KOBİ'lerde Yazılım Süreç İyileştirme Faaliyetlerinin Analizi: Sistematik Literatür Taraması

Literatür Makalesi/Review Article

Suna DURMUŞ[1], Özden ÖZCAN TOP[2], Sevgi ÖZKAN YILDIRIM[2]

[1]HAVELSAN A.Ş., Ankara, Türkiye
[2]Bilişim Sistemleri, ODTÜ, Ankara, Türkiye
sdurmus@havelsan.com.tr, ozdenoz@metu.edu.tr, sevgiozk@metu.edu.tr

Özet—Yazılım firmaları güzümüz ekonomisinin çok önemli bir dişlisidir. Bu kuruşların çoğunluğu küçük ve orta ölçekli işletmelerden (KOBİ) oluşmaktadır. Bu firmalar, rekabetçi iş ortamlarında yüksek kaliteli ürün ve hizmet üretebilmek için Yazılım Süreç İyileştirme (YSİ) çalışmalarından faydalanmayı hedeflemektedir. Bu amaç doğrultusunda, KOBİ'lerin şirket yapısına uygun olarak YSİ modelleri geliştirilmektedir. Bu çalışmada, geliştirilen YSİ modellerinin özelliklerini, KOBİ'lerde YSİ faaliyetlerini gerçekleştirmenin zorluklarını ve YSİ faaliyetleri için kritik başarı faktörlerini analiz etmek için sistematik bir literatür taraması gerçekleştirilmiştir. Bu kapsamda, 2007'den 2020'ye kadar yayınlanan 61 makale incelenmiş, bunun sonucunda KOBİ'lerde kullanılan 28 YSİ modeli tespit edilmiştir. Ayrıca, KOBİ'lerde YSİ uygulamalarını zorlaştıran 10 farklı durum ve çalışmalarının başarısını etkileyen yedi faktör raporlanmıştır.

Anahtar Kelimeler— yazılım süreç iyileştirme, YSİ, KOBİ, CMMI, ISO/IEC 15504

Analysis of Software Process Improvement Activities in SMEs: A Systematic Literature Review

Abstract— This Software industry is a very significant cog in today's economic landscape. The majority of these organizations mainly comprise small and medium enterprises (SMEs). These enterprises aim to benefit from Software Process Improvement (SPI) activities in producing high-quality products and services in competitive business environments. For this purpose, SPI models have been developed for specific SME characteristics. In this study, we performed a systematic literature review to analyze the characteristics of these SPI models, the challenges of performing SPI activities in SMEs, and the critical success factors for SPI activities. In this context, 61 articles published from 2007 to 2020 were examined, as a result, 28 SPI models used in SMEs were found out. In addition, ten different situations that make SPI implementations challenging in SMEs and seven factors that affect the success of SPI studies in SMEs were reported.

Keywords— software process improvement, SPI, SMEs, CMMI, ISO/IEC 15504

1. INTRODUCTION

Software Process Improvement (SPI) is essential for organizations to increase productivity, efficiency, product quality and stakeholder satisfaction [1]. To improve and assess the maturity of software development processes, many standards, frameworks, models and methodologies have been developed over the past three decades. The standards, frameworks, models, and methodologies will be referred as "models" in this paper. Models developed by the Software Engineering Institute (SEI) and the International Organization for Standardization (ISO) are the primary sources of process improvement studies for software organizations [2]. Capability Maturity Model Integration (CMMI) of SEI [3] and ISO/IEC 33001 [4] guide Software Process Assessment (SPA) and quality

improvement. However, these two models are mainly used by large-scale software development organizations [5, 6, 7], and certification processes with these models are also particularly challenging for SMEs [8].

SMEs (refers to employing up to 249 people) are the major contributors to the world economy. They are the predominant form of enterprises, including approximately 95% of all firms across the world [9]. SPI practices in SMEs enable improvement in software processes and thus, improvement in product quality, efficiency, and customer satisfaction. Moreover, adaptation of new employees in organizations becomes easier when processes are defined with the help of SPI models. In addition, in some business areas (e.g. military domain), SPI certifications are an indicator of how systematically the processes are performed in organizations. Therefore, SPI certifications may be mandatory as a prerequisite for involving in bidding processes in domains like health and military. Last and foremost, if SMEs cannot continuously improve the way they perform their processes, they are likely to be overtaken by their competitors in the market. Therefore, continuous software process improvement activities have to be one of the priorities of SMEs to stand out in a competitive world.

Despite these significant benefits of SPI, little attention has been given to this core question: 'how to perform process improvement activities in SMEs efficiently?' In this study, we aim to identify the benefits of implementing SPI activities in SMEs, the challenges of performing SPI practices in SMEs, the characteristics of the SPI models used in SMEs, and the critical success factors of SPI studies in SMEs.

In the literature, we found 14 SLR studies focusing on SPI from different perspectives [1, 10-22]. Eight of them specifically focus on SMEs [10-13, 16, 18-20], remaining six studies do not mention any organization size [1, 14, 15, 17, 21, 22]. The studies, [16], [18], and [20] review and discuss the existing approaches on SPI for SMEs. CMMI and ISO/IEC 15504 were reported as the most used SPI models in SMEs [10, 11]. A comparison of software process improvement and assessment models were presented in [11], [12], and [20]. Six SLR studies focus on success factors, recommendations and difficulties in implementing SPI models in software organizations [12-15, 19, 21].

Our SLR presented in this paper differs from the ones given above in terms of its purpose. We aim to analyze the recent studies to highlight potential benefits of SPI practices, to reduce negative perceptions on the workload of performing SPI, and thus, to support SMEs' improvement initiatives.

The paper is structured as follows: Section 2 presents the Systematic Literature Review process. Findings and discussions are given in Section 3. Lastly, the conclusion is provided in Section 4.

2. SYSTEMATIC LITERATURE REVIEW PROCESS

SLR is an approach for investigating, classifying and interpreting the existing literature related to a specific research field and questions of interest [23]. The main reason to perform an SLR is its rigorous approach that could help to extract data from up-to-date literature and analyze the results from a scientific perspective [15]. In this study, we used Kitchenham's systematic review guideline for performing SLRs and followed the steps given below [24]:

1. Determine the research questions.
2. Determine the search criteria and data sources in accordance with the scope of the study.
3. Filter the initial search results based on the defined inclusion/exclusion criteria.
4. Extract data and perform a quality assessment of the studies.
5. Analyze the extracted data.

2.1. Research Questions

We defined the following research questions for this SLR:

- RQ1: What are the categories of the research purposes of the papers included in our paper pool?
- RQ2: What is the importance of SPI for SMEs?
- RQ3: What are the characteristics of the SPI models that are used in SMEs?
- RQ4: What are the challenges of performing SPI practices in SMEs?
- RQ5: What are the critical success factors for SPI studies in SMEs?

2.2. Search Criteria and Data Sources

We performed the search using the terms given below:

(("Process Improvement" OR "SPI") AND ("SME" OR "small and medium" OR "small settings" OR "small organization" OR "medium settings" OR "medium organization"))

We used EBSCO Host, IEEE Explore, Scopus, ScienceDirect, and Google scholar databases to specify the relevant studies.

2.3. Inclusion-Exclusion Criteria and Study Selection

In order to find the relevant papers concerning the research questions, we applied the following 5-step process:

STEP 1-List the Studies: First, we filtered the search results according to publication date (January 2007 to November 2020), source types (Journal Paper, Conference Paper, and Book Chapter), and language (English). Then, we downloaded the filtered papers in a local folder and

classified them according to source database name (i.e. EBSCO Host, IEEE Explore, Scopus, ScienceDirect, and Google scholar). At this stage, 686 studies were found.

STEP 2 – Read the Abstracts of the Initial Search Results: By reading papers' abstracts, we checked the studies' relevance to our scope. If the abstract was not sufficient for the evaluation; the introduction, methodology, and conclusion sections were examined. While examining each article, we carefully checked whether the article mainly focused on SMEs and included process improvement practices in the software field. At the end of this step, 583 studies were removed from the paper set.

STEP 3-Remove Duplicates: In this part, we checked the duplicated papers and removed 17 duplicate studies from the result set.

STEP 4 – Perform Quality Assessment: We reviewed each paper that reaches this stage according to Dyba & Dingsoyr's quality assessment method [25]. We prepared a checklist based on Dyba & Dingsoyr's quality assessment criteria. The list, shown in Table 1, contains four questions. There are two answer options: yes/no. For a paper to pass the quality assessment; at least three responses should be "Yes". At this stage, 25 articles were excluded from the SLR study set.

Table 1 Quality assessment checklist

No	Questions	Answers
1	Is the paper present a sound research approach?	Y/N
2	Are the purpose(s) of the study clearly stated?	Y/N
3	Are the research methodology and its organization clearly stated?	Y/N
4	Are the contributions of the study presented clearly?	Y/N

STEP 5 - Determine the Final Study Set: Sixty-one papers were included in the SLR. The paper elimination process results are shown in Table 2.

Table 2 Paper elimination process results

	STEP 1	STEP 2	STEP 3	STEP 4
EBSCO Host	140	15	11	11
IEEE Explore	82	39	35	23
Scopus	422	26	20	12
ScienceDirect	36	17	14	9
Google Scholar	6	6	6	6
Total	686	103	86	61

When we examined the publication venue of these study set (Figure 1), we found that 28 items were published in the indexed journals. Three of them were published in books and remaining 30 papers were published in conference proceedings.
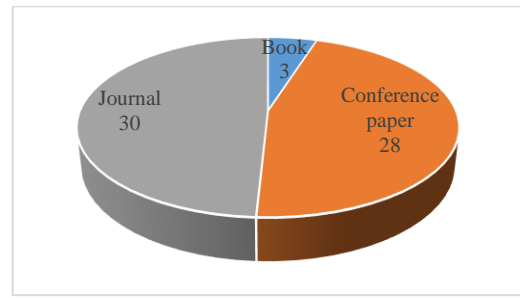

Figure 1 Publication venue of papers

3. FINDINGS AND DISCUSSIONS

Figure 2 represents the number of papers according to the publication years. The distribution shows that the highest publication trend is in 2010. After 2010, the studies have been almost distributed evenly over the years.
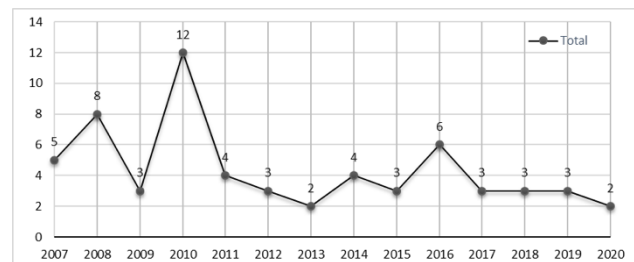

Figure 2 Distribution of studies over years

Figure 3 shows the countries where the studies were carried out. According to these results; India, Malaysia, Mexico, and Spain have more interest in practicing SPI in SMEs. The country list indicates that most of the studies have been conducted in developing countries. These countries have focused on developing their SPI and SPA models; thus, they have aimed to provide cost-effective solutions specific to their SMEs. In addition, based on the information provided in the papers, we see that the governments have provided support in developing in-house SPI models. For example, the Brazilian SPI model has been designed with the support of the Brazilian Government [6], and the COMPETISOFT project was supported by the Latin American countries [26].
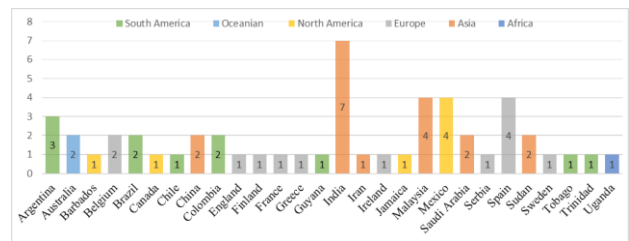

Figure 3 Distribution of studies over countries

Below, we provide the findings and discussions based on research questions.

RQ1: What are the categories of the research purposes of the papers included in our paper pool?

In this research question, we aim to analyze the study areas of each publication and provide an overview of existing research trends on SPI practices in SMEs. We categorized the research purposes in six main groups. Table 3 displays the primary purpose of each study.

Table 3 Categories of the research purposes of the papers included in our paper pool

Research Purpose Categories	Papers
Specifying importance of SPI models for SMEs	[29], [30]
Specifying challenges of applying SPI models in SMEs	[27], [28], [31], [32]
Specifying/Developing tailored SPI models for SMEs	[7], [8], [33], [34], [35], [36], [37], [38], [39], [40], [41], [42]
Developing new SPI models for SMEs	[6], [26], [43], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64], [65]
Developing SPA models for SMEs	[66], [67], [68], [69], [70], [71], [72], [73], [74]
Specifying the Success Factors for SPI Implementation in SMEs	[75], [76], [77], [78], [79], [80], [81], [82], [83]

Almost all papers in the SLR emphasize the importance of SPI activities for SMEs. Specifically, the primary research purpose of the two papers [29, 30] is to reveal the significance of SPI. In this perspective, Niazi and Babar stated that the efforts put in the SPI activities could assist SMEs in decreasing costs and market time and increasing productivity [29]. Moreover, Tosun *et al.* mentioned that SMEs generally rely on engineers rather than software processes. As a result, software quality is based on employee qualification and experience and it becomes an important threat for such organizations [30]. For this reason, having defined and improved processes is an essential asset for SMEs.

Despite the importance of SPI, four studies in Table 3 [27, 28, 31, 32] emphasized that implementing SPI models can be challenging for SMEs. Staples *et al.* [28] specified that CMMI and other SPI models require a long time to implement. These models are costly and complex for SMEs. Therefore, the cost-benefit analysis of SPI activities needs to be carefully analyzed [31].

In order to reduce the SPI implementation challenges for SMEs, certain studies have focused on tailoring the existing models. As given in Table 3, twelve papers [7, 8, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42] have tailored the existing models to reduce SPI workload at a reasonable level for SMEs. Guidelines, road maps and tools have been developed based on SMEs' characteristics [7, 8, 36, 37]. Besides the tailored models, new SPI practices have been developed to match the SMEs' process improvement needs. Twenty-five out of 61 studies in our paper pool also emphasized the need to develop specific SPI practices for SMEs. The details are described in RQ3 in Section 4.

In addition to SPI endeavors, the studies specific to SPA also exist in the examined literature. According to our analysis, nine papers [66-74] have performed research on the SPA field in SMEs. For example, self-assessment models have been developed to provide faster, cheaper and more efficient assessment approaches for SMEs [67, 71-74]. The last study area of examined papers is the success of SPI practices in SMEs. According to Table 3, nine papers reported the critical factors for the successful implementation of SPI practices in SMEs [75-83]. These factors are discussed in the scope of RQ5 in Section 4.

RQ2: What is the importance of SPI for SMEs?

In order to answer this question, we examined each article in detail and found out the keywords that emphasize the importance of SPI. Then, we categorized the keywords. As displayed in Table 4, six main items were extracted from the papers: Increasing Software Quality, Increasing Customer Satisfaction, Increasing Productivity, Survival, Competitiveness, and Certification for Software Development.

The key to the survival of software development companies is to produce and market high-quality software products [43, 77]. In order to develop and deliver high-quality software, SMEs have started to adopt SPI models [45]. The researches have shown that SMEs could increase customers' satisfaction by improving quality, operational effectiveness and efficiency [44]. Increasing productivity is another motivation for SMEs to implement SPI models [58]. The effort invested in SPI activities can assist organizations in reducing cost and time to market [29, 68]. Besides these, the SPI models provide a competitive advantage to the businesses [7], as it enables addressing the primary business objectives correctly and surviving in a competitive environment [46]. Another factor that describes SPI's importance for SMEs is the evidence of conformance to standards such as ISO/IEC 15504 or CMMI. These evidences become essential, especially when bidding on government businesses. In that case, receiving certification may become a prerequisite for job opportunities [35, 42, 83].

Table 4 SPI importance for SMEs

SPI Importance for SMEs	Studies
Increasing software quality	[8], [29], [30], [34], [43], [44], [45], [47], [50], [56], [62], [67], [68], [77], [73], [83]
Increasing customer satisfaction	[7], [35], [36], [41], [44], [52], [53], [55], [56], [58], [59], [65], [68], [76], [77]
Increasing productivity	[29], [30], [45], [49], [52], [58], [67], [68], [69], [75]
Survival	[7], [43], [46], [52]
Competitiveness	[7], [49], [57], [73]
Certification for software development	[35], [42], [83]

RQ3: What are the characteristics of the SPI models that are used in SMEs?

In order to address this question, the SPI approaches discussed in each paper in our paper pool were examined. The list of the SPI approaches is given in Table 5. The results were evaluated in three categories. The first category is "Established Models", which is composed of internationally proven models. One of the Established Models, CMMI, has been used extensively in SMEs for SPI activities. As can be seen in Table 5, 19 papers indicate the usage of CMMI in SMEs for process improvement purposes. In addition to CMMI, the ISO standards, PMBOK, and Six Sigma methodologies are used in small and medium settings.

As most of the Established Models are complex and require significant investments in terms of cost and budget for SMEs; lower-cost and simple solutions are needed. In this context, the second category contains the "Tailored Models" which are developed based on the Established Models. These models mainly aim to reduce the heavy workload caused by the Established Models for SMEs with lightweight practices. There are 12 models that fall into the "Tailored Models based on Established Models" category as shown in Table 5.

Table 5 SPI approaches used in SMEs

	SPI Approach	Studies
Established Models	CMMI	[7], [8], [28], [30], [31], [32], [33], [34], [36], [37], [38], [39], [40], [41], [42], [56], [72], [82], [83]
	ISO/IEC 12207	[35], [72], [77]
	ISO/IEC 15504	[32], [35], [72]
	Six Sigma	[7], [32], [75]
	ISO 9000	[32], [63], [76]
	ISO 9001	[78]
	ISO 9004	[27]
	ISO/IEC 25010	[56]
	ISO/IEC 29110	[59], [65], [74]
	ISO/IEC 90003	[72]
	PMBOK	[50], [57]
Tailored Models based on Established Models	COMPETISOFT	[26], [60], [61], [64], [67], [69]
	AHAA	[68]
	CIP-UQIM	[50]
	iSPA	[48]
	OWPL	[70]
	PDSA+Rp	[57]
	REPI	[47]
	RUP	[62]
	SAMAY	[46]
	SPIALS	[71]
	SPM-S	[43]
	SPRINT	[54]
New Models	COST-WORTH	[55]
	iFLAP	[66]
	LAPPI	[45]
	MECA	[44]
	Quicklocus	[73]

We examined each Tailored Model listed in Table 5, then analyzed the reference models of them and presented the results in Table 6. According to this table, the COMPETISOFT model's processes include the parts of CMMI, ISO/IEC 12207, ISO/IEC 15504, and ISO/IEC 29110 practices. Moreover, ISO/IEC 15504 and CMMI are merged in the AHAA model [68]. In addition, CMMI and ISO 9001 are used together in the CIP-UQIM study [50]. The last example, SAMAY is developed based on ISO models (ISO/IEC 15504, ISO/IEC 29110, and ISO 10018) [46]. Among all these models, CMMI is the most referenced model. In other words, researchers intended to customize CMMI practices based on the characteristics of SMEs. In addition, certain researchers have adapted two or more Established Models to obtain a solution that suits the needs of SMEs. According to, Solyman *et al.*, merging more than one Established Model could better represent the different characteristics of SMEs [56].

Table 6 Relations between tailored models and the referenced models

	CMMI	ISO/IEC 12207	ISO/IEC 15504	ISO/IEC 29110	ISO 9001	ISO 90003	ISO 10018	Six Sigma	PMBOK
AHAA	√		√						
COMPETISOFT	√	√	√	√					
CIP-UQIM	√				√				√
iSPA	√	√	√			√			
OWPL			√						
PDSA+Rp	√	√	√		√			√	√
REPI	√								
RUP	√								
SAMAY			√	√			√		
SPIALS	√								
SPM-S	√								
SPRINT		√							

In this SLR, we also aimed to analyze the Tailored Models regarding their novelties and contributions to the literature. We observed that the tailored models offer new tools, guidelines, and roadmaps specific to SMEs for SPI activities [48, 54, 60, 68]. For example, the self-assessment tool [68], developed for CMMI and ISO/IEC 15504 assessments, enables small organizations to assess their process maturity in a fast and cost-effective manner by themselves. In addition, there are studies [47, 48, 57, 70] that prepare training guidelines and aim to simplify the complexity of SPI and improve feasibility of using Established Models in SMEs. Moreover, certain studies worked on reducing the scope of the established SPI models by limiting the practices and focusing on specific process areas [43, 46, 47]. For example, in the Simplified Software Process Improvement Model (SPM-S) [43], CMMI process areas are rated by SMEs according to their needs and the top 10 processes are included in SPI studies.

The last category of SPI approaches contains newly developed models which are not directly based on the Established SPI models. According to Table 5, there are five studies in this category: MECA [44], LAPPI [45], COST-WORTH [55], iFLAP [66], and Quicklocus [73].

MECA, which stands for "Monitor, Evaluate, Control, and Act", offers continuous monitoring for software processes and aims to improve process maturity [44].

LAPPI is used for lightweight and cost-effective process modeling and improvement in SMEs [45]. LAPPI technique mainly includes workshops with company's resources to identify the problematic process area of the organization, recognize undefined processes and then quickly model the processes and make them visible in a whole organization [45].

COST-WORTH (COaching Support Tool to better identify WORKing process improvements THrough introduction of intelligent manufacturing system solutions) aims to assist SMEs in selecting and applying Information and Communication Technology solutions by an application-oriented methodology [55].

iFLAP, stands for Improvement Framework Utilizing Light Weight Assessment and Improvement Planning, provides process assessment and improvement planning guidelines for SMEs [66]. It is possible to use iFLAP to evaluate a single process area, it is also adaptable for all process areas.

Quicklocus is a low-cost methodology used for software process evaluation in SMEs. In this methodology, evaluation scope is reduced up to three process areas and four software development processes. Quicklocus methodology proposes that immature process areas can be better understood through evaluation, to be included in the scope of the software process evaluation. Moreover, it is stated that if an area is deemed efficient, it could also be included in the evaluation scope to understand its strengths better and to use as a reference for other process areas [73]. The evaluation team consists of three people; questionnaire and interview techniques are used to gather data. The evaluation duration is limited to one day due to resource constraints.

These five models given above were specifically developed for SMEs. COST-WORTH, LAPPI, and MECA models focus on SPI. On the other hand, iFLAP and Quicklocus models are used for SPA. These five newly developed models aim to understand the SMEs' current processes and provide easy, lightweight and low-cost solution for SPI and SPA. Aligned with these models, tools and guidelines were developed as well. Moreover, all these models consist of multi-phased (iterative) SPI and SPA programs. For example, the QuickLocus method has three phases: Readiness, Evaluation and Post-evaluation. The LAPPI model is applied in 13 steps. The iFLAP model also has three main steps that begin with project selection and role and responsibilities definition, then continue with the assessment step and finally end with improvement planning activities. The workshops and interviews are the critical parts of these phases.

When we examined the Tailored Models and New Models listed in Table 5, we found that majority of these studies were carried out in similar countries such as India, Malaysia, Mexico and Spain (Figure 3). These countries have given emphasis on SPI studies to support their SMEs and to provide software development standard where they can be more productive. We also analyzed that certain Tailored Models and New Models focus on specific process area. For example, REPI study provide framework for requirement management [47]. Moreover, PDSA+Rp study contains project management practices [57]. The processes most mentioned in the studies are requirements management, project management, quality management and configuration management processes.

RQ4: What are the challenges of performing SPI practices in SMEs?

There is a gap between SMEs and large companies in terms of access to financial instruments [84]. SMEs usually maintain businesses with limited resources and small teams. Employees who work at SMEs may be responsible for more than one role in technical, administrative and organizational activities. Due to these characteristics, implementing SPI activities is not straightforward for SMEs. For this reason, we analyzed all papers included in this SLR for specifying the challenges of implementing SPI practices in SMEs and categorized them in 10 groups.

As shown in Figure 4 the most frequently mentioned difficulty is the "*lack of resources*". In 34 papers, it was indicated that SMEs have cost, time, and employee related constraints for performing SPI activities successfully. For example, Min *et al.* stated that, many SMEs do not have personnel in specific areas of expertise due to the limited resources, such as quality management and quality assurance [39]. Lack of quality perception and training in staff may negatively affect the success of the SPI program [30, 56].

The second challenge listed in Table 7 is "*Lack of processes/Immature processes*". As reported in the reviewed studies, some processes are not implemented or poorly formalized in SMEs [31, 56]. For example, Habra *et al*. pointed out that SMEs usually do not have risk management processes [70]. This can be related to the short-term view of SMEs, these companies are generally project-oriented and their processes are rarely driven by a long-term strategy [70]. Defining these missing processes and ensuring their maturity require significant effort that makes SPI activities difficult in SMEs.

"Lack of Management support" is listed as another challenge of SPI activities. The studies indicated that managers might not give enough importance to the SPI activities in SMEs due to the other priorities in projects/organizations with time and budget constraints or lack of knowledge about SPI importance [29, 32]. In addition, lack of management support makes it challenging to get employees' commitment in SPI [78, 79].

"Training" is also a powerful way to enhance the qualification of staff and it helps creating awareness on SPI and encourages the development of new processes [29, 31].

On the other hand, the resources devoted to training are very limited in SMEs because of budget constraints [70]. Eight of the papers in our paper pool [29, 31, 38, 52, 56, 60, 70, 78] indicated that SMEs cannot provide sufficient training to employees that would support the successful implementation of SPI.

Another SPI challenge we listed in Table 7 is "*resistance to change*". As SPI activities may introduce significant changes in performing business, it is very likely to observe resistance to such a change in organizations [6, 34, 47, 60]. Creating awareness and motivating individuals through the benefits of SPI would impact reducing this resistance [60].

"*Having little or no experience with SPI activities*" is another challenge for SMEs. İbrahim and Ali stated that lack of SPI awareness in organizations might result in ineffective SPI implementation [38, 71, 72]. Another challenge given in Table 7 is the "insufficient qualified staff". It was stated in [29, 47, 51] that small-sized organizations experience difficulties in hiring well qualified staff or enhancing the current staff's skills to perform SPI due to resource limitations. In addition, SMEs have to face "*high staff turnover rate*" that would affect projects negatively by causing loss of key skills and experience in SMEs [39, 80, 82].

"*Lack of communication*" is another challenge for SPI success. Communication is usually informal and face-to-face in SMEs. It is very likely that problems in communication cause issues in information flow [55, 72, 80]. The last challenge mentioned in Table 7 is "*lack of motivation*". As motivation provides positive attitudes towards participation to SPI activities, its absence could be considered a barrier in successful SPI activities [46].

Table 7 Challenges of performing SPI in SMEs

SPI Challenge	Studies
Lack of resources	[7], [8], [28], [29], [30], [31], [32], [38], [39], [40], [41], [42], [43], [45], [51], [52], [53], [54], [55], [56], [58], [60], [61], [69], [70], [71], [72], [75], [77], [78], [79], [80], [82], [83]
Lack of processes/ Immature processes	[7], [8], [28], [29], [30], [31], [36], [38], [39], [43], [52], [53], [54], [56], [59], [62], [70], [75], [77]
Lack of management support	[29], [32], [39], [47], [56], [59], [70], [74], [77], [78], [79]
Lack of training	[29], [31], [38], [52], [56], [60], [70], [78]
Resistance to change	[6], [34], [47], [60]
Little or no experience about SPI	[38], [71], [72]
Insufficient qualified staff	[29], [47], [51]
High staff turnover rate	[39], [80], [82]
Lack of communication	[55], [72], [80]
Lack of motivation	[46], [75], [80]

In addition to the findings discussed above, we specified associations among the challenges given in Table 7. For instance, lack of motivation among individuals for performing SPI practices may affect a high staff turnover rate [80]. Moreover, insufficient resources have effects on

process maturity, training and staff qualifications. Therefore, overcoming one challenge would provide improvements on the other SPI challenges. From an opposite perspective, observing one SPI challenge in an organization may increase the potential of having other difficulties.
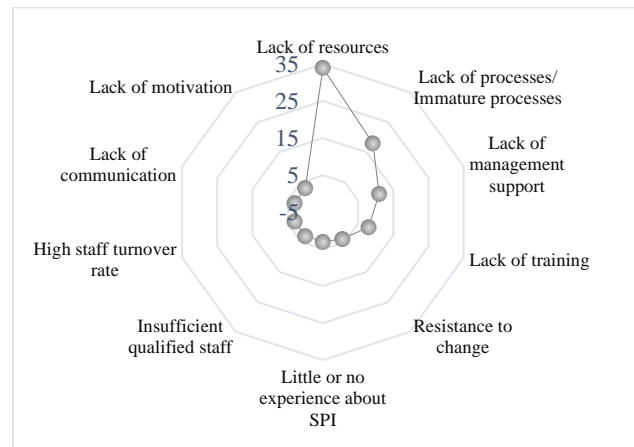

Figure 4 Frequency analysis of the identified SPI challenges

RQ5: What are the critical success factors for SPI studies in SMEs?

The critical success factors are key areas where managers need to focus on achieving SPI goals and ensuring successful implementation of SPI practices [14]. Keeping in mind the success factors specified in previous SLRs [12-15, 19, 21], each article was examined in detail and success factors were explored. The data extracted from our paper pool is given in Table 8. We found seven fundamental critical success factors for improving software processes in an efficient way. The details of each success factor are described below. The factors given here are strongly related to the SPI challenges discussed in RQ4.

Resources, Staff Involvement, Management Commitment and *Training* factors are aligned with the previous SLRs [13, 15]. Additionally, we found that *Skills, Alignment with Business Strategy and Goals* and *Communication* factors affect the success of SPI programs in SMEs. According to Figure 5, the most frequently reported success factor in the literature is resources. The frequencies of the remaining success factors are similar.

Resources: SPI and SPA activities are expensive and require human resource, time, budget and technological assets [69]. In order to get long-term benefits from SPI programs, proper allocation of resources in SMEs is necessary [81]. On the other hand, SMEs have limited resources and rarely have budget for SPI activities [32, 40, 82]. Therefore, management of the resources is very critical for the success of SPI program. It was stated that the *resource constraint* is one of the most important success factors in SPI programs [38, 70, 72, 76, 79]. Managers need to take appropriate actions to manage resources effectively and eliminate SPI programs' potential failure risks [27]. For example, the SPI program's

objectives have to be aligned with the available resources in an organization [60], and resources need to be allocated based on the SPI activities' priorities [69]. In addition, Min *et al*. stated that as the existing SPI models' workload is not proper for the SMEs and use of simplified and tailored SPI models for SMEs' characteristics would help deal with limited resources [39].

Table 8 Critical success factors

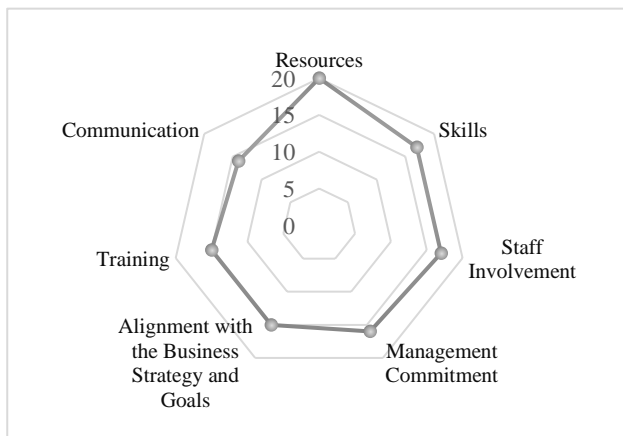| Critical Success Factor	Papers
Resources	[27], [28], [31], [32], [38], [39], [40], [55], [60], [62], [69], [70], [72], [76], [77], [78], [79], [80], [81], [82]
Skills	[7], [32], [39], [43], [46], [47], [50], [56], [62], [72], [75], [77], [78], [79], [80], [81], [82]
Staff Involvement	[34], [35], [43], [45], [46], [47], [50], [55], [66], [75], [76], [77], [78], [79], [80], [81], [82]
Management Commitment	[27], [29], [30], [34], [35], [46], [47], [49], [50], [66], [75], [78], [79], [80], [81], [82]
Alignment with the Business Strategy and Goals	[6], [26], [30], [31], [43], [46], [48], [49], [57], [76], [78], [79], [80], [81], [82]
Training	[26], [30], [46], [47], [50], [52], [53], [56], [75], [77], [78], [79], [80], [81], [82]
Communication	[26], [30], [32], [46], [52], [58], [72], [75], [77], [78], [79], [80], [81], [82]

Figure 5 Frequency analysis of the identified critical success factors

As stated by Huang & Zhang that enterprises invest a lot of resources to SPI programs, but the results of SPI programs may not be satisfying and may not be in line with business objectives [31]. In addition, it may take a long time to get the return of investment for SPI programs, although SMEs prefer to get benefits from SPI programs in shorter periods [28]. As a result, the possibility of not getting enough efficiency from the allocated resources of the SPI program discourages SMEs from using SPI models [32, 72, 80].

Skills: Experienced and qualified personnel are crucial for efficient SPI programs [32, 43, 72]. Additionally, it is mandatory that the organizational management have knowledge on SPI activities for successful execution of SPI programs, [46, 72]. Most of the employees in SMEs have limited skills to fully grasp the structure of SPI models to implement them in organizations [46]. Therefore, organizations need to provide comprehensive training [56, 75, 79]. From this perspective, tailoring SPI models for

SMEs becomes important as simplified models facilitate knowledge sharing and create awareness on improved software development processes [47, 62].

Staff Involvement: In SMEs, where the number of employees is significantly smaller than large scale organizations, the role of employees in SPI programs become more critical and act towards achieving these goals. *Staff involvement* meant that all staff share the same goal in an SPI Program [46]. It also includes sharing knowledge and experience to support SPI activities [66, 79]. Especially, the involvement of staff in SPI programs who know about how to run processes is vital for the success of SPI programs [45, 47].

The critical point here is that staff involvement should be decided and managed from the beginning of an SPI program [66, 81]. Driving an SPI Program from bottom to up at the organizational hierarchy and promoting involvement of all affected parties active in the SPI program significantly improve the success of SPI programs [81]. Therefore, organizations need to develop mechanisms to involve each employee in SPI activities in an efficient manner [55, 80].

Management Commitment: SPI is a challenging activity for organizations as discussed in Section 4, RQ4. It was stated that one of the key success factors of successful SPI programs in SMEs is the *commitment of all stakeholders* [80]. Existing literature has especially emphasized the importance of *management commitment and support* [78, 79, 81]. Managers are responsible for providing resources to meet SPI requirements and fulfillment of SPI activities [49]. According to Tadic *et al*., inadequate and poor management skills and support may cause the failure of SPI programs and even loss of business [27]. Sharma & Sangal provide evidence for a direct relationship between lack of management commitment and project failure [80]. In addition, management support is necessary to encourage new or redesigned processes' usage in an organization [46, 47, 75]. It was stated that getting support from top management facilitates institutionalization of software processes [49, 79]. Moreover, top management has a role in ensuring that SPI programs goals are associated with the business goals [79].

Alignment with the Business Strategy and Goals: Every organization has its specific business strategy and goals [31]. Before commencing an SPI Program, organizations need to clearly state their business goals [26, 30, 52, 57]. As significant time and resources are dedicated to SPI programs, the results obtained by an API program must be aligned with business goals [6, 26, 31]. Goal alignment is also a powerful management tool that emphasizes employees' roles and responsibilities and indicate value of employees to organizations. Therefore, managers need to work on engaging employees' work with mutual goals to ensure the commitment of employees to SPI programs and higher levels of job performance satisfaction [78].

Training: Training is essential for SPI programs' employees to develop new skills and information that would facilitate the implementation of SPI models [30]. Sharma & Sangal performed an empirical study where they

statistically found a significant relationship between lack of training and SPI success in SMEs [80]. Training is also important as it provides a good understanding of why organizations need SPI, what SPI programs' objectives are and their potential benefits and scope [30, 47, 79]. Therefore, training can be used as an effective tool to eliminate resistance to change of employees in SPI programs when training programs are tailored according to SMEs' characteristics and needs [53].

According to Gordon et al., training is essential to overcome the problems detected in the SPI study [46]. Sami & Khalili state that training of new processes is necessary for the success of SPI studies [50].

Communication: Communication is an important success factor, as it can encourage collaboration and provide awareness among employees on SPI Programs [46]. Communication plays a crucial role in altering individual's attitudes, as a well-informed employee will have a better attitude than a less-informed individual. It is also a powerful tool for share of experiences and knowledge among SPI practitioners [77]. On the other hand, according to İbrahim & Ali, lack of communication is the most important obstacle in SPI programs' success [72]. As it causes misunderstanding, lack of trust and communication breakdown in SPI programs, insufficient communication, and information sharing certainly weaken the execution of SPI programs [79, 80]. There is a very strong and open intrapersonal communication environment in SMEs [30]. The communication method is generally informal due to frequently shared activities and direct communication channels [32]. Therefore, managers need to ensure that these communication channels are effectively used [80]. For the success of an SPI program, communication should be structured and transparent and enable giving constructive feedback to improve collaboration [81].

4. CONCLUSION

In this study, we identified and discussed the benefits of implementing SPI activities in SMEs, the challenges of performing SPI practices in SMEs, the characteristics of SPI models, and the critical success factors of SPI studies in SMEs based on a systematic literature review. The SLR included 61 papers published between 2007 and 2020. According to the findings, we can say that there is a constantly growing interest in improving software processes in SMEs. CMMI and ISO/IEC 15504 are still the most frequently used SPI models in SMEs although the challenges they introduce. There are many reasons why CMMI and ISO models are preferred. CMMI Institute and ISO continuously improve their models according to today's needs. In addition, these models used by certain number of companies are considered proven. Finally, certificates of these models are valid in the global world.

The results also revealed that several tailored SPI models were developed based on the established models (i.e., CMMI and ISO/IEC 15504). However, data on the actual usage of these tailored models is quite limited. Among these tailored models, COMPETISOFT has been actively used in Latin American countries. The results of the SLR

also indicated that India, Malaysia, Mexico and Spain have more interest in SPI studies in SMEs than other countries. Requirement management, project management, quality management and configuration management processes are the most studied processes in the reported case studies.

In this SLR, we found that SMEs have to deal with several challenges while implementing SPI practices: *lack of resources, lack of processes/Immature processes, lack of management support, lack of training, resistance to change, little or no experience about SPI, insufficient qualified staff, high staff turnover rate, lack of communication and lack of motivation.* In addition, we synthesized that there are associations among these challenges; for example, insufficient resources may cause a decrease in process maturity and staff qualifications. Moreover, lack of motivation may have a negative effect on staff turnover rates. Therefore, overcoming one challenge would provide improvements on other SPI challenges. On the other hand, the presence of one challenge can trigger other challenges to occur.

Our SLR revealed that seven critical factors that affect the success of SPI programs in SMEs: *resources, skills of the employees, involvement levels of staff to SPI programs, and commitment of management, alignment of SPI goals with business goals, delivering training on SPI models and programs to employees,* and *effective use of communication channels.* The most important success factor is having enough resources to run an SPI program. However, the possibility of not getting enough efficiency from the allocated resources for SPI programs may discourage SMEs from using SPI models. Although it may take a long time to get the return of investment from an SPI program, it is very important for SMEs to be in a continuous improvement state.

To sum up, this study extends the previous SLRs substantially, by a rigorous and up-to-date literature review. This study guides the practitioners to assess the existing SPI and SPA models. We believe that this research assists the selection of the SPI studies and enhances the success of the SPI programs by highlighting the critical factors for implementing SPI programs in small and medium enterprises.

Future studies will concentrate on supporting the literature review results with quantitative data from the industry. Specifically, the following points highlight the future directions of this study, empirical studies can be performed with SPI practitioners to

- Analyze the industrial usage of SPI models in SMEs and compare the findings with the literature,
- To investigate the SPI standard and models adopted by the SMEs to address SPI challenges.
- To validate identified success factors and identify additional success factors.

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