focus	20	18	0	0	8
Process documentation	29	17	0	0	0
Consultation	23	19	1	0	3
Metrics and Measurement	26	20	0	0	0
Allocation of resources	38	8	0	0	0
Rewards	8	17	11	7	3
Gap analysis	39	6	0	0	1
Resistance to change	38	8	0	0	0
Visibility into the SPI process planning	34	10	0	0	2

H= High; M= Medium; L = Low; Z = Zero; N/S = Not Sure.

up as effective factors on the transition time between CMMI levels.

By using effective factor criterion, the study has identified 21 factors that are generally considered effective factors for the transition time between CMMI levels. Descriptive Figure 1 shows visual description for the identified effective factors in Saudi Arabia. Since X axis represents the factors, Y axis represents the numbers from 0 to 100, while red columns represent the percentage and blue columns represent the high frequency. Figure 2 shows visual description for 10 factors which are non effective in Saudi Arabia. Each pie represents the high frequency of each factor, and its percentage.

DISCUSSION

This paper presented an empirical study on factors that affect the transition time between CMMI levels in Saudi Arabia. A good understanding of the factors that can delay the transition time between CMMI levels is expected to help organisations to identify what strategies they need to use in order to address these factors and accelerate the transition time from one level to another of CMMI. The study believes that these factors can be very useful for Saudis' CMMI based SPI practitioners as these can help them in planning for CMMI level 3 in their organisations.

The results indicate that software development

Table 2. Identifying the high frequency and percentage of each factor.

Factor	Saudi Arabia	
	High frequency	**Percent**
Training	41	89
Management commitment	39	85
Gap analysis	39	85
Turnover of staff	38	83
Review	38	83
Allocation of resources	38	83
Resistance to change	38	83
Separation of process and product concerns	37	80
CMMI experienced staff	37	80
Defined SPI implementation methodology	34	74
Visibility into the SPI process planning	34	74
Imposed partner	33	72
Management of changement	32	70
Unscheduled events	31	67
Investments of a company	29	63
Management and staff involvement	29	63
Awareness	29	63
Process documentation	29	63
Frequency of process assessment	26	57
Metrics and Measurement	26	57
Consultation	23	50
Self-Motivation power	22	48
Group focus	20	43
Cost of appraising	15	33
Income level	13	28
Communication	9	20
Financial motives	8	17
Rewards	8	17
Market conditions changes	4	9
Many roles to one Person	3	7
Job respect	3	7

organisations need to improve their training, planning, and staff also needs training courses (for example, introduction to CMMI, Intermediate CMMI and SCAMPI), therefore, this kind of similar understanding was noticed by Alam (2009) and also Alam et al. (2010). Management commitment is one of the factors that have the most importance for any organization as identified by Alam et al. (2010) and Ponnu and Chuah (2010). Thus, management may delay the transition from a particular CMMI level to a higher one if there is one or more of the following points:

i. If the management has identified projects for the CMMI and others for the important work.
ii. If limited its role in contracting with a consultant and a follow-up an evaluation without efforts to improve the operations.
iii. If the management was working as "let alone the process now until we deploy the product or software to the client, then we complete the documents later".
iv. If the management did not seriously consider the workflow reports and then makes decisions based on their own impressions rather than on facts.
v. If the management seeks only behind the certificate without obtaining the real value of the application.

Turnover of staff, often resign - or said - fundamental work team who built the company's quality system after the end of an appraisal is to assign the task to a new team, perhaps a newly appointed, to complete the march. The new team needs more time in this case, which leads to consumption of more time in the transition. Chiboiwa et al. (2010) explained some external influences that increase the level of staff turnover which are; a level of payment, dissatisfaction with the reward system in an organisation, and opportunities for

Table 3. Effective factors in Saudi Arabia.

Factor	Saudi Arabia	
	High	Percent
Training	41	89
Management commitment	39	85
Gap analysis	39	85
Turnover of staff	38	83
Review	38	83
Allocation of resources	38	83
Resistance to change	38	83
Separation of process and product concerns	37	80
CMMI Experienced staff	37	80
Defined SPI implementation methodology	34	74
Visibility into the SPI process planning	34	74
Imposed partner	33	72
Management of changement	32	70
Unscheduled events	31	67
Investments of a company	29	63
Management and staff involvement	29	63
Awareness	29	63
Process documentation	29	63
Frequency of process assessment	26	57
Metrics and measurement	26	57
Consultation	23	50

Table 4. Non effective factors in Saudi Arabia.

Factor	Saudi Arabia	
	High	Percent
Self-Motivation power	22	48
Group focus	20	43
Cost of appraising	15	33
Income Level	13	28
Communication	9	20
Financial Motives	8	17
Rewards	8	17
Market conditions changes	4	9
Many roles to one person	3	7
Job respect	3	7

alternative employment outside the country.

Imposed partner, this factor is identified as a factor that has a negative impact on the transition time of CMMI. Since, the partner type in huge projects would affect the employee's productivity and delay the documentation processing.

Consequently, this will consume time, therefore, it will delay the transition time between CMMI levels (this partner is added to the organization because of his high social situation).

Other factors identified in this study completely agree with Balla et al. (2001) Iversen and Ngwenyama (2003) and Akmenek and Tarhan (2003).

Through this empirical study, the recommendation was that practitioners of CMMI-based SPI can design and develop better strategies to decrease the transition time by avoiding the factors identified in this study.

RESEARCH LIMITATION

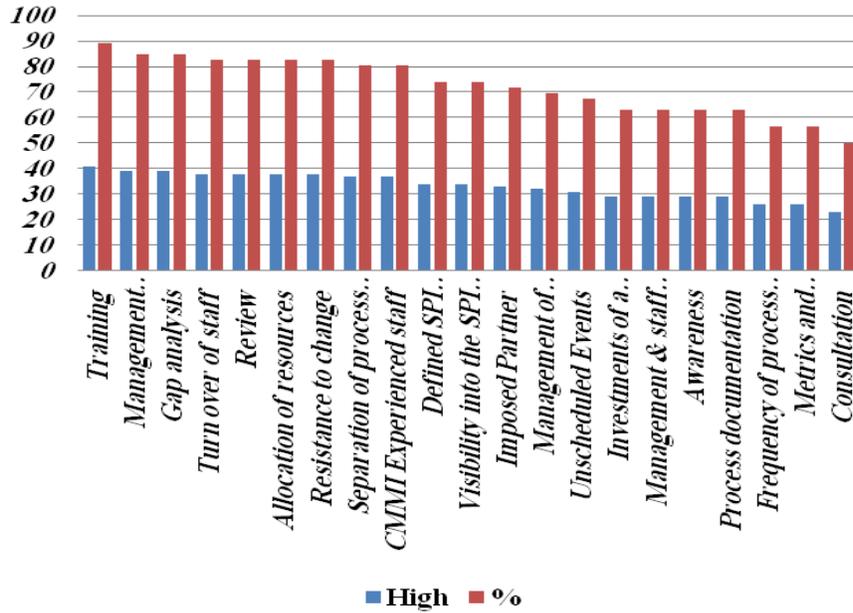Creating this research has faced some limitation which

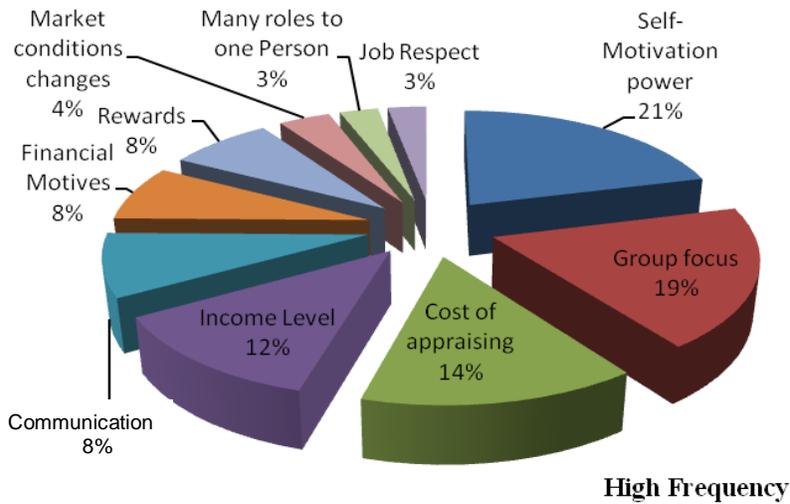**Figure 1.** Effective factors in Saudi Arabia.

Figure 2. Non Effective factors in Saudi Arabia.

attributed to: Lack of the literature that investigated the transition time of CMMI-based SPI; Most of Saudis' companies use another software process improvement models rather than CMMI.

CONCLUSION

This study focused on factors that affect the transition time between CMMI levels in Saudi Arabia. It analyzed the experiences, opinions and views of practitioners in order to identify factors that have an impact on the transition time between CMMI levels. The study identified

factors that are effective on the transition time between CMMI levels. Focusing on these factors offers cost-effective opportunities in order to decrease the time spent through the duration between CMMI levels. In order to determine the effective factor, the study used the following criterion:

If the majority of respondents (≥ 50%) consider that factor has a high effect on transition time of CMMI then we treat that factor as effective factor.

Using this criterion, the study has identified 21 factors that are generally considered effective factors for the

transition time between CMMI levels. It has identified two new effective factors affecting the transition time between CMMI levels, they are; turnover of staff, and Imposed partner. These two factors were not identified in the literature as effective factors that affect the transition time between CMMI levels. The study recommends that Saudis' organizations should focus on these effective factors to accelerate the transition time between CMMI levels. A good understanding of the transition time factors of CMMI should help organisations on accelerating moving between CMMI levels. The decrease of transition time between CMMI levels can lead organisations to business benefits.

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