

Full Length Research Paper

An empirical study of factors that affect the transition time between CMMI (Capability Maturity Model Integration) levels in Saudi Arabia

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Accepted 15 March, 2011

In recent years, software process improvement (SPI) has been the concern of software industries. Numerous studies have been done in the 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 CMMI (capability maturity model integration) 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. We 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 this, we designed a questionnaire. We sent out 117 requests to participants, and 46 responded from 12 companies. We 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, after which we identified 21 factors that are considered effective factors on the transition time between CMMI levels. Also, we identified two new factors (Turnover of staff and Imposed partner) which were not identified in the literature.

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

INTRODUCTION

In recent years, issues associated with software quality are widely diffused to affect development cost and time (Sommerville, 1996; Okay and Semiz, 2010). The software industry has been more concerned about the 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, some projects could not be delivered on time (The Royal Academy of Engineering, 2004). Therefore, in general, time is still the main issue that affects an

organization's business benefits. SPI has some models; capability maturity model integration (CMMI) is one of the reference models that have a strong connection with organizations' quality. CMMI can be described as a collection of the best practices gathered from the experiences with software- capability maturity model (SW-CMM), and other standards and models (SEI, 2007). However, there is obvious difference in the organizations' transition time in order to move from one level to another. Despite the fact that 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 (Goldenson and Herbsleb, 1995). Therefore, the transition time between

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CMMI levels 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, apply 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 have an effect (positively or negatively) on transition time between CMMI levels, based on the perceptions and experiences of practitioners in a developing country like Saudi Arabia. As such, we limited our research to the companies that have already achieved CMMI level 3 or companies which have CMMI level 2 and have already started achieving CMMI level 3. Our investigation has several interesting findings which enabled us to identify and explain the relative factors which affect the transition time between CMMI levels in Saudi Arabia. We have analyzed the experiences, opinions and views of practitioners in the literature (that is, case studies, reports and journal papers...etc). Also, we have conducted a study on factors that have an impact on the transition time between CMMI, and have critically analyzed and discussed 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 were done for 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. This 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 has achieved the movement of CMM from CMM Level 1 to CMM Level 2 in 10 months and which ordinarily would be achieved in 19 months on the average time according to the data of SEI (2004). They analyzed ten factors that affected the adoption of CMM, and 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 achievement of CMM-Level 3 in 7 months, which ordinarily would be achieved in 19 months according to SEI (2004). The identified factors were: Management commitment, awareness, staff involvement, training, experienced staff, consultations and quality environment. Olson and Sachlis

(2002) discussed the movement of CMM from CMM-Level 1 to CMM-Level 3 in 14 months which would ordinarily be completed in 38 months based on the time average according to 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 just in 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. It is important to conduct an empirical research in order to provide more certainty in exploring 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 we believe to what we observe (Harrison et al., 1999; Perry et al., 2000). Therefore, the empirical research helps researchers move toward 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 movement between CMMI levels. The decrease of transition time between CMMI levels can lead organisations to business benefits.

METHODOLOGY

Research approach

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

1. Conducting a face to face meeting, to extract the factors that affect the transition time between CMMI levels without any suggestions from the researchers.
2. Factors filtration: To identify and avoid redundancy of factors which have different names with the same meaning between practitioners and literature review.
3. Survey design: Designing a questionnaire in favor of this study in order to collect the data from respondents.
4. Distribution stage: To distribute and apply the questionnaire in Saudi Arabia.
5. Data analysis was done according to the data collected from respondents.
6. Results: To find out the findings and determine the effective factors from the data set.

Study scope

In this research, the study scope is on the companies which have already adopted CMMI and achieved CMMI level 3 or companies which have CMMI level 2 and have already started the process of achieving 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 our study and scope, we sent out 117 requests to participants, of which only 46 out of the 12 companies distributed over Saudi Arabia responded back. This implied that 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 there is no particular practitioner that was over-represented (Coolican, 1999). This research addressed the issue of overrepresentation 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, we have used a questionnaire as the main instrument to gather survey data from companies. 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 authors' university. Guelford (1965) suggested that reliabilities of Cronbach's alpha are high if Cronbach's alpha is over 0.70. Therefore, in our analysis, the pre-test of the expert questionnaire appeared with a high average Cronbach alpha of 0.799; this indicated that the questionnaire was acceptable and internally consistent. We used e-mail, telephone calling and face to face meeting sessions. Since it was possible to illustrate the objectives of the research with the different terms used in the questionnaire and clarify the purpose of different questions included in the questionnaire, data validation was ensured before each survey session was concluded. The survey session duration was about 45 min.

Effective factor

In this study, we defined effective factor to measure 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, we have used the following definition:

"If the majority of respondents ($\geq 50\%$) consider that a factor has a high effect on the transition time of CMMI, then we treat 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 with a dependence on what was suggested by Alam (2011), we used a survey research method to gather data about Saudis practitioners' perspective of the factors that affect the transition time between CMMI levels. A survey of data collection was 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). We have 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, data validation was ensured for the terms used in the questionnaire, before completing each survey session. We conducted 10 interviews in 7 different software companies in Saudi Arabia, with flexible schedules so that interviewees could make an appointment at any time that will be suitable for them (Fowler, 2002). We sent 117 questionnaires by email to those included in our scope. The questionnaire was based on the factors that affect the transition time between CMMI levels. We designed a questionnaire to gather the effective factors where each respondent was asked to rank each factor that 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).

RESULTS

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 as training (89%), management commitment (85%) and gap analysis (85%). This indicates that in the Saudi practitioners' opinion, training can play a vital role in the transition time between CMMI levels. Therefore, this result almost agrees with that of 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, change of management, unscheduled events, investments of a company, management and staff involvement, awareness, process documentation, frequency of process assessment, metrics and measurement, and consultation. Table 4 shows the non effective factors on the transition time between CMMI levels which are having less impact. From our empirical study in Saudi Arabia, we have noted that the factors - turnover of staff and imposed partner - are new effective factors; whereas, to the best of our knowledge, in literature and previous studies, we did not find that these new factors have been identified or taken up as effective factors on the transition

Table1. 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
Change of management	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.

time between CMMI levels.

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

DISCUSSION

In this paper, we 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 identify what strategies they need to use in order to address these factors and accelerate the transition time from one level of CMMI to another. We believe 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.

Our results indicate that software development organisations need to improve their training planning, and the staffs also need training courses (for example introduction to CMMI, Intermediate CMMI and SCAMPI). However, this kind of similar understanding was noticed by Alam (2009) and Alam et al. (2010). Management

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

Factor	Saudi Arabia	
	High	Percentage
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 change	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

Commitment is one of the factors that are mostly important for any organization as identified by Alam et al. (2010) and Ponnu and Chuah (2010). Thus, management may delay the transition of CMM from a particular CMMI level to a higher one as a result of one or more of the following points:

1. If the management has identified projects for the CMMI and others for the important work.
2. If it has limited its role in contracting with a consultant and a follow-up of an evaluation without efforts to improve the operations.
3. If the management is working on the process now until we deploy the product or software to the client, then we complete the documents later.
4. If the management did not seriously consider the workflow reports and then makes decisions based on their own impressions rather than on facts.

5. If the management seeks only the certificate without obtaining the real value of the application.

When the turnover of staff is often low, the duty of the fundamental work team that built the company's quality system after the end of an appraisal, is to assign the task to a new team, perhaps one that is 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 alternative employment outside the country.

The imposed partner 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

Table 3. Effective factors in Saudi Arabia.

Factor	Saudi Arabia	
	High	Percentage
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
Change of management	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	Percentage
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

processing. Consequently, this will consume time and 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 are completely in agreement with the study of Balla et al. (2001), Iversen and Ngwenyama (2003) and Akmenek and Tarhan (2003).

Through this empirical study, we recommend that practitioners of CMMI-based SPI can design and develop

better strategies to decrease the transition time with the factors identified in this study.

RESEARCH LIMITATIONS

This research has some limitations which are attributed to:

1. Lack of the literature that investigated the transition time of CMMI-based SPI.

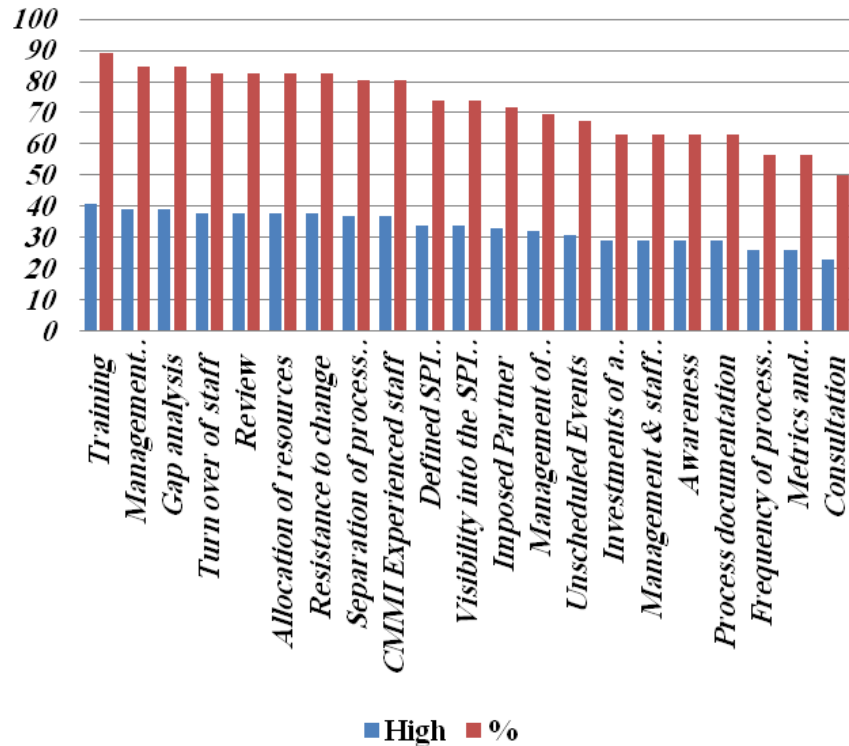


Figure 1. Effective factors in Saudi Arabia.

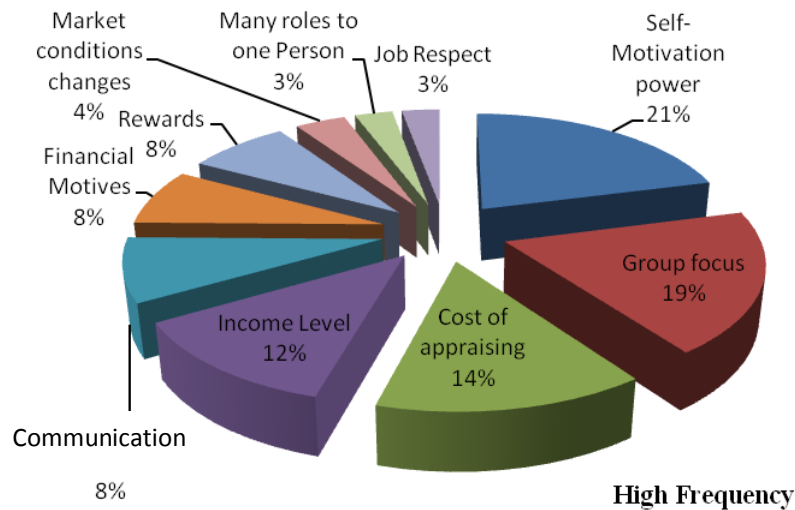


Figure 2. Non effective factors in Saudi Arabia.

2. Most of the Saudis' companies use other software process improvement models rather than CMMI.

Conclusion

This study focused on factors that affect the transition time between CMMI levels in Saudi Arabia. We analyzed

the experiences, opinions and views of practitioners in order to identify the factors that have an impact on the transition time between CMMI levels. Also, we identified factors that are effective on the transition time between CMMI levels. Focusing on these factors, cost-effective opportunities were offered so as to decrease the time spent through the duration between CMMI levels. In order to determine the effective factor, the following criterion

was used:

“If majority of the respondents ($\geq 50\%$) consider that a factor has a high effect on transition time of CMMI, then we treat that factor as an effective factor.”

Using this criterion, we identified 21 factors that are generally considered as effective factors for the transition time between CMMI levels. Also, we identified two new effective factors that affect the transition time between CMMI levels, which are: Turnover of staff and imposed partner. These two factors were not identified in the literature as effective factors affect the transition time between CMMI levels. We recommend 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 accelerate movement between CMMI levels. However, the decrease of transition time between CMMI levels can lead organisations to business benefits.

ACKNOWLEDGEMENTS

The authors are grateful to the entire workers in this research, especially Dr. Rodina Ahmad and the people who supported them in one way or the other. Also, the authors thank the University of Malaya for their support.

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