Identification of Factors that Affect the Transition Time between CMMI Levels from Geographical Region Perspective: An Empirical Study

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Abstract: *A software industry has been more concerned about Software Process Improvement (SPI). 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 effect of Geographical Region on 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 geographical region impact on factors that can affect the transition time between CMMI levels. We conducted 18 interviews in 15 different software companies to extract the factors and compare these factors with what are in the literature to avoid redundancy, based on that we designed a questionnaire. We sent out of 236 requests to participants, 92 responded from 30 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. We identified 11 factors from both data sets that are considered effective factors for the transition time between CMMI levels. And also identified one new factor (turn over of staff) which was not identified in the literature.*

1. Introduction

During recent years, 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 [36]. Issues associated with software quality are widely diffusion to affect the development cost and time [45]. 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, still there are some projects fail to deliver on time and cost [47]. In addition to disappointing execution, some software projects frustration in the operational failure (e.g., the explosion of the Ariane 5 [26], and the London Ambulance Service [11]) or the demise of organizations (e.g., Oxford Health's 'computer glitch' [23], and One.Tel billing system [34]). An ability on delivering quality software within budget and schedule, still to be an obsession of software organizations [6, 36, 38, 49]. In order to address the software process management different techniques and approaches have been developed, one of the most widely used is SPI. SPI is a defined framework of processes and procedures that define the software production process, define the methods to control the software production, define a measurement initiative that benchmarks the effectiveness of the software production and implement the defined procedures and look for continuous improvement opportunities [14]. SPI has some models; Capability Maturity Model Integration (CMMI) is one of the reference models which concerns 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 [41]. The deference here with CMM is that CMMI is an integrated model for system, software, supplier sourcing, IPPD and recommended to the software, systems engineering, and manufacturing industries, but CMM have separate model for all these models and specified with software industry. CMMI has two representations which are continuous and staged representations. In CMMI model with a staged representation, there are five Maturity Levels (ML). ML1 is initial, ML2 is managed, ML3 is defined, ML4 is quantitatively managed, and ML5 is optimizing [41]. However, there is obvious different time in the organizations' duration in order to move from level to another. Despite Software Engineering Institute (SEI) has specified an average transition time between CMMI levels, there are still an obvious deviation in various software organizations from different Geographical Regions in terms of their transition time between CMMI levels. Research shows that the effort put into these models and standards can assist in producing high quality software, reducing cost and

time, and increasing productivity [6, 38, 49]. However, little attention has been paid to the effective implementation of these models and standards [15]. Therefore, still the transition time between CMMI levels needs more investigation. Thus, the main objective of this study is to identify the factors that affect the transition time between CMMI levels-based SPI from different geographical regions perspective, and in light of that, applying the factors in an empirical study over Malaysian and Saudi's companies. This paper presents the results of an empirical study aimed at identifying and investigating the factors which has an effect on transition time between CMMI levels, based on the perceptions and experiences of practitioners in developing countries, i.e., Saudi Arabia and Malaysia. We limit our research on the companies which are already achieved CMMI level 3 or companies which have CMMI level 2 and already started ongoing to achieve 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 from different practitioners. We have also identified a set of research questions that need to be explored in this line of research.

This paper makes the following contributions to the SPI discipline:

- It presents the results of a first of its kind study; as far as we concerned; in developing countries to identify the impact of geographical region on factors that affect the transition time between CMMI levels.
- It provides information about how practitioners' perspective is different in terms of moving to a certain level of CMMI.
- It identifies potential future research areas that can be explored and research to identify ways to accelerate the transition time from CMMI level to another.

We have analyzed the experiences, opinions and views of practitioners in the literature (i.e., case studies, reports and journal papers). We have also conducted a study on factors that have an impact on the transition time between CMMI, and critically analyzed and discussed each factor that affects the duration/transition time between CMMI levels and how the Geographical Region can positively or negatively affects these factors with a detailed description of the research methodology used. In addition, we will compare the factors identified by different practitioners from different geographical regions. Our results may provide feasible and timely advice to SPI decision makers in designing appropriate strategies to accelerate the transition time between CMMI levels. There are four Research Questions (RQ) that have motivated the work reported in this paper:

- *RQ1.* What factors, as identified in the empirical study, have impact (positively or negatively) on the transition time between CMMI levels in Malaysia and Saudi Arabia?
- *RQ2.* Are there similarities in the identified factors which provide impact to the transition time from respondents of differing geographical region?
- *RQ3.* Are there differences, in the factors recognised by respondents, between different geographical regions?
- *RQ4.* How would the geographical regions influence the transition time between CMMI levels?

In this study, our hypothesis is that there is no significant difference in the factors between Saudi Arabia and Malaysia, while the alternative hypothesis is that there is a significant difference in the factors between Saudi Arabia and Malaysia.

This article is organized as follows: Section 2 describes the background. Section 3 describes the research design. Findings are presented and analyzed in section 4. Section 5 provides the discussion and section 6 describes conclusion.

2. Background

2.1. Geographical Region Impact

Geographical Region has been one of the most effective issues on software process improvement [21]. Whereas, a variety geographical regions have a variety capability levels and using a different region of assessed organizations lead to different analysis results [21]. The SEI Process Maturity Profile [43] explores 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 significance of cultural factors in SPI [34], whereas the same software process improvement methods were selected and implemented at case study sites in Germany and United States, 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 United States sites. This indicates that the geographical regions characteristics have a significant impact [34]. Several researches confirmed the importance of being aware of the differences between the various national, organizational, and geographical region level cultures affected in SPI [7, 9, 22, 31, 40]. This means that neither SPI solutions nor programs can be transferred successfully as such. The specific cultural features need to be understood to be able to speak even the same language [9]. According to a survey on 64 software professionals McGuire [28] 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 [22], propose that 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 [7], propose that SPI should even utilize expertise from the social studies. As it is ineluctable that culture differs from organization to organization, and from geographical region to another, it can be understood that ready wrapped solutions are bound to be insufficient and thus also likely to cause opposition. In multinational corporations, often there are conflicting demands from the multinational corporations business units due to the growth and maturity of their operations vary from one geographic region to another [48]. A system that performs effortlessly in one geographical region may be a total failure in another. This is because the management in different geographic regions faces different sets of IT cases [48].

2.2. Factors that Affect the Transition Time Between CMMI Levels

Guererro and Eterovic [16], explore a case study that has achieved the moving from CMM Level 1 to CMM Level 2 in 10 months which would be achieved in 19 months on the average time according to SEI data [44]. They have 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. Akmenek and Tarhan [1], Balla *et al.* [5], Iversen and Ngwenyama [19] have described an achieving of CMM-Level 3 in 7months time which would be achieved in 19 months according to SEI [44]. Identified factors were as: management commitment, awareness, staff involvement, training, experienced staff, consultations, and quality environment. Olson and Sachlis [32] discussed the moving from CMM-Level 1 to CMM-Level 3 in 14 months which would be completed in 38 months based on the time average according to SEI data [44]. Identified factors were management commitment, staff involvement, training, consultant, implementation plan, and process documentation. Zeid [50] has explained how the organization, ITSoft moved from CMM Level 2 to CMM Level 3 in a short time just two months and from CMM Level 1 to CMM Level 2 in 9 months. Identified factors were as: Training, experienced staff, quality environment, implementation plan, process documentation, and metrics and measurement. Jackelen [20], has 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

one month. The paper discusses 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. 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 empirical research enables rigorous experimentation by encouraging multiple analysis from multiple perspectives using different approaches and, being based on experiences and direct data collection, helps to compare what we believe to what we observe [18, 37]. Therefore, empirical research helps researchers move toward swell-founded decisions [37]. An empirical investigation of SPI implementation factors will provide SPI practitioners with valuable insights through planning of SPI strategies [30]. In order to provide more confidence in this study, it is important that the practitioners' experiences and perceptions should be explored independently and without any suggestion from the researcher [30]. This is what motivated the use of transition time factors extracting interviews as staring point in this study. However, despite the increasing importance of CMMI, and the need for an empirically tested body of knowledge regarding aspects of transition time of CMMI, there are little studies on identifying factors that can affect the transition time between CMMI levels. In this paper we present a comparative study of the factors that have an impact on the transition time between CMMI levels in Malaysia and Saudi Arabia. A good understanding of the transition time factors of CMMI will help organisations to accelerating the moving between CMMI levels. The decrease of transition time between CMMI levels can lead organisations to business benefits.

3. Research Design

3.1. Research Approach

In this study, we identified people who are already involved in software development industry. Project manager, team leader, process engineers, consultants, project directors and general managers are our aim to extract factors which are having high impact on duration of CMMI-based SPI. For this purpose, we have done the following:

- Conducting a face to face meeting, to extract the factors that affect the transition time between CMMI levels without any suggestions from the researchers.
- Factors Filtration, to identify and avoid redundancy of factors which have different name with the same meaning between practitioners and literature review.

- Survey Design, designing a questionnaire in favor of this study in order to collect the data from respondents.
- Distribution stage, to distribute and apply the questionnaire into Malaysia and Saudi Arabia.
- Data Analysis, according to data, which are collected from respondents, we have used SPSS by applying linear by linear association Chi-square test. The linear by linear association test is preferred when testing the significant differences between two ordinal variables since it is more powerful than Pearson chi-square test [27, 29].
- Results and caparisoning, to find out the results and to determine the significant differences between the two data sets.

3.2. Population and Sample Profile

Software organizations and companies are considered as the target population for this study. This population includes companies from different geographical regions, developing either software or combined software and hardware products for a wide variety of markets which are already adopted CMMI and achieved CMMI level 3 or whose are achieved CMMI level 2 and ongoing to achieve CMMI level 3. According to our study and our scope , we had sent out of 236 requests to participants, of which only 92 were responded from 30 companies distributed over Malaysia (18 companies) and Saudi Arabia (12 companies). This means the response rate was (39%). However, we have high confidence in the accuracy and validity of the data. Ninety-two practitioners voluntarily participated in this study. It was important to ensure that there is no particular group was overrepresented [8]. 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 [2, 3, 4, 30]. Sample size can be one of kinds of bias. The larger the sample the less likely the sampling bias [8]. There are 30 participating companies in our sample. It is significant to show that this sample is large enough to minimize the possibility of bias.

3.3. Data Instrumentation

In this study we have used a questionnaire as a main instrument to gather survey data from companies. A questionnaire was pre-tested by 7 SPI personnel in domestic software companies and 4 graduate students at the authors' university. Guielford [17], 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 a high average Cronbach alpha of 0.799381; this is an indication that the questionnaire was

acceptable and internally consistent. A survey research method can use one or more data elicitation techniques such as interviews and self administered questionnaires [25]. It is deemed suitable for eliciting quantitative and qualitative data from respondents [25]. We determined on using a questionnaire as a data collection instrument, we have used e-mail, telephone calling and face to face meeting sessions. Since, possibility of illustration the objectives of the research and different terms used in the questionnaire and clarifying the purpose of different questions included in the questionnaire, and ensuring data validation before finishing each survey session. The survey session duration was about 45 minutes.

3.4. Effective Factor

In this study, we defined effective factor to measure of the extent to which a 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 factor has a high effect on transition time of CMMI then we treat that factor as an effective factor.

A similar approach has been done in the literature [29, 31, 39]. Rainer and Hall [39] identified important factors in SPI with the criterion that if the 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.

3.5. Data Collection

According to the research objectives and available resources, we have used a survey research method to gather data about Malaysians and Saudis practitioners' perspective of the factors that affect the transition time between CMMI levels based SPI initiatives. A survey of data collection is considered suitable for gathering quantitative and qualitative data from a number of respondents [17]. A survey of data collection can use one or more data elicitation techniques such as interviews and questionnaires [25]. We have used a closed format questionnaire as a data collection instrument 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 validation before completing each survey session. We have conducted 18 interviews in 15 different software

companies between Malaysia and Saudi Arabia, with flexible schedules so that interviewees could make an appointment at any time suitable for them [13]. We had sent 236 questionnaires by email to whom included in our scope which is the companies that already achieved CMMI level 3 and the companies which are ongoing to achieve CMMI level 3. A questionnaire was based on factors that affect the transition time between CMMI levels based SPI initiatives. We have 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 (i.e., High, Medium, Low, Zero, or Not sure).

4. Findings

In order to achieve our objectives and to answer RQ1, RQ2, RQ3, and RQ4, we had distributed the same questionnaire to two different geographical regions in developing countries, i.e., Malaysia and Saudi Arabia. After applying our methodology on the returned questionnaires some noticeable findings have been obtained and classified in the subsequent section.

4.1. Factors that Affect the Transition Time Between CMMI Levels in Malaysia

We have defined the effective factor which is, if the majority of respondents (≥50%) consider that factor has high effect on transition time of CMMI, and then we treat that factor as effective factor. In order to answer RQ1, Table 1 shows the list of factors that affect the transition time between CMMI levels in Malaysia. The identified effective factors in the transition time are management commitment (i.e., 91%). This indicates that, in the Malaysians practitioners' opinion, management commitment can play a vital role in the transition time between CMMI levels and this result agrees with [1, 5, 19]. Other frequently effective factors in Malaysia are public holidays events (85%), and communication (85%). It indicates that practitioners consider that the large number of Malaysian holidays may take time, therefore as long as we measure this time, thus prolonging the duration mathematically. Consequently, this is reflected in the total output from the time of transition between CMMI levels. Also, the result show the following factors as effective factors: communication, allocation of resources, management of changement, training, separation of process and product concerns, turn over of staff, cost of appraising, gap analysis, financial motives, income level, rewards, investments of a company, process documentation, consultation, and awareness as effective factors in Malaysia. From our empirical study in Malaysia, we have noted that the factors-turn over of staff, Public holidays events, cost

of appraising and financial motives-; based on our knowledge; these new factors have not been identified in the previous studies or have been taken up as effective factors on the transition time between CMMI levels.

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

Factors	Malaysia	
	High	%
Management Commitment	42	91
Public Holidays Events	39	85
Communication	39	85
Allocation of Resources	38	83
Management of Changement	37	80
Training	37	80
Separation of Process and Product Concerns	34	74
Turn Over of Staff	33	72
Cost of Appraising	33	72
Gap analysis	32	70
Financial Motives	29	63
Income Level	29	63
Rewards	29	63
Investments of a Company	27	59
Process Documentation	24	52
Consultation	24	52
Awareness	23	50
Review	22	48
Self-Motivation Power	20	43
CMMI Experienced Staff	19	41
Management & Staff Involvement	18	39
Metrics and Measurement	18	39
Resistance to Change	18	39
Frequency of Process Assessment	17	37
Unscheduled Events	16	35
Defined SPI Implementation Methodology	15	33
Group Focus	15	33
Visibility into the SPI Process Planning	15	33
Many Roles to one Person	13	28
Imposed Partner	13	28
Job Respect	5	11
Market Conditions Changes	2	4

4.2. Factors that Affect the Transition Time Between CMMI Levels in Saudi Arabia

In order to answer RQ1, Table 2 shows that the list of factors that affect the transition time between CMMI levels in Saudi Arabia. The identified effective factors in the transition time are training (89%), management commitment, and gap analysis, 85% to each. This indicates that, in the Saudi practitioners' opinion, training can play a quite vital role in the transition time between CMMI levels. This result almost agrees with [1, 5, 19, 32]. Other frequently effective factors in Saudi Arabia are turn over 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 & staff involvement, awareness, process documentation, frequency of process assessment, metrics and measurement, and consultation. From our empirical study in Saudi Arabia, we have noted that the factors-

turn over of staff and imposed partner-are new effective factors. To the best of our knowledge, these new factors have not been identified in the literature as effective factors on the transition time between CMMI levels.

Table 2. Factors that affect the transition time between CMMI levels in Saudi Arabia.

Factors	Saudi Arabia	
	High	%
Training	41	89
Management Commitment	39	85
Gap analysis	39	85
Turn Over 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 & 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
Public Holidays Events	0	0

4.3. Geographical Region Impact on Transition Time Factors Between CMMI Levels

In two different geographical regions; i.e., Malaysia and Saudi Arabia; we have found that; the same questionnaire which was applied in two different geographical regions; it has gained different results. Whereas, some of factors were effective in Malaysia but they were not effective in Saudi Arabian's region. Table 3 shows that the effective factors in Malaysia only are public holiday events, communication, cost of appraising, financial motives, Income level, and rewards. Whereas, Table 4 shows that the effective factors in Saudi Arabia only are review, resistance to change, CMMI experienced staff, defined SPI implementation methodology, visibility into the SPI process planning, 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 special effect. Table 5 shows that the shared factors which are effective in both Malaysia and Saudi Arabia. Therefore, we found from Table 5 that

the effect rate based on shared effective factors in Malaysia is 69.36%, where the effect rate in Saudi Arabia based on these factors is 75.36%. Consequently, the geographical region impact on the transition time in Malaysia is 30.64%, where the geographical region impact on the transition time in Saudi Arabia is 24.64%. This indicates that with different geographical regions there are different effective factors, different effect rate and this is our underlying justification behind the different time of transition between CMMI levels. Therefore, these results agree with Paulish [34] who claimed that the geographical regions characteristics have a significant impact. However, these results may not necessarily be generalized elsewhere but a better understanding for varying reasons of transition time between CMMI levels is necessary and still needs more investigation.

Table 3. Effective factors in Malaysia only.

Effective Factors	High	%
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. Effective factors in Saudi Arabia only.

Effective Factors	High	%
Review	38	83
Resistance to Change	38	83
CMMI Experienced Staff	37	80
Defined SPI Implementation Methodology	34	74
Visibility into the SPI Process Planning	34	74
Imposed Partner	33	72
Unscheduled Events	31	67
Management and Staff Involvement	29	63
Frequency of Process Assessment	26	57
Metrics and Measurement	26	57

Table 5. Effective factors in both Malaysia and Saudi Arabia.

Shared Factors	Malaysia		Saudi Arabia	
	High	%	High	%
Training	37	80	41	89
Management Commitment	37	80	39	85
Gap analysis	32	70	39	85
Turn Over of Staff	33	72	38	83
Allocation of Resources	38	83	38	83
Separation of Process and Product Concerns	34	74	37	80
Management of Changement	42	91	39	85
Investments of a Company	27	59	29	63
Awareness	23	50	29	63
Process Documentation	24	52	29	63

4.4. Comparison of the Two Data Sets

Comparison of factors that affect the transition time between CMMI levels from two data sets provided evidence that there are similarities and differences between the findings in the two data sets. Focusing on factors that affect the transition time across the two data sets may offer CMMI based SPI practitioners cost-effective opportunities in order to decrease the time spent through the duration between CMMI levels.

This is because there are a number of factors that have a wide effect on the transition time of CMMI can be treated. In order to find significant differences between the two data sets (i.e., Malaysia and Saudi Arabia) we have used the chi-square test. We have found a number of significant differences between the two data sets (i.e., *p* value in Table 6 is highlighted for significant differences). The null hypothesis for the Chi-Square test is that there is no significant difference in the factors between Saudi Arabia and Malaysia, while the alternative hypothesis is that there is a significance difference in the factors between Saudi Arabia and Malaysia. By looking at the p-value, we can decide whether to reject or accept null hypothesis, the null hypothesis is rejected if the p-value is less than α=0.05. From Table 6, we found 19 factors with significance difference (p<0.05) or in other words we can say that these 19 factors are different in both countries. This indicates that geographical region play a vital role on factors that affect the transition time between CMMI levels, therefore this answer RQ 4.

Figure 1 summarized the factors identified through the two data sets. Our results show that the two data sets have cited 11 factors. These findings indicate that organizations should focus on these factors to decrease the transition time between CMMI levels based SPI initiatives, because we have confidence that these

factors do indeed have an impact on transition time of CMMI if they are effective in both data sets. Figure 1 shows that through shared factors, we found new effective factor in both-turn over of staff-which has been identified in our empirical study, and has not been identified in the literature. In order to answer RQ2 and RQ3, it is very clear from Figure 1 and Table 6 that there are both similarities and differences in factors between the two data sets.
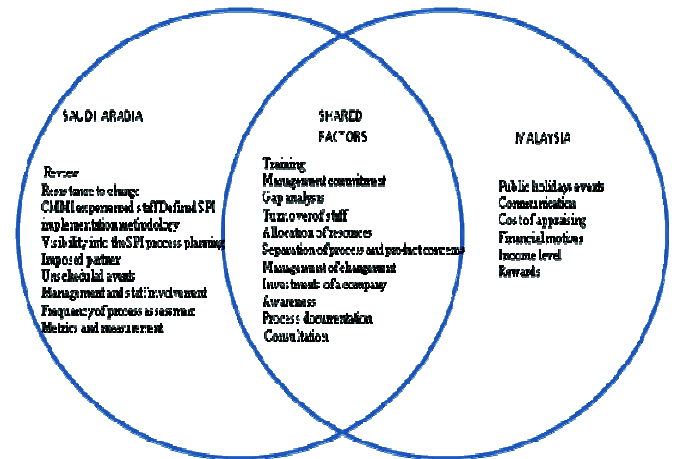

Figure 1. A summary of factors that affect the transition time between CMMI levels as stated by Malaysia and Saudi Arabia. The area in which both the factors overlap represents the shared factors.

Table 6. Comparison of two data sets.

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	χ^2	df	p
Self-Motivation Power	22	8	2	4	10	20	10	5	2	9	0.017	1	0.896
Turn Over of Staff	38	8	0	0	0	33	11	1	0	1	2.488	1	0.115
Market Conditions Changes	4	3	32	6	1	2	6	10	20	8	9.321	1	0.002
Cost of Appraising	15	18	6	3	4	33	10	0	0	3	8.511	1	0.004
Management of Changement	32	11	1	1	1	37	8	1	0	0	4.769	1	0.029
Investments of a Company	29	14	1	1	1	27	12	6	0	1	0.371	1	0.543
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
Job Respecting	3	6	21	16	0	5	4	11	20	6	2.004	1	0.157
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	0.000	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
Resistance to Change	38	8	0	0	0	18	10	6	4	8	22.716	1	0.000
Visibility into the SPI Process Planning	34	10	0	0	2	15	12	7	9	3	16.052	1	0.000
H= High, **M**= Medium, **L**= Low, **Z**= Zero, **N/S**= Not Sure													

Using Figure 1, it becomes clear that 40% of the factors are shared between the two data sets and 60% of the factors are only effective in an individual data set. Table 6 shows that 59% of the factors have significant differences while 41% of the factors have no significant differences between the two data sets (i.e., Malaysia and Saudi Arabia).

5. Discussion

In this paper, we presented a comparative study of factors that affect the transition time between CMMI levels in Malaysia and 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 consider in order addressing these factors and accelerating the transition time from level to another of CMMI. We trust that these factors can be very useful for Malaysian and 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 (e.g., introduction to CMMI, Intermediate CMMI and SCAMPI). One of the important identified is management commitment which is effective factor in both data sets and has a high effectiveness. Turn over of staff, this is a new effective factor, whereas-staff turn over-causes delaying in terms of the time, this factor is relevant with the time, in Malaysia it has 72% of effectiveness and in Saudi Arabia it has 83% of effectiveness. A comparison of factors that affect the transition time between CMMI levels with the two data sets (i.e., Malaysia and Saudi Arabia) indicates that there are both similarities and differences between factors that affect the transition time, by Malaysian and Saudis' practitioners. Focusing on the factors that affect the transition time between CMMI levels, we recommend that CMMI based SPI practitioners can design and develop better strategies to decrease such transition time by the factors identified which have relatively different degrees of significance in the two different geographical regions.

6. Conclusions

This study focuses on factors that affect the transition time between CMMI levels in Malaysia and Saudi Arabia. We analyzed the experiences, opinions and views of practitioners in order to identify factors that have an impact on the transition time of CMMI based SPI initiatives. We identified factors that are effective for the transition time between CMMI levels. Focusing on these factors offers cost-effective opportunities toward decreasing the time spent through the duration between CMMI levels. Our findings show that there are both similarities and differences between the factors that affect the transition time between CMMI levels which are identified through Malaysia and Saudi Arabia. In order to determine the effective factor, we have 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.

A similar approach has been done in the literature [29, 31, 39]. Rainer and Hall [39] identified important factors in SPI with the criterion that if the 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. Using this criterion we have identified 11 factors from both data sets that are generally considered effective factors for the transition time between CMMI levels. These factors are training, management commitment, gap analysis, turn over of staff, allocation of resources, separation of process and product concerns, management of changement, investments of a company, awareness, process documentation, and consultation. Our results recommend that organizations should focus on these factors to decrease the transition time between CMMI levels based SPI initiatives, because we have confidence that these factors do indeed have an impact on the transition time of CMMI which they are effective in both data sets. We have identified one new effective factor affects the transition time between CMMI levels, which is-turn over of staff- it was not identified in the literature. We recommend that organizations should also focus on this new effective factor and the shared factors in both data sets to accelerate the transition time between CMMI levels, because different practitioners who were processing real issues on a daily basis frequently cited these factors.

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