

## **Empirical investigation of factors that support pursuing software process improvement: analyses of Saudi practitioners views**

**Mohammad Zarour**

Department of Software Engineering, Prince Sultan University, Rafha Street, Riyadh 11586 Saudi Arabia

**Abstract:** There is a big consensus that the quality of the software process has a great influence on the quality of the developed software. Hence, improving process quality helps in developing better software products with fewer defects on time and within budget. Accordingly, many software companies worldwide are conducting software process improvement (SPI) initiatives to enhance their maturity in developing software. The success in pursuing such initiatives is affected by several factors. The literature documents various experience studies in conducting SPI initiatives. Very few of these studies have been conducted in the Middle East region in general and particularly in Saudi Arabia. In this paper, we report the results of a survey-based empirical study to identify factors that supported the SPI initiatives in Saudi Arabia. A survey to identify reasons for such success has been dispatched to practitioners in various Saudi IT companies. Responses have been collected and analyzed. We have also reviewed various factors reported in the literature related to Saudi SPI initiatives. Results from the literature review and our conducted empirical study have been synthesized and analyzed in this paper. The presented work in this paper complements a previously published work that studied the failure factors that hamper SPI initiatives. This would complete the whole picture of what should and what should not be adopted by companies aiming to conduct successful SPI initiatives.

**Keywords:** Software Process, Improvement, SPI, Failure factors.

### **1. Introduction**

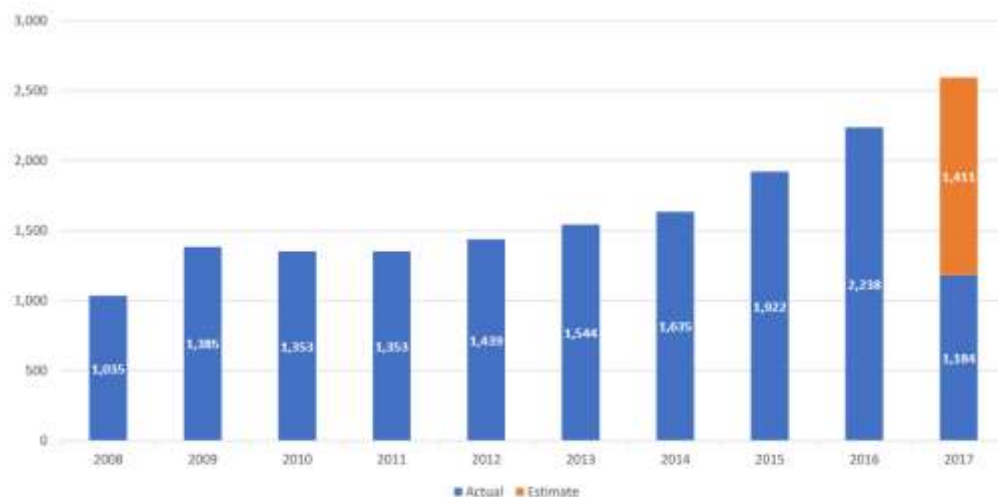
There is a growing consensus that a high-quality software process results in a high-quality software product with reduced cost, met deadlines and increased productivity [1-5]. This consensus resulted in more interest in conducting software process improvement (SPI) and gain better organizational maturity and processes' capability in developing software. Software process improvement is a widely used approach to enhance software process in software organizations [6]. Various SPI reference models and standards are available that includes ISO 9000 series of standards [1], ISO15504 (SPICE) [7] and the Capability Maturity Model Integration (CMMI) [8]. CMMI-staged model focuses on determining the organizational maturity while CMMI-continuous model and ISO15504 both focus on determining the process capability.

Despite the flourishing software industry worldwide, a relatively small proportion of the software development organizations has been reported to adopt SPI models. For instance, the published CMMI institute appraisal report has documented 15,088 CMMI-SCAMPI A appraisals worldwide in the period between 1 January 2008 - 30 June 2017 [9], See Figure-1. Although this number is small

compared to the size of global IT industry, it is still very promising as the reported numbers in CMMI process maturity profile in 2008, for example, was only 3113 appraisals.

Various reasons that prevent software organizations from widely adopting and pursuing SPI initiatives have been published [6], [10]–[17][18]; the literature shows that software development organizations are facing problems in the implementation of SPI initiatives using maturity models like CMMI [10]. Moreover, small-sized and medium-sized organizations have expressed many concerning the relevance and applicability of models like CMMI [10], [19], [20]. One of the biggest challenges stated is that an SPI program is a high-priced undertaking, and organizations need to commit significant resources over a long period [21]. With reference to the CMMI process maturity profile report [9], we noticed that the number of appraisals, based on CMMI, is still low today, but the adoption rate is promising.

Based on the numbers of the reported appraisals by country shown in [22], Saudi Arabia is one of the countries with few appraisals; compared to developed countries, Saudi Arabia has conducted 22 CMMI-Dev. appraisals in the period between January 1, 2007 – June 30, 2015. United states have conducted 2738 appraisals, China conducted 4380 appraisals, France conducted 220 appraisals, UK conducted 161 appraisals for the same period.



**Fig. 1:** Number of Global Appraisals by the Year 2008 –2017 [9]

This research is expected to provide SPI practitioners of Saudi Arabia, as well as, their collaborating international parties, with some insights into the practitioners' perception of SPI and factors that can support its implementation in the Saudi market.

The research questions that motivated this research work are:

1. RQ1: What are the most important factors that support conducting successful SPI initiative from a practitioners' viewpoint?
2. RQ2: How are these factors related to the Practitioners' roles?
3. RQ3: How are these factors related to the Organizations' size?

The presented work in this paper complements a previously published work that studied the failure factors that hamper SPI initiatives. This research would complete the whole picture of what should

and what should not be adopted by companies aiming to conduct successful SPI initiatives. The rest of the paper is organized as follows: Section 2 presents background and related work related to software process improvement and empirical work conducted to evaluate success factors. Section 3 presents the adopted research methodology and how it is applied. Section 4 presents the results both demographic results and findings related to the success factors under study. Section 5 provides a comparison with similar studies. Section 6 discusses the possible limitations and section 7 presents the conclusion and future work.

## **2. Related Work**

Although many success stories related to SPI implementations have been published, many organizations are still facing problems in achieving the same results [6], [16][13]. There are many different reasons, presented in the literature, why an SPI initiative succeeds. Some researchers link the success of an SPI initiative to the organization size (e.g. large or SMEs) [23][24], [25]. Others propose that some development processes improve the ability for successful SPI, e.g. SPI and agile methodologies [26], [27]. Hence “there is a growing interest over the recent years in SPI for SME’s and adopting agile principles for SPI” [28]. Alignment of SPI initiatives with business goals is also considered as one of the critical factors for a successful SPI initiative [29].

Adopting any of the SPI approaches do not come without upfront investment. SPI initiatives are usually “costly and improved processes need time to be disseminated, making the impact of SPI hard to measure and justify” [30], [31], at least on the short term. Accordingly, interested practitioners are reluctant to conduct SPI [31]. Niazi et al. [32] presented the importance of using an effective strategy to successfully implement SPI. This means that we are not lacking SPI models and framework neither top-down nor bottom-up, instead we need better strategies to implement them and deeper understanding of the factors affecting such implementation. One of the influencing factors for successful SPI implementation is the human factors and their perception of SPI [33]. In this paper, we try to explore practitioners’ perception of SPI and factors that affect conducting improvement initiatives considering success factors discussed and summarized in [14] which is a recent study of SPI success factors identified via three research strategies (informal literature review, systematic literature review and interviews). A summary of these success factors is given in Table 1. Although the findings in [14] refer to 34 success factors, we have chosen 21 success factors out of them as we believe that the remaining success factors can be easily mapped to one of these 21 success factors.

## **3. Research Methodology**

For this research, a survey-based empirical study has been designed to understand the success factors of SPI initiatives specifically in the Saudi market using practitioners’ viewpoint (See Figure-2). The approach adopted to collect responses is an online survey using Google Forms available at [34]. This research methodology is the same one used to study the SPI failure factors that hump successful SPI adoption initiatives published in [35].

**Table 1:** List of Success Factors [14]

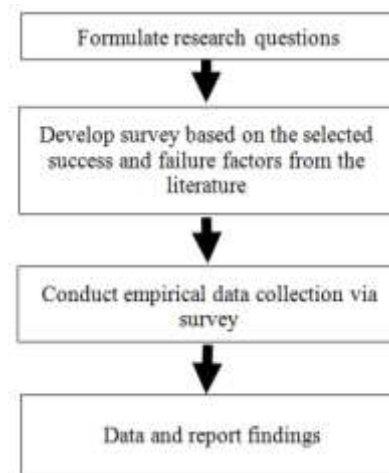
ID	Success Factors
SF1	Senior management commitment
SF2	Training availability
SF3	Availability of awareness events of SPI and activities
SF4	Allocation of needed resources
SF5	Availability of experienced staff
SF6	Defined SPI implementation methodology
SF7	Staff involvement in the SPI process
SF8	Encouraging communication and collaboration
SF9	Managing the SPI project
SF10	Applying standards and procedures in SPI
SF11	Availability of Formal documentation of the SPI
SF12	Organization develops a review process for SPI imp.
SF13	Using automated tools to conduct the SPI
SF14	Company culture supports conducting SPI
SF15	Customer satisfaction will be enhanced with SPI
SF16	External implementation agents are useful for SPI
SF17	Logical sequence or order of SPI imp.
SF18	Availability of Measurement for SPI
SF19	Ability to tailor improvement initiatives
SF20	Formalized relationship between development teams
SF21	Higher staff moral

The SEPG group in the Software Engineering Department of Prince Sultan University has helped in publicizing the survey among practitioners in IT organizations. The team also explained survey questions to ensure the understanding of participants. Practitioners have been contacted via various means, including phone calls, face-to-face meetings, and emails. Those who agreed to participate in this study were contacted by email that includes the link to the survey. Participants are all playing various IT roles in the domestic software industry.

A total of sixty practitioners were invited to participate in this study. Thirty-four surveys were completed, giving a response rate of around 57%. The questionnaires were manually reviewed for correctness and completeness to prevent any irrelevant entries from being included in the results. Eight surveys were excluded due to incomplete or irrelevant answers. We ended up with twenty-six valid surveys.

Worth mentioning here that we are not sampling the Saudi practitioners in the IT field where we cannot claim that the collected sample is statistically representative for the local IT market size of the Kingdom. A truly representative sample, in such cases, is impossible to attain and the researcher

should try to remove as much of the sample bias as possible in order to make the sample fairly representative [36].



**Fig. 2:** Research methodology [35]

But what we are sampling here is the practitioners to represent different kinds of IT organizations, where we believe twenty-six surveys are suitable sample size according to [37].

Moreover, we are not surveying certain organization that adopted SPI but we survey practitioners' perception of SPI, hence, we are committed to collect data from practitioners with various roles and experience levels that includes developers, requirement engineers, designers and quality assurance representatives, team leader/ project manager, and senior managers.

The frequency analysis method is used to group the data into frequency tables to facilitate reading and analyzing descriptive information. This is useful in comparing and contrasting within groups of variables or across groups of variables. To analyze the success factors, the occurrence of each factor in each questionnaire was counted and the relative importance of each factor was identified by comparing the occurrences of one factor against the occurrence of other factors.

## **4. Results**

### **4.1 Demographic Data**

The survey started by asking some demographic questions to understand the background of the participants and their organization nature. Demographic questions asked about the participants' Roles, participants' IT-related activities, organization size, years of experience, organizations' SPI initiative, and the awareness level of SPI initiatives in the organization. For more details about the demographic data refer to the complementary research published in [35].

## 4.2 Survey Findings

### (1) Factors That Mostly Hamper the SPI Initiatives from Practitioners' Viewpoint (RQ1)

Table 2 lists the SPI success factors from the viewpoint of 26 practitioners who participated in this empirical study. The table is divided into two main columns: 'Success Factors' and 'Practitioners' Perception'. The latter was further divided into three sub-columns. (1) 'Positive' column that counts the participants who either strongly agree or agree on the success factor. (2) 'Negative' column that counts the participants who either strongly disagree or disagree on the success factor. (3) 'Neutral' column that counts the participants who did not experience the success factor during their work.

### (2) Factors Identified based on Participants' Roles (RQ2)

To analyze the SPI perception of various practitioners' groups, the practitioners have been divided into two main groups:

- Technical members: This includes developers, requirement engineers, designers and quality people
- Managers: This includes team leader/project manager and senior managers

Table 3 lists the success factors and the rating of both groups; technical and managers. In this sample 65% belongs to managers group while 31% belongs to technical member group. One participant did not specify his role and has been excluded from this sample.

The managers group members rated the success factor 'Defined SPI implementation methodology' in the first place and in the second place come the 'Availability of experienced staff', 'Applying standards and procedures in SPI to ensure quality', 'Organization develops a review process for the SPI implementation' and the availability of 'Logical order or sequence of SPI implementation'.

Seven success factors are rated in the first place by technical members that include: 'senior management commitment', 'Customer satisfaction will be enhanced if we conduct SPI', 'Applying standards and procedures in SPI to ensure Quality', 'Organization develop a review process for SPI implementation', 'Company culture support conducting SPI', 'Ability to tailor improvement initiatives' and 'High employee turnover'. In the second place, technical members rated five success factors that include: 'Allocation of needed resources', 'Managing the SPI process', 'Availability of formal documentation of the SPI process', 'Availability of measurement for SPI' and 'Formalized relationship between development teams'.

To analyze the significant difference in the responses of technical members and managers as a response to the survey questions which are of ordinal type (Likert scale), we used fisher exact test with ( $\alpha = 0.05$ ). As shown in Table 4, none of the challenges has a p-value  $<0.05$  which means there is no significant difference in any of the specified success factors across the two groups of technical members and managers.

**Table 2:** Success Factors identified via the Survey

Success Factors	Practitioners' Perception (n=26)								
	Negative			Neutral		Positive			
	SD	D	%	N	%	A	SA	%	
Senior management commitment	1	3	15	5	19	9	8	65	
Training availability	1	1	8	5	19	16	3	73	
Availability of awareness events of SPI and activities	1	4	19	2	8	14	5	73	
Allocation of needed resources	0	3	12	5	19	14	4	69	
Availability of experienced staff	0	2	8	5	19	13	6	73	
Defined SPI implementation methodology	1	3	15	1	4	12	9	81	
Staff involvement in the SPI process	0	3	12	6	23	12	4	62	
Encouraging communication and collaboration	0	2	8	4	15	11	8	73	
Managing the SPI project	2	1	12	6	23	12	4	62	
Applying standards and procedures in SPI	0	4	15	1	4	13	8	81	
Availability of Formal documentation of the SPI	0	3	12	4	15	12	6	69	
Organization develops a review process for SPI imp.	1	1	8	3	12	14	7	81	
Using automated tools to conduct the SPI	0	4	15	4	15	10	8	69	
Company culture supports conducting SPI	0	3	12	4	15	10	9	73	
Customer satisfaction will be enhanced with SPI	1	3	15	0	0	11	10	81	
External implementation agents are useful for SPI	2	2	15	5	19	13	2	58	
Logical sequence or order of SPI imp.	0	2	8	3	12	17	2	73	
Availability of Measurement for SPI	1	3	15	1	4	16	2	69	
Ability to tailor improvement initiatives	2	2	15	2	8	14	4	69	
Formalized relationship between dev. teams	2	2	15	2	8	16	3	73	
Higher staff moral	1	4	19	2	8	14	4	69	

**Table 3:** Success Factors identified based on practitioners' roles

Success Factors	Managers (17)							Technical (8)							Fisher Exact Test $\alpha = 0.05$
	SD	D	N	A	SA	%	SD	D	N	A	SA	%			
SF-1	1	3	5	9	8	53%	0	1	2	4	4	100%	0.1312		
SF-2	1	1	5	16	3	71%	0	0	0	5	1	75%	1.0000		
SF-3	1	4	2	14	5	71%	0	0	2	5	1	75%	1.0000		
SF-4	0	3	5	14	4	65%	0	1	1	5	2	88%	0.5211		
SF-5	0	2	5	13	6	76%	0	0	1	5	1	75%	1.0000		
SF-6	1	3	1	12	9	82%	0	0	2	4	2	75%	0.5784		
SF-7	0	3	6	12	4	65%	0	2	0	3	2	63%	0.5304		

SF-8	0	2	4	11	8	71%	0	0	2	4	2	75%	1.0000
SF-9	2	1	6	12	4	47%	0	0	1	5	2	88%	0.2451
SF-10	0	4	1	13	8	76%	0	0	1	6	2	100%	0.5257
SF-11	0	3	4	12	6	65%	0	0	0	4	3	88%	0.5211
SF-12	1	1	3	14	7	76%	0	0	1	6	2	100%	0.5257
SF-13	0	4	4	10	8	65%	0	0	0	3	3	75%	0.2807
SF-14	0	3	4	10	9	65%	0	0	2	6	2	100%	0.2727
SF-15	1	3	0	11	10	71%	0	0	0	5	3	100%	0.2622
SF-16	2	2	5	13	2	59%	0	0	0	5	0	63%	0.5221
SF-17	0	2	3	17	2	76%	0	0	3	6	0	75%	1.0000
SF-18	1	3	1	16	2	59%	0	0	2	7	0	88%	0.2550
SF-19	2	2	2	14	4	59%	0	0	0	7	1	100%	0.2536
SF-21	2	2	2	16	3	65%	0	0	0	6	1	88%	1.0000
SF-22	1	4	2	14	4	59%	1	0	0	6	2	100%	0.1221

### (3) Factors identified based on organization size (RQ3)

Table 5 lists the success factors and ratings based on organization size grouped into three groups: large consists of 13 organizations; medium consists of 2 organizations and small consists of 1 organization. The ten remaining organizations did not specify their organizations' size hence they have been excluded from this analysis. The large-sized organization's members rated the success factor 'Availability of formal documentation of the SPI process' and 'Organization develops a review process for SPI implementation requirements' in the first place. For Medium and small sized organizations, the number of organizations participating is small (2 medium size organizations and 1 small size organization) which may not generate a representative rating for each group. Nevertheless, participants from medium size organizations rated all success factors in the first place except 'senior management commitment' and 'using automated tools to conduct SPI' which come in the second place. The participant from the small size organization rated all success factors in the first place except 'Formalized relationship between development teams' and 'Higher staff moral' which come in the second place.

Note that fisher exact test with ( $\alpha = 0.05$ ) shows that none of the success factors rated by various organization sizes has a p-value  $<0.05$  which means there is no significant difference in any of the specified success factors across varied sizes.

## 5. Comparison with Similar Studies

Another interesting dimension in this study is the comparison with similar published studies. Regarding the success factors, Niazi et. al. [13][14] have studied the critical success factors for SPI implementation in Australian organizations through an empirical study that included 34 Australian practitioners. Table 7 presents a summary of success factors identified by Saudi practitioners compared to similar factors identified by Australian practitioners as depicted in [13].



**Table 4:** Failure Factors Identified Based on Organization Size

Success Factors	Large (13)			Medium (2)			Small (1)			Fisher Exact Test $\alpha = 0.05$
	D	N	A	D	N	A	D	N	A	
SF-1	4	2	7	0	1	1	0	0	1	0.6786
SF-2	2	2	9	0	0	2	0	0	1	1.0000
SF-3	4	2	7	0	0	2	0	0	1	1.0000
SF-4	2	2	9	0	0	2	0	0	1	1.0000
SF-5	2	1	10	0	0	2	0	0	1	1.0000
SF-6	3	0	10	0	0	2	0	0	1	1.0000
SF-7	2	1	10	0	0	2	0	0	1	1.0000
SF-8	2	3	8	0	0	2	0	0	1	1.0000
SF-9	2	4	7	0	0	2	0	0	1	0.7857
SF-10	3	1	9	0	0	2	0	0	1	1.0000
SF-11	2	0	11	0	0	2	0	0	1	0.3925
SF-12	2	0	11	0	0	2	0	0	1	1.0000
SF-13	3	2	8	1	0	1	0	0	1	1.0000
SF-14	3	2	8	0	0	2	0	0	1	1.0000
SF-15	4	0	9	0	0	2	0	0	1	1.0000
SF-16	3	3	7	0	0	2	0	0	1	1.0000
SF-17	2	1	10	0	0	2	0	0	1	1.0000
SF-18	3	1	8	0	0	2	0	0	1	0.6374
SF-19	4	1	8	0	0	2	0	0	1	1.0000
SF-20	2	1	10	0	0	2	0	1	0	0.2929
SF-21	3	0	10	0	0	2	0	1	0	0.1321

Saudi practitioners rated in the first place four factors, namely: ‘Defined SPI implementation methodology’, ‘Applying standards and procedures in SPI’, ‘organization develops a review process for the SPI implementation’ and ‘customer satisfaction will be enhanced with SPI’. The Australian practitioners rated two success factors in the first place, namely: ‘Senior management commitment’ and ‘Training availability’. Success factors rated by Saudis in the first place are rated by Australians in the fifth to the eighth places, and factors rated by Australian in the first are rated by Saudis in the second and fourth places. By analysing these findings, we can see that the Saudis are more interested in SPI implementation issues and the importance of clear preparations to conduct SPI initiatives (first three factors) as well as showing benefits gained from conducting SPI initiative from customers’ perspectives.

Australians do not rate these factors in the first or even the second place not because they are not important but maybe these factors are well understood and well managed in Australian organizations, so they are not an issue for them. On the other hand, Australians rated senior management

commitment and availability of training as critical success factors for SPI implementations. These factors are rated by Saudis in the fourth and second places respectively! One possible interpretation of this is that training for Saudis can be easily secured. Despite the slight difference on rating ‘training availability’, we can say that both Saudis and Australians agree on of the importance of it. The same argument can be applied to other factors.

To identify the statistical dependence between the ranks of the two variables (i.e., Australian ranking and Saudi ranking), the Spearman’s rank-order correlation was used. As shown in Table 8, the Spearman’s correlation coefficient,  $r_s$ , is 0.036 and this shows a weak positive correlation between the results obtained from the two samples. The obtained results are statistically insignificant ( $p = 0.8768$ ).

**Table 5:** Success Factors identified by Australian and Saudi practitioners (Australians, UKs, Vietnamese and Saudis)

Success Factors	Australian (n=34)		Saudi (n=26)	
	%	Rank	%	Rank
Senior management commitment	68%	1	65%	4
Training availability	68%	1	73%	2
Availability of awareness events of SPI and facilitation activities	59%	2	73%	2
Allocation of needed resources	47%	3	69%	3
Availability of experienced staff	38%	4	73%	2
Defined SPI implementation methodology	35%	5	81%	1
Staff involvement in the SPI process	32%	6	62%	5
Encouraging communication and collaboration/sharing best practices	15%	7	73%	2
Managing the SPI project	15%	7	62%	5
Applying standards and procedures in SPI to ensure quality assurance	15%	7	81%	1
Availability of Formal documentation of the SPI process	9%	8	69%	3
Organization develop a review process for SPI implementation requirements	9%	8	81%	1
Using automated tools to conduct the SPI	6%	7	69%	3
Company culture supports conducting SPI	6%	7	73%	2
Customer satisfaction will be enhanced if we conduct SPI	6%	7	81%	1
External implementation agents are useful for successful SPI	6%	7	58%	6
Logical sequence or order of SPI implementation	6%	7	73%	2
Availability of Measurement for SPI	6%	7	69%	3
Ability to tailor improvement initiatives	6%	7	69%	3
Formalized relationship between development teams	3%	6	73%	2
Higher staff moral	3%	6	69%	3

**Table 6:** Success Factors Correlations rank across practitioners (Australians and Saudis)

		Ref.1	Ours
Spearman's rho	Ref. 1	Correlation coefficient	1
		Sig. (two tailed)	0.8768
		N	21
	Ours	Correlation coefficient	0.036
		Sig. (two tailed)	0.8768
		N	21

## 6. Limitations

The success factors used in this research have been studied and identified in the SPI literature. Hence, the success factors used in this research are collected from few but highly ranked recently published articles which, in their turn, have conducted formal literature review and surveys to identify these factors. We believe that the selected papers cover the most relevant published literature in the SPI domain.

Regarding the conducted empirical study using the questionnaire survey, one of the possible threats related to construct validity is concerned with practitioners' interpretation of various factors. We solve this issue by providing contact details for the author and his SEPG team to answer any question of any participants in the study. Although the survey is published online, many of the participants have been met face-to-face and survey questions have been explained to them before they start filling it. We do not have any evidence that proves this limitation as none of the participants reported it as a problem. Regarding the internal validity, the measurement scale used is based on a clear Likert scale and the questions are based on success factors that are clearly documented in the literature. SEPG Members have answered the survey, as a pilot study, to verify its clearness and preciseness before submitting it to practitioners. Moreover, the generalization of the results to other situations and people undergoes further research; hence we cannot generalize it for the time being and this makes external validity in process.

## 7. Conclusion and future work

In this research work, we have identified the common success factors documented in the literature for adopting SPI initiatives. These success factors have been formally studied, reviewed and documented in the literature.

We analysed the experiences, opinions and views of Saudi practitioners related to these factors to identify which factors that have a positive impact on the implementation of SPI programs in Saudi domestic IT organizations. We believe that focusing on these factors offers SPI practitioners the opportunity for implementing practices that have an impact on the SPI implementation process. Our results also show that various groups of practitioners are aware of what is imperative to implement SPI programs. We have also compared the findings of our empirical study in Saudi Arabia with

similar studies in the litterateur and found that there are both similarities and differences between practitioners in rating success factors.

This work is to be complemented with another ongoing research that would document the experience of Saudi organizations that have conducted SPI initiatives (mainly based on CMMI) and have a closer look on the factors that help domestic IT organizations undergo a successful SPI initiative.

## **8. Acknowledgment**

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