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The Impact of Using CMMI Practices on the Success of Small and Medium Jordanian Software Firms

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Key words: Software process, CMMI practices, quality model, process model, large-scale, knowledge

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Abstract: Capability Maturity Model Integration (CMMI) is a quality model used in the development of many products. Software products differ from other types of products because they are intangible; evolve quickly and with no physical forms. To assure the quality of developed software a good quality model should be applied. One of the good models is CMMI. CMMI generally used in large-scale firms but it may be customized to use in small and medium firms. In this research, we are going to find the impact of using CMMI practices on the success of small and medium software firms. The results showed that there is a real problem in these firms regarding software process improvement (CMMI). Most firm's staff have no knowledge about CMMI. They did not know how it would help in producing high quality software. The research results will help small and medium firms to compete in software development industry, help them also in adopting high quality models in their development process.

INTRODUCTION

Software industry evolves very quickly and the number of small and medium software firms increase over time. This rapid increasing presents new challenges in software process improvement for these firms (Saranya and Kannan, 2013). One of the main problems in small and medium software firms is that they cannot use high quality models like CMMI in their development process due to many reasons (Saranya and Kannan, 2013); cost of model implementation, staff experiences, time needed to implement these models, limited resources and strict deadlines. Small and medium enterprises play important roles in the growth of countries economy due to their significant impact on fross National Product (GNP) in the developing countries small and medium firms have a significant impact on Gross Domestic Product (GDP) and employment (Putra and Hasibuan, 2015).

Now a days software quality is the key factor to competitive advantage; the use of standards models remains limited for many of SMES. There is a need to assist and encourage SMEs adopting standard morels like CMMI to improve their software process development methodologies (Basri and O'Connor, 2010). Adopting a standard model for the first time is a costly process for small and medium firms; large firms have means to benefit from CMMI model. Small and medium firms can benefit from CMMI by implementing software process initiatives (Santos *et al*., 2017). Software quality depends on the process that used to develop it (Mishra and Mishra, 2009). The main problem in this research is that SMEs not following a high quality standard model in their development process, so, the developed software may have many problems like software bugs, low performance, low quality and most of the projects run over time and budget. To solve poor quality software, small and medium firms

should adopt a quality model such CMMI to guide their software development process (Chevers *et al*., 2017).

Much software process models have been developed to address problems in software development industry but the majority of them were for large-scale firms, we have to customize these models to be suitable for small and medium firms (Engdashet *et al*., 2016). CMMI is an enhancement framework used by software firms to design a high-quality software; it is a process improvement measurement used by software firms to measure the maturity of used process model (Kehinde, 2017). Software development quality is dependent on the process model that used in creation of software product. Software process improvement used by many software firms to increase the quality of the software product and to reduce the time of development (Trudel *et al*., 2006).

Different types of firms produce software products but most of these firms are SMEs ranging from 1-50 employee's (Al-Tarawneh *et al*., 2013). In 1993, the Software Engineering Institute (SEI) released the Capability Maturity Model (CMM)1 V1.1 with five staged maturity levels as a means to both appraise maturity level and guide process improvement effort for software organizations (Moe *et al*., 2002). SMEs play an important role in software development sector in the world and play a fundamental role in developing countries economic (Paulk *et al*., 1993). SMEs can benefit from CMMI many advantages such project management, project control and process quality improvement (Wu *et al*., 2006). Software industry in Jordan has many problems like poor project management, limited resources, limited skilled people, unawareness of process improvement models and expert people (El-Sheikh and Tarawneh, 2007). The majority of related studies showed that small and medium software firms have many problems in the field of software process improvement (El-Sheikh and Tarawneh, 2007).

Large-scale firms need to conduct a software process improvement to deliver high-quality software (Chevers, 2014). In this research, we will use the Capability Maturity Model Integration (CMMI) as the baseline forour survey because it is the major model for software process improvement and success of many software firms (Chevers, 2014). Most firms do not use quality models like CMMI. Most of the researches said that CMMI is for large firms (Scott, 2010).

In order to build high-quality software a systematic methodology needed. The methodology should consist of defined steps, called software process (Pressman, 2005). In small and medium firms, a person plays many roles such as programmer, designer and quality assurance and it is wrong in software development to play more than one role (Thapliyal and Dwivedi, 2010). CMMI is a standard used to measure the software development process it consists of five capability levels (Raffo and Wakeland, 2008). Software firms apply a software process model to ensure the quality of their products; also, they apply a quality model that serves the different stages of the process model. For example, the planning process is a stage in any process model, so, we need a quality model to ensure that our planning is not risky and in the right way (Dangle *et al*., 2005). CMMI consist of five staged levels each level has a keys process area Fig. 1.

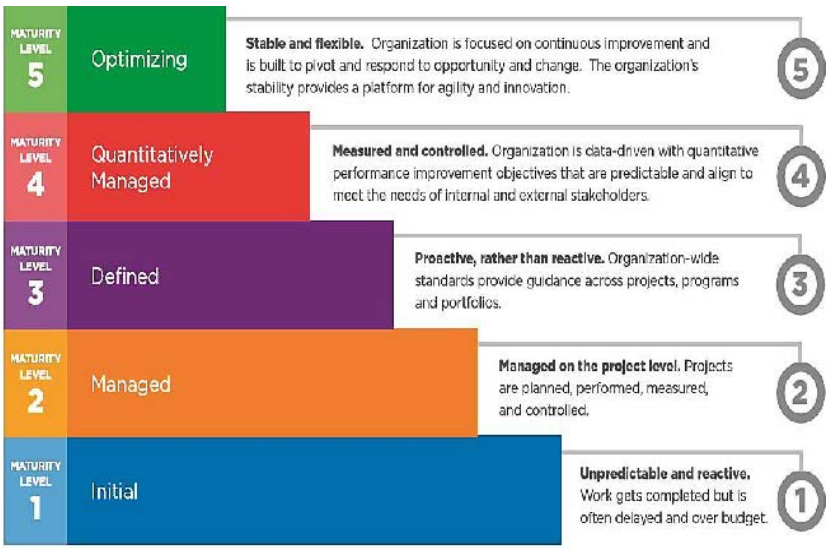

Fig. 1: Capability maturity model integration (Santos *et al*., 2017)

Small and medium software firms need lightweight development processes to reduce cost and time of projects, to achieve this; they need to use both of CMMI and of agile methods (Silva *et al*., 2015). Agile methods conform with CMMI initial levels (1, 2) (Silva *et al*., 2015).

The majority of software firms pay attention to the importance of agile methods in software development; they recognized that agile methods could not cover all development needs. Software firms need a quality model conforms with agile development needs to produce a high-quality software (Palomino *et al*., 2017). Small and medium software firms need to use a quality-model and apply software development best practices. Implementing a quality models need many resources. They need to adopt a lightweight methodology conforms to a quality with available resource, agile and CMMI practices are a good choice (Altarawneh and Shiekh, 2008).

Literature review: Several empirical researches about implementing process improvement models in small and medium software firms have been done. Rad *et al*. (2017) proposed a model to enhance software process improvements in SMEs; their study showed how to integrate two or more quality models to help firms in their process improvement. The model built based on CMMI practices and agile practices. Engdashet *et al*. (2016) developed an integrated framework of agile and CMMI for small firms.

Their study showed that producing a high quality software was a challenging activity. They also showed that several software process models have been developed and the CMMI is the most widely used model. In their research, they integrated agile methods with specific practices of CMMI to get hybrid model works as alternative for formal software process models. Pusatli (2011) presented evaluation for the proper implementation of measurements programs in small and medium software firms in turkey. They found that firms use some of CMMI practices only for international projects.

Al-rousan and Al-Shargabi (2017) proposed a new maturity model for software process improvement, the new model guide the web-based software development firms to improve their software process model. The proposed model built based on the experiences of others organizations that implemented CMMI practices and the critical success factors from the literature. Basri and O'Connor (2010) presented the issues that affect the adoption of quality models by small firms. They found that quality models should be divided into 3 types: acceptance level, awareness level and new standard criteria. They also found that small firms suffered from lack of resources and awareness knowledge to implement quality models.

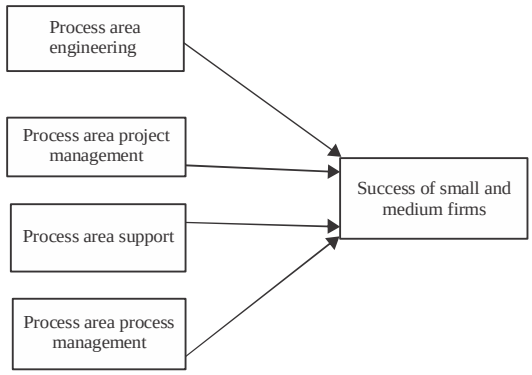

Fig. 2: Research model

Lester *et al*. (2010) showed how ten small and medium firms benefits from using CMMI practices. The examined firms did not use CMMI at all, when they have used it, their work expanded and the number of employee increased. Their study indicated that CMMI practices impact positively on these firms. Hidayah and Nugroho (2012) stated in their study that small firms are growing rapidly but they still use Ad hoc development methods.

They proposed a set of recommendations to help small Indonesian firms. These recommendations will help in choosing a development method and a quality model, according to firm's conditions. Almomani *et al*., conducted a systematic literature review for software process improvement in SMEs. Their study showed that most of software process improvement applied in Europe and America.

Their study also showed that the majority of proposed models cover the initial stages of CMMI. Silva and Carneiro (2016) showed that CMMI practices impact on the success of small and medium firms positively. Their study considered the environmental and industrial factors in the countries of firms.

Research model: In this study, we are going to build our research model based on literature and related work Fig. 2 to understand the research model variables we have to define our research importance and issues to be addressed in this research. The importance of this study appears from the following points: the importance of Small and Medium-sized Enterprises (SMEs) in software industry, problems that facing SMEs in implementing software process improvement and the adequate CMMI levels for SMEs. The research model

identifies a set of four main variables represents CMMI processes area and their sub-processes (practices), CMMI practices divided to four categories.

CMMI process area engineering:
- Requirements development
- Technical solution
- Product integration
- Verification
- Validation

CMMI process area project management:
- Project planning
- Project monitoring and control
- Supplier agreement management
- Integrated project management
- Risk management
- Quantitative project management

CMMI process area support:
- Configuration management
- Process and product quality assurance
- Measurement and analysis
- Causal analysis and resolution
- Decision analysis and resolution

CMMI process area process management:
- Organizational innovation and deployment
- Organizational process performance
- Organizational training
- Organizational process definition
- Organizational process focus

The research model examines the following issues:

- The impact of using CMMI process area engineering on the success of small and medium firms
- The impact of using CMMI process area project management on the success of small and medium firms
- The impact of using CMMI process area support on the success of small and medium firms
- The impact of using CMMI process area process management on the success of small and medium firms

Every category has its sub process area; we are going to find the impact of each sub process on the success of small and medium software firms. We also have to examine the main problems in SMEs regarding the concept of software process improvement to find how CMMI practices reduce the effect of these problems. Small and medium software firms in general are facing the following problems in applying software process improvement (Akbar, 2013):

- Poor planning
- Cost over runs
- Customer dissatisfaction
- Defected products as output and a lot of rework
- Lack of skilled resources
- Limited resources and revenue to run process improvement program
- Process unwariness
- Organizational culture

Small firms and medium firms in Jordan are facing the following problems (El-Sheikh and Tarawneh, 2007):

- Poor project management
- Limited resources
- Limited skilled people
- Unawareness of process improvement models and expert people
- Organization culture

The research model examines the impact of using CMMI practices on the success of firms, according to the current problems in these firms.

MATERIALS AND METHODS

To achieve the research goals (as stated in the Research model) we are going to do semi-structured, closed-questions questioner with 210 participants representing 30 different small software firms in Jordan and analysis the data qualitatively using a suitable analysis tool stand of grounded theory research procedures. The objectives of the questioner is to determine CMMI practices in small and medium firms and the problems related to software process improvement. The researcher distributed around 210 questionnaires on to the 30 firms over the survey. All firms running businesses from producing software products to software quality assurance. The questionnaire divided into a six main sections. The first section includes demographic and general data regarding the participant in the survey.

The second section includes the CMMI process area engineering; this study aims to know participant's knowledge in CMMI practices which focus on project's requirements management and the inconsistency between requirements. The third section includes the CMMI

process area project management this section aims to determine project-planning standards; like project planning monitoring and risk management. The forth section includes CMMI process area support this section aims to know integrity of work products using configuration identification, control, status accounting and audits. The fifth section includes CMMI process area process management, this section measures process maturity and organizational process elements. Sections two to five represents research model. The sixth section added to the survey, to determine main problems in implementing CMMI practices in small and medium software firms.

RESULTS AND DISCUSSION

The study conducted a survey of 30 small and medium software firms in Jordan; a 210 questionnaire distributed to different workers in these firms the valid questionnaires were 160 (76.19%). In the first section of research survey, we analysied demographic and general data regarding the participants in the survey. Figure 3 shows that males represent about 83% of survey participants. The female ratio was about 17% which indicates that females have no willingness to work in such firms. Figure 4 shows that about half of respondents have a little work experience. The ratio of respondents who have more than 10 year's experience not quit enough.

Firms need more experts in the field of software process improvement, to avoid quality and management problems. Figure 5 illustrates the education background for the respondents, their education background varies from PHD to diploma and a very little mall ratio to other education less than diploma, a good ratio for respondents who have a bachelor degree, then for diploma degree. Figure 6 shows many job titles in these firms such as large firms. The job title, quality assurance got the lowest ratio (0.075%) which means that there a shortage in experts in the field of quality assurance people. The core of software process improvement needed for these firms. Other job title varies between different titles and it common like large firms. In survey sections (2-5) we examined what are the main CMMI process area in SMES. We did not tell the respondents a bout CMMI our questionnaire questions asked about some software development practices that they use in their research. A little small ratio of the respondents wrote in the top of questionnaire "it is look like a CMMI Model". The first process are we have examined is process area engineering.

Figure 7 shows process area engineering and its sub processes. Requirement development does not apply in

Fig. 3: Participants gender

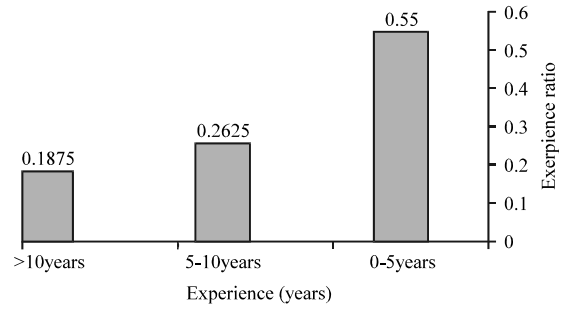

Fig. 4: Work experience

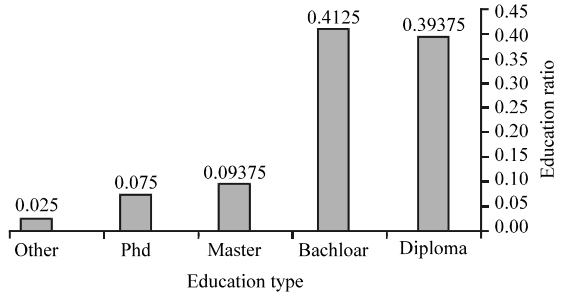

Fig. 5: Participant education

these firms with ratio of 37%; it is a high ratio according to the research sample. According to product integration, 50% does not know practice; that means most sub process unknown to the respondents. The second process area is project management and its sub processes area Fig. 8. Most of respondents, answered with "yes" for sub process roject planning which is a good indicator. The bad indicator, they answered with "no" for sub process, risk management. The ratio was 83% for "no" this large ratio indicates that the respondents do not know the most important sub-process in project management or they do not use it.

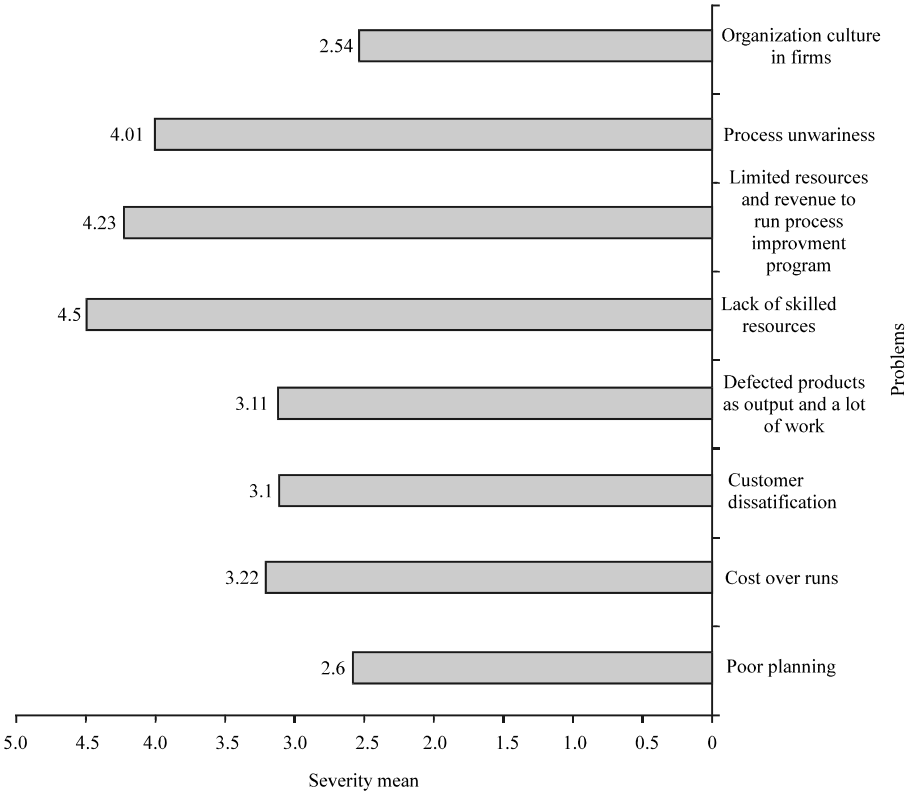

Fig. 6: Job title

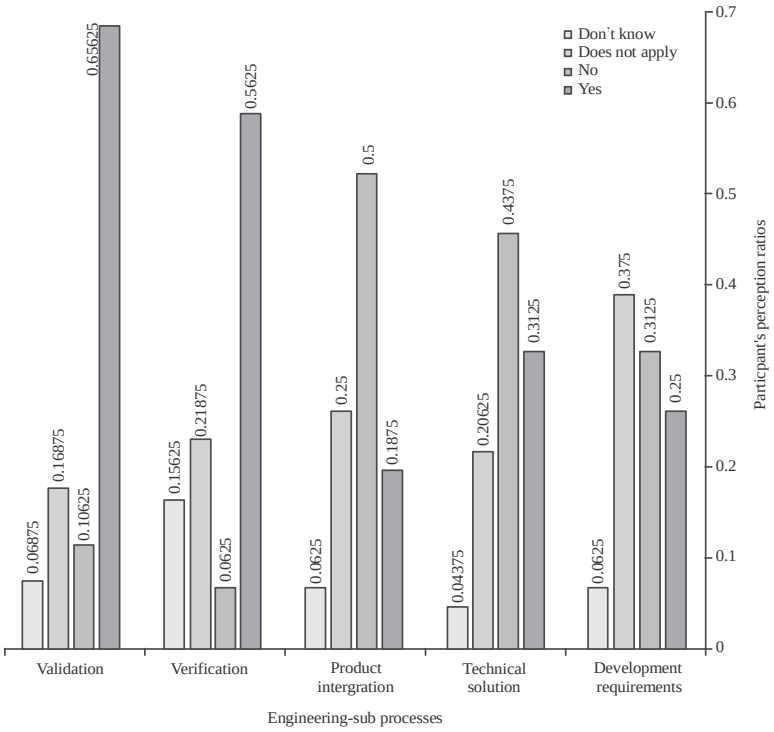

Fig. 7: Process area engineering

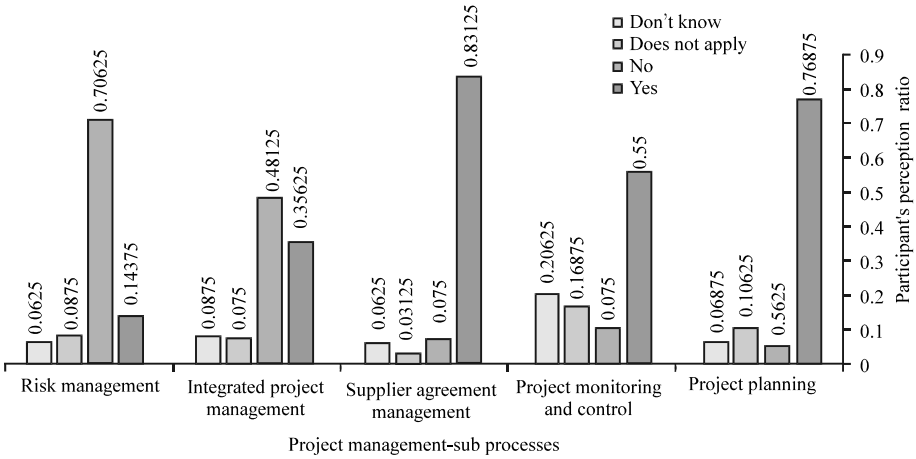

Fig. 8: Process area project management

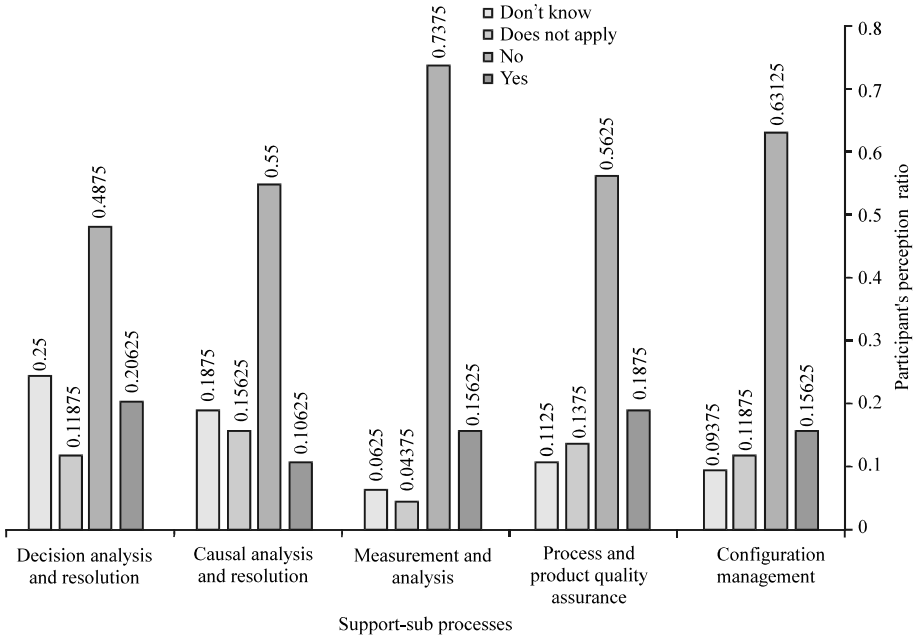

Fig. 9: Process area support

The third process is support and its sub processes area Fig. 9. The results for this process show that ub process project planning which is a good indicator. The bad indicator, they answered with "no" for sub process, risk management. The ratio was 83% for "no" this large ratio indicates that the respondents do not know the most important sub-process in project management or they do not use it.

The third process is support and its sub processes area Fig. 9. The results for this process show that most of respondents did not know these practices. Process area measurement and analysis ratio was 0.7375. The fourth process area is process management and its sub-processes Fig. 10. The results for this process is not good at all, the majority of respondents did not know this process area, some of them wrote beside this question "what do you mean" and answer with "no". Process management is the most important process are in CMMI Model. The answer "no" indicates that there are shortages in software process practices and experienced people.

In section six, we examined the main problems in SMEs regarding the concept of software process improvement. Table 1 shows the respondent's perceptions level of the problems in SMEs related to software process improvement. Participant's perceptions toward problems at SMEs came with total average 3.55125 and medium severity. Lack of skilled resources got the first order with average 4.52, limited resources and revenue to run process improvement program got

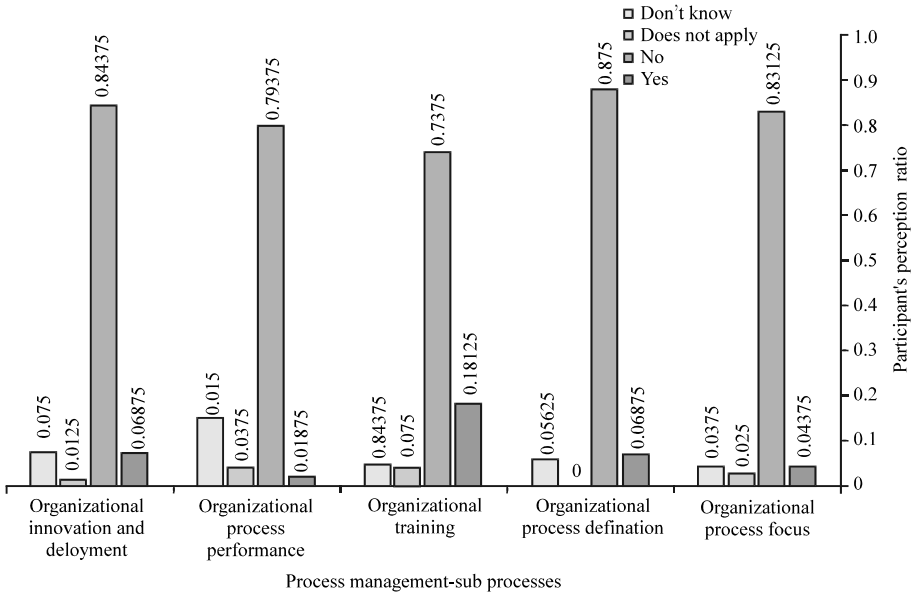

Fig. 10: Process area-process management

Table 1: Participant's perceptions toward problems at firm

Severity	Sig	t-value	SD	Mean	Problem
Low	0.79	2.6	0.81	**0.29	Poor planning
Medium	0.000	*6.16	0.96	3.22	Cost over runs
Low	0.000	*4.75	0.97	3.1	Customer dissatisfaction
Medium	0.000	*4.77	0.97	3.11	Defected products as output and a lot of rework
High	0.000	*13.03	0.85	4.52	Lack of skilled resources
High	0.000	*12.63	0.91	4.23	Limited resources and revenue to run process improvement program
High	0.000	*10.24	0.93	4.01	Process unwariness
Low	0.765	**0.27	0.76	2.54	Organizational culture in firms
Medium	000	8	0.91125	3.55125	Total problems

the second order with average 4.23, process unwariness got the third order with average 4.01. The previous three problems got a high severity. Cost over runs, defected products as output and a lot of rework got medium severity. Poor planning, customer dissatisfaction and organizational culture in firms got low severity.

Figure 11, we can determine the main problems in SMEs regarding to software process improvement. SMEs need skilled resources and process awareness to run process improvement program. Process awareness is necessary to implement such a model. From the previous results we find that SMEs in Jordan missing a lot of process area needed to implement CMMI Model where the majority of them use ad hoc methodologies to develop software product. Figure 11 shows that process is not mature in these firms; they did not reach to level 1 or level 2 of CMMI model. This implies that these firms are still need more work on the field of software process improvement.

Research findings: The literature showed that small and medium firms have the following problems:

Small and medium software problems

Problem:

- Poor project management
- Limited resources
- Limited skilled people
- Unawareness of process improvement models
- Undefined process model

The survey analysis for CMMI practices in small and medium software firms showed the following problems Table 2. The survey also shows problems with high severity in small and medium firms related to software process improvement (Table 3).

The survey showed the significant problem related to software improvement; the lack of skilled resources. The literature also confirmed this problem. The survey results

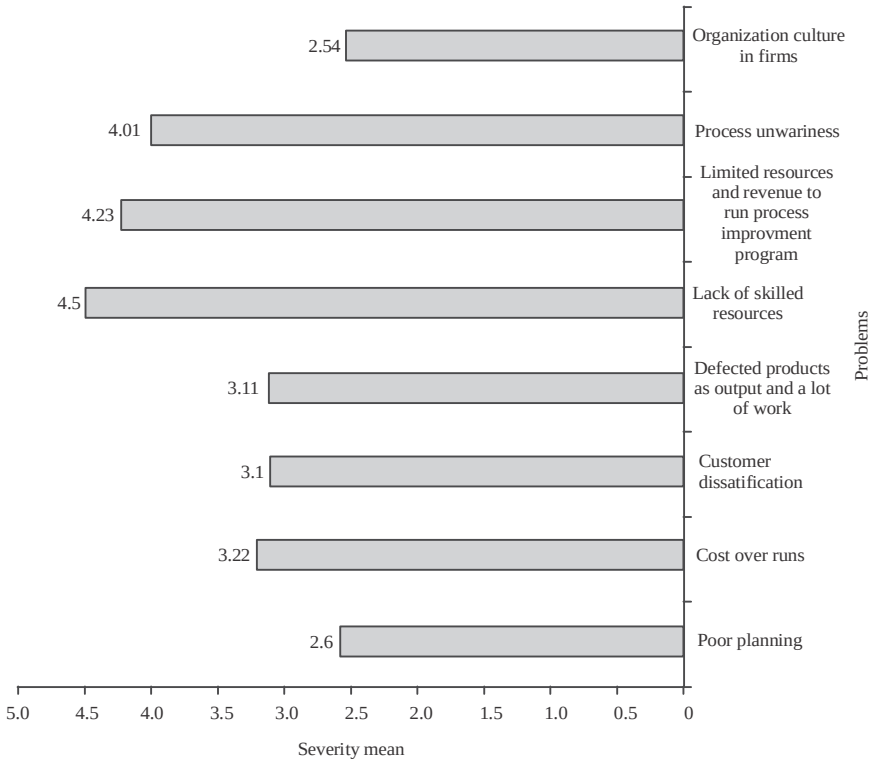

Fig. 11: Severity

intersect with many problems stated in the literature, like limited resources and process unwariness. The related work showed many problems related to implementation of CMMI in small and medium firms, many models built to solve these problems; according to the available resource (human and technical), organizational factors and industrial factors in these firms. The related work also showed that implementing CMMI is a success factor for small and medium firms. CMMI practices will solve many problems defined in this research. Table 4 summarizes the main problems and the description of problems in small and medium Jordanian firms.

In this research, we determined the main problems related to software process improvement in small and medium firms. We presented a set of recommendations to help small and medium firms to benefit from CMMI practices. In our recommendations, we focused on process unawareness because it is the key of software process improvement. CMMI level 1 and 2 could be implemented with available resource. CMMI will help small and medium firms to develop high quality software with little efforts and within time. In order to achieve the maturity in their process, they have to do following:

- Employ skilled people in the field of software process improvement
- Implement development methodologies that conform to CMMI Model (like agile methods)
- Spread CMMI culture among the staff
- Focus on project management skills

Table 2: Problems related to CMMI in small and medium firms

Process area	Problem with high ratio	Ratio(%)
Engineering	Requirement development does not apply	37
Project management	Risk management	83
Support	Measurement and analysis	73
Process management	Organizational innovation and deployment	84

Table 3: Problems related to software process improvement

Problems	Mean	Severity
Lack of skilled resources	4.52	High
Limited resources and revenue to run process improvement program	4.23	High
Process unwariness	4.01	High

Table 4: Small and medium firms problems in Jordan

Problems	Description	Reasons
Ad-hoc development	Software process unawareness, undefined software process	Lack of skilled resources methodologies
Quality issues	Undefined quality models, unawareness of process improvement models	Limited resources and revenue to run process improvement, shortage of CMMI knowledge
Poor project management	Risk management, project delay, project run over budget	Organizational innovation and deployment

- Assign critical tasks to qualified staff
- Training and seminars about standards models
- Exchange experts among them
- Define their process clearly
- Looking for long time revenue
- Ask for large firms support in the field of software process improvement (by sending quality assurance people for training)

Apply CMMI level 1 and 2 as follow:

- Training
- Evaluate current process (CMMI level 1)
- Define process
- Evaluate process: process not defined back to c
- Apply (CMMI level 2)sub processes
- Evaluate process; process not clear back to e
- Continues evaluation

CONCLUSION

The research aimed to find the impact of using CMMI practices on the success of small and medium Jordanian software firms. We conducted a survey on small and medium software firms in Jordan, the survey results showed that there are many problems in these firms regarding software process improvement. The results showed the types of problems related to software process improvement. The main problems are process management and support process area. We concluded that most of processes area and its sub-processes are not applied. Most of SMEs in Jordan do not apply CMMI Model, the staff have a little knowledge about it. The problems are due to many reasons like lack of skilled resources, limited resources, revenue to run process improvement program, process unwariness and cost over runs. We determined the main problems related to software process improvement in small and medium firms. The related work and survey results indicated that CMMI has a positive impact on the success of small and medium firms. We presented a set of recommendations to help small and medium firms in their software process improvement initiatives. The recommendations stated based on CMMI best practices and agile development methods. The CMMI Model in SMES in Jordan need more investigation and more related research should be done.

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