Chapter 7
The Route to Software Process Improvement in Small and Medium-sized Enterprises

Mary-Luz Sánchez-Gordón, Ricardo Colomo-Palacios, Antonio de Amescua Seco, and Rory V. O'Connor

Abstract The software development industry is dominated by a myriad of small and medium-sized enterprises (SMEs). The main goal of this chapter is to provide a characterization of SMEs based on previous studies. It also includes an overview of a number of software process models and software process improvement (SPI) models, which are aimed at assisting SMEs in improving the way they develop software. Furthermore, this chapter discusses the extent of SPI approaches published in the literature as a way to understand the particular context and some of the major challenges faced. From there, we propose an approach to integrate software process practices. This proposal is based on the results of our study on this topic carried out in small software companies. It is focused on what small organizations could actually do, more than on what they are currently practicing.

7.1 Introduction

In the current global economy more and more based on knowledge, software is key. Hence, countries need the capacity to adopt, adapt and develop relevant software [131]. According to the *Organization for Economic Co-operation and Development* (OECD), small and medium-sized enterprises (SMEs) constitute the dominant form of business organization in all countries world-wide, accounting for over 95% and up to 99% of the business population depending on the country [91]. In most developing and transition economies, the sector is dominated by small and young enterprises. Local software expertise is in a stronger position to understand local needs and, as a consequence, to develop relevant and innovative applications and content [131]. Therefore, it is of particular importance to ensure that this sector can support the public and private sector local needs [131]. Moreover, this sector is able to generate skilled jobs and foreign exchange earnings through the export of products and services produced at a distance [131, 130].

However, the implementation of controls and structures to properly manage their software development activities is necessary. This constitutes a major challenge. In this sense, a common way to achieve process management software development is through the introduction of a software process [88]. Although such management is recognized as important to business success, some studies (e.g., [10, 24, 27]) suggest that SMEs do not adopt a proactive and highly prioritized approach to software process improvement (SPI).

The aim of this chapter is to provide a characterization of SMEs based on previous studies and to give an overview of existing SPI initiatives. From there, we propose an approach to integrate software process practices based on the results of our study about this topic, carried out in very small software companies.

7.2 Background and Context

The term SME refers to a category of company that is essentially not a large organization. There is no globally accepted uniform definition of SMEs. The term SME covers a wide range of definitions and measures, varying from country to country and among the sources reporting SME statistics. Some of the commonly used criteria are the number of employees, total net assets, sales and investment level. However, the most common definitional basis used is employment, and here again, there is variation in defining the upper and lower size limit of an SME. Despite this variance, a large number of sources define an SME to have a cut-off range of 0-250 employees [9]. For instance, the European definition of SME [30] states:

> *The category of micro, small and medium-sized enterprises (SMEs) is made up of enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding 50 million euro, and/or an annual balance sheet total not exceeding 43 million euro.*

There are two further classifications within the SME category: small and micro enterprises. A small enterprise is defined as employing:

> *fewer than 50 persons and whose annual turnover does not exceed 10 million euro [. . .]*

and a micro enterprise is defined as employing:

> *fewer than 10 persons and whose annual turnover does not exceed 2 million euro [. . .]*

7.2.1 Software SMEs

Although an international classification exists for computer software and services, little international official data is available outside Europe and North America. In Europe, Eurostat uses the General Industrial Classification of Economic Activities within the European Communities (NACE Rev.2) that identifies computer software and related computer services as a subcategory:

- Division 62: computer programming, consultancy and related activities
- Division 63: information service activities

In 2010, according to Eurostat [31], 99.8% of enterprises in this sector were medium-sized (<250 employees). Small enterprises (<50 employees) make up at least 98.8% and micro (<10 employees) are 94%. In this sector, micro enterprises employed more than 30.74% of people and made up 24% of turnover. Similar scenarios occur in many other countries, especially in Brazil and Canada [53].

Likewise, the definition of "small" and "very small" enterprises is challengingly ambiguous, as there is no commonly accepted definition of the terms. For instance, Laryd and Orci [57] have proposed a classification of *Very Small Entities* (VSEs). In this classification, 3 different sizes constitute VSEs: the extra extra small (XXS), which are companies that had less than 3 employees; the extra small (XS), which are companies that had between 3 to 16 employees; and small (S), which are companies that had between 16 to 50 employees. According to Sánchez-Gordón [115], VSE includes small software development departments and small projects within larger organizations, which employs less than 25 people. In this study, we used a paper published by the Centre for Software Process Technologies [69] to help define the size of small organizations. This last definition has been accepted by the *International Organization for Standardization* (ISO) due to the crucial role played by VSEs in the software industry [45].

Besides the number of employees, McFall et al. [69] realized that the priorities and concerns for organizations with fewer than 20 employees are different from those of larger organizations. Not all the software companies are the same and vary according to factors including size, market sector, time in business, management style, product range, and geographical location [88]. Richardson and von Wangenheim [109] stated that these companies often require different approaches because of specific business models and goals, resource availability (financial and human), process and management capability, organizational differences, among other things. Clarke and O'Connor [25] defined this as the situational context which includes 8 classification factors: personnel, requirements, application, technology, organization, operation, management and business.

Although the Software SME sector has been examined by researchers in terms of the number and proportion of individual organizations that qualify as SMEs, due to the rich variety of software development settings, the implementation of a set of practices for software development may be quite different from one setting to another [44]. One clear example is the startup phenomenon, there is no unique definition in literature on what constitutes a startup [93]. However, high uncertainty and rapid evolution are the two key characteristics for startups, which better differentiate them from more established companies [39].

7.2.2 Software Process in SMEs

The software process involves all the stages and activities that are followed by an organization to develop a software product [147]. Sommerville [123] states that a development process should be updated, improved and maintained in order to meet current business and customer requirements. Thus, a software process model is an abstracted description of a software development process [123, 102] and it is prescriptive [123] since it indicates how software should be developed.

According to Pressman [102], there are three major general categories of software process models, namely: *waterfall*, *incremental*, and *evolutionary*. Furthermore, there are also specialized process models such as component-based and test-driven. Nevertheless, Boehm and Turner [14] outlined that there are two major software process categories: *agile* and *plan-driven*, which have been considered traditionally as opponents: On one hand, agile methods are based on iterative and incremental development using short development cycles [14]. The most important priority of agile methods is to keep the customer satisfied with early and continuous delivery of software functionality. Although agile software development methods have caught the attention of software engineers and researchers worldwide, scientific research still remains quite scarce [2]. On the other hand, the traditional software development world, characterized by the engineering and process improvement advocates, includes plan-driven methods that focus on the quality of the software artifacts and the predictability of the processes [14].

In practice, software development is beset with many challenges and constraints [44]. Although there are multiple approaches for organizing the software development process and multiple factors influencing the software development process [25], SMEs can have a low software development process priority [10], since they are focused on the product quality and delivery time rather than in the process quality [12]. Software SMEs report that they adopt a mix-and-match philosophy to their software development process, mixing aspects of different prescribed software development approaches in order to fulfill their needs within their constraints [26]. In other words, these companies do not use a software process model in a "text-book" fashion [27, 140, 138], preferring instead either to drop elements of their chosen model or, develop something proprietary best suited to their specific needs. Likewise, software engineering work practices are chosen opportunistically, adapted and configured to provide value under the constrains imposed by their context [93, 138]. In fact, organizations are adopting multiple methodologies on projects and choosing to follow a hybrid approach to software development [138, 129].

There is evidence that the majority of small, especially very small software organizations, are not adopting existing standards as they perceive them as being orientated towards large organizations and studies have shown that small firms' negative perceptions of process model standards are primarily driven by negative views of cost, documentation and bureaucracy [53]. Small companies generally need external assistance in order to adopt and implement standards [55]. As a result, in 2010, the ISO published the ISO/IEC 29110 standard, which addresses specifically the software lifecycle needs of VSEs, and it is still under development. Its adoption has

been sometimes difficult, sometimes easier, but it is still incipient [77] and its impact on literature is also plain [78]. Therefore, it is an emerging standard and has work to be done yet.

The existence of a software process does not guarantee that software will be delivered on time, that it will meet the customer's needs, or that it will exhibit the technical characteristics that will lead to long-term quality characteristics [102]. Thus, the process itself can be assessed to ensure that it meets a set of basic process criteria that have been proved to be essential for a successful software engineering practice. For this reason, over the past years different approaches to software process assessment and improvement for the SME context have emerged.

7.2.3 Software Process Improvement in SMEs

While other industries have agreed in sets of best practices, to date, the software industry does not have universally accepted practices. The low adoption of best practices, as indicated from several previous surveys (e.g., [27, 69, 55, 21, 84]), suggests that process improvement should be a high priority for many software SMEs. These surveys have also established that many SMEs are interested in improving their software processes.

There exists a broad variety of *Software Process Improvement* (SPI) approaches. The most prominent due to their acceptance rates among large organizations are the ISO 9000 and ISO/IEC 15504 standards, and the Capability Maturity Model (CMM) and Capability Maturity Model Integration (CMMI) of the Software Engineering Institute (SEI). However, they are not being widely adopted and their influence in the software industry therefore remains more at a theoretical than at a practical level [27]. Schweigert et al. [121] have also not found a commonly accepted agile maturity model.

Despite significant investments in SPI that these large organizations have done, they still face problems in their implementation [81, 82]. Although SMEs adapt and use these models to initiate their improvement efforts, in many cases the efforts have not led to the expected improvements and failure rates are high. In spite of their importance, in general it has been observed that the successful implementation of these models is not possible in the context of SMEs [45], as they are not capable of dealing with the requirements and bear with the costs associated to the implementation of these SPI initiatives [47, 142, 124]. Moreover, there are significant differences in their awareness of quality issues and in the resources available [40]. Therefore, SPI initiatives in SMEs should be implemented using another approach to deal with their particular needs. On one hand, Kautz [47] and Mishra and Mishra [72] identified that CMM, ISO/IEC 90003:2004, TickIT, Bootstrap and IDEAL models were not considered to be necessary or appropriate in SMEs contexts. On the other hand, Garcia et al. [35] state that SMEs are increasing the use of CMMI in number year by year but they did not show evidence to support it.

Nevertheless, the Software Engineering community has shown an ever-increasing interest in tackling SPI in SMEs [96], but it is still a problem scarcely studied in the world. Notable international initiatives are *European Systems and Software* (ESSI) promoted by the European Union, which have promoted the SPIRE project (Software Process Improvement in Regions of Europe), the MoProSoft model in Mexico, the MPS.BR project in Brazil, the SIMEP-SW in Colombia, the COMPETISOFT model in Latin America and ITMark, among others. However, none of them have been widely accepted or implemented, this has motivated the academia and the software industry to work together to study the components needed to improve the quality of their products and services, as well as the process performance.

Accordingly, many researchers are focusing their attention on adapting and using SPI approaches and how to guide and prioritize the SPI efforts in SMEs [96]. This means that often researchers consider small organizations together with medium enterprises, not differentiating their specific characteristics [109]. Therefore, this can affect research approaches and results. Due to limited in scale and resources, small software companies find software process improvement a major challenge [65].

Regarding the most prominent models, novel assessment methods tailored to the context of SMEs have been developed, such as an adaptation of the IDEAL model [96], *Rapid Assessment for Process Improvement for Software Development* (RAPID), *Software Process Improvement Initiation* (SPINI), and *Método de Avaliação de Processode Software* (MARES). Regarding CMM, MESOPYME with objectives similar to those of the IDEAL model, and for CMMI, EPA which is an example of an ARC class-C compliant method and its expansion ADEPT. Finally, the approach presented in [128] and the *Agile Framework for Small Projects* (AFSP; [58]) are derived from Boehm and Turner's Agility/Discipline assessment.

In summary, taking into account studies and efforts in the area of SPI for small organizations [49, 26, 126, 55, 12, 120], it is evident that there is a need to find mechanisms that allow them to incorporate process improvement into their daily work, taking into account their business model, situational factors, limited resources, and cost and time constraints which are specific to their environment.

The systematic review carried out by Valtierra et al. [135] present a list of the most frequently improved processes: project planning, requirements management, configuration management process, and risk management. However, some organizations focus in processes such as requirements development, verification, project monitoring and control, and process and product quality assurance. Additionally, Pino et al. [96] in their systematic review included the documentation process as one of these processes.

7.3 Research Methodology

According to [114], in order to achieve an overview of the state of the question, a research must be carried out following the guideline on *Systematic Literature Re-*

Table 7.1 Key contributions of primary search.

Ref.	Title
[55]	The Application of International Software Engineering Standards in Very Small Entities
[72]	Software Process Improvement in SMEs: A Comparative View
[96]	Software process improvement in small and medium software enterprises: a systematic review
[125]	An extended systematic review of software process Improvement in small and medium web companies
[135]	Characterization of Software Processes Improvement Needs in SMEs

views (SLRs) by Kitchenham and Charters [48]. An SLR is defined as a methodical way to synthesize existing work in a manner that is fair and accurate. An SLR is a means of identifying, evaluating and interpreting all available research relevant to a definite topic.

7.3.1 Motivation and Objectives

The literature presents a lack of studies on the whole view about the best known SPI methods, models and frameworks in SMEs. At the present time, there is limited documented and published research work regarding SPI in SMEs [55, 96, 135]. Therefore, this study will facilitate the understanding of the current status of research in this topic and outline further research. Finally, it will assist practitioners in the realization of the different approaches.

7.3.2 Research Method

This study has been undertaken as a SLR based on the Kitchenham and Charters' guidelines [48]. This section describes the steps carried out in this SLR.

7.3.2.1 Planning

The goal of this study is to develop an overview of the current status of the more SPI-identified approaches of the scientific literature on SMEs. After reviewing the literature on SLR for similar research objectives, it can be identified that there is no previously published search on the topic. We used a primary set of publications and manually searched for the SPI approaches and its references. This initial review reflected 40 SPI approaches to be explored in this study. For this primary search, we refer to the authors and publications summarized in Table 7.1, which later on also serve as control values.

Then, an SLR protocol was adapted to describe the plan for the review. The protocol includes research background, research questions, search strategy, study selection criteria and procedures, data extraction, and data synthesis strategies to ensure that the study is undertaken as planned and reduce the possibility of researcher bias. Next, the implementation of each step followed is briefly described.

7.3.2.2 Research Questions

The research question is threefold:

1. What is the impact of the SPI approaches in the scientific literature?
2. What has the evolution of the SPI approaches been?
3. Which research trends are revealed from the systematic review of the SPI approaches?

The keywords used to find an answer to the research questions were the name of SPI approach (e.g., MoProSoft, IDEAL, CMMI), which were taken from the predefined list (Sect. 7.3.2.1): `software process improvement`, `software process`, `sme`, and `small company`. Sometimes, it was necessary to include the name of the standard on which it is based in order to limit the search. For instance, the resulting search strings were:

- MOPROSOFT, (IDEAL) **and** (CMMI) **and** (software process)
- (CMMI) **and** (software process) **and** (sme **or** small company)

The results expected at the end of the systematic review were, among others, to discover what surveys exist as well as to identify the implications of each SPI approach in scientific literature. Authors also expected to see which applied researches had been carried out on the topic, as well as which trends are revealed from the performance of the systematic review.

7.3.2.3 Search Strategy and Search Process

Having the search strings to conduct the review the selected sources were: IEEE Xplore, ACM Digital Library, ScienceDirect, Wiley Online Library and Springer Link. The search process included: first, the search string was selected; then a selected source was chosen and each search string was applied. Once the search results were obtained, a list of relevant studies was made based on titles, abstracts, conclusions, references, and keywords. Having the single result sets available, all results were combined and used as basis for the data analysis.

When there was doubt about its relevance, the reference was included leaving open the possibility of discarding the paper during the second phase when the full texts of the papers were studied. Sometimes, further studies were identified and included due to its relevance. After that, each full article was retrieved, read and analyzed to verify its inclusion or exclusion (Table 7.2) and the reason for that was

Table 7.2 Inclusion (I) and exclusion (E) criteria.

Kind	Criteria
I	Studies written in English or Spanish language
I	Studies explicitly related to each SPI approach
I	Studies in the SME context
E	Studies that are not written in the specified languages
E	Studies that are not relevant to the topic
E	Studies out of the SME context

properly documented. A test-retest approach and re-evaluation of a random sample of the primary studies was made. Finally, the primary studies were identified.

7.3.2.4 Data Extraction

The data extracted from each paper was documented in a spreadsheet and kept in a reference manager. In addition, mind maps of the features of each initiative were made in order to understand the relations between them. After identification of the papers, the following data was extracted:

1. Source (journal or conference),
2. Title,
3. Authors,
4. Publication Year,
5. Relevance (defined during further analysis),
6. SPI approach features, and
7. Comments of the research, including which questions were solved.

7.3.3 Data Synthesis and Results

The searches for this SLR were conducted from December 2014 to January 2015. A total number of 1,825 studies were found from all sources based on the search strings defined. 90 primary studies were selected based on the in-/exclusion criteria. Table 7.3 presents the results of the search and the source of the documents. The results of the review are discussed in the following subsections.

7.3.3.1 Impact of the SPI Approaches in the Scientific Literature

Regarding the first research question, the 90 papers studied included one novel standard, 13 of the most recognized models and methods, five well-known frameworks and two techniques which were Pisko and its extension, LAPPI (Table 7.4). It is

Table 7.3 Inclusion (I) and exclusion (E) criteria.

Source	Papers
Wiley Online Library	315
ScienceDirect	474
ACM Digital Library	209
IEEE Digital Library	152
SpringerLink	675
Number of potential papers	1825
Selected by abstract	297
Selected by full text (without duplicates)	90

Table 7.4 Papers by type.

Type	SPI approaches	Papers #	Papers %
Standard	ISO/IEC 29110*	18	20
Model/Method	OWPL, MARES, EPA, Adept** , Impact, Mesopyme, ASPE/MSC***, iFlap, Processus, SPM, RAPID, XPMM Model, Agile SPI	30	33
Framework	MoProSoft, COMPETISOFT, MPS.BR, ITMark, Tutelkan	36	40
Technique	Pisko – LAPPI	6	7

* Includes UP-VSE model, ** include Automotive/Adept, and *** include ASPEI/MSC

worth mentioning that ASPE/MSC and Adept also have been extended (ASPE/MSC, ASPEI/MSC and Adept, Automotive/Adept). They are distributed as follows: frameworks (40%), models/methods (33%), standards (20%) and techniques (7%). In the light of this, we can see that a lot of effort has been put into developing frameworks and models/methods. As Table 7.5 shows, the frameworks arosed since 2005. In this segment, it is worth noting that 50% of the publications in 2007 are about MPS.BR. In 2010, an important fact to take into account is the emergence of the ISO/IEC 29110 standard reflected in 38% of the papers published on that year.

Table 7.5 Papers by year.

Type	1997	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Framework							2	2	7	2	5	7	3	4	1	3
Model/Method	1	1	4	3		2	2	4	2	4	2	1	1	1	2	
Standard										1		5	1	2	3	6
Technique				1	1	1			1	1					1	

Figure 7.1 shows that 80% of the articles were published from 2006 and the remainder (20%) was published in the previous seven years. This seems to mean that there is an increasing interest in this field.

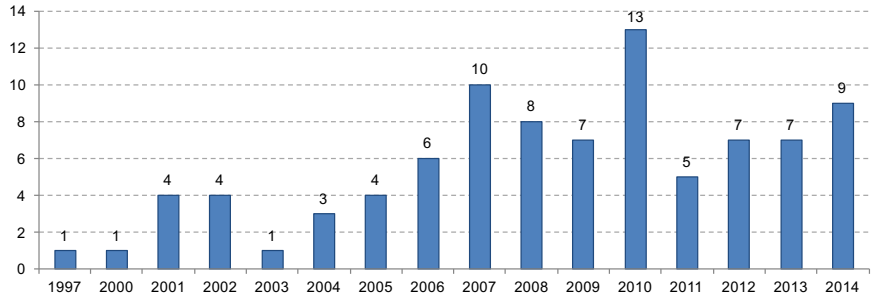

Fig. 7.1 Number of publications per year.

It is also important to remark that we have found scarce publications in some of the most cited models/methods: Impact (1), Mesopyme (1), Processus (2), SPM (2), XPMM (2) and RAPID (3). There is no hard evidence of their evolution after 2006. Adept (2) and ASPE/MSC (2) are in a similar situation after 2009. Likewise, EPA has 5 publications, but its last one was in 2009. Agile SPI has one paper published in 2010, which was taken from references found in the COMPETISOFT model. In consequence, there are 10 SPI approaches that demonstrate actual work in progress (Table 7.6). They make up for the 70% of total.

Table 7.6 Current SPI approaches.

SPI Approach	Type	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
ITMARK	Framework									1	1
iFlap	Method			1					1		2
Tutelkan	Framework					1	1				2
OWPL	Method			1				1	1		3
MARES	Method	2					1				3
Pisko-LAPPI	Technique		1	1					1		3
MoProSoft	Framework		1	1		1		2	1	1	7
COMPETISOFT	Framework		1	1	4	3	2	1			12
MPS.BR	Framework	2	5		1	2		1		1	12
ISO/IEC 29110	Standard			1		5	1	2	3	6	18
Total											**63**

7.3.3.2 Evolution of the SPI Approaches

The process of gradual, increasing change and development has resulted in a progression of SPI approaches including techniques, methods/models, frameworks, and integration of approaches. Thus, the ISO launched the ISO/IEC 29110 in 2010 in order to benefit the SPI in SMEs. Figure 7.2 and Fig. 7.3 show the 21 SPI approaches

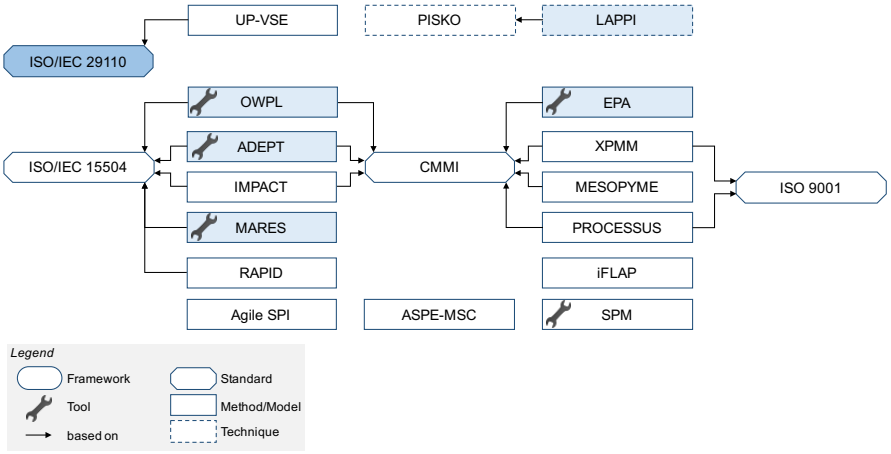

Fig. 7.2 Relations between models/methods, techniques and standards.

(Table 7.4) and their relations—bearing in mind UP-VSE model is taken as part of the ISO/IEC 29110 standard. These relations were identified during this review. The CMMI, ISO/IEC 15504, ISO/IEC 12207 and ISO 9001 standards have been the major foundation on which most of the models and methods have been developed.

Figure 7.2 shows that EPA, XPMM, MESOPYME, OWPL, PROCESSUS, IMPACT and ADEPT are based on CMMI. However, some of them are also based on others standards. Therefore, XPMM and PROCESSUS are based on ISO 9001, and IMPACT, ADEPT and OWPL on ISO/IEC 15504. Likewise, RAPID and MARES are based on ISO/IEC 15504. Furthermore, there are models based on other ones, like SPM which is based on QFD/SPI model focused on the House of Quality or ASPE/MSC that is tailored out of existing approaches, these standards are adapted and simplified either by incorporating a matrix (as in SPM model) or process guides (as in ASPE-MSC). The same applies to iFlap that is based on the inductive method. Finally, UP-VSE is a software process model based on the Unified Process, which implements the requirements engineering practices of ISO/IEC 29110-5-1-1. Therefore, UP-VSE has been taken as papers of the standard in order to illustrate how ISO/IEC 29110 arises in this context. Moreover, agile methodologies such as XP or Scrum also have inspired new approaches, such as the XPMM model or Agile SPI. The latter is less known but was studied for COMPETISOFT in order to develop its process-improvement model. Finally, LAPPI is an evolution of the PISKO technique. The LAPPI technique provides an easy to use, lightweight tool for process modeling and improvement target identification. Therefore, it is useful in the diagnosing phase of SPI.

Figure 7.3 depicts the frameworks and their relations with the standards CMMI, ISO/IEC 15504, ISO/IEC 12207, ISO 9001, and ISO/IEC 29110. CMMI, ISO/IEC 15504, ISO/IEC 12207 have a major influence on MoProSoft, MPS.BR and COMPETISOFT. In turn, the last one is based on the top two. CMMI also provides the basis for Tutelkan, which incorporates ISO 9001 and ITMARK that in turn encom-

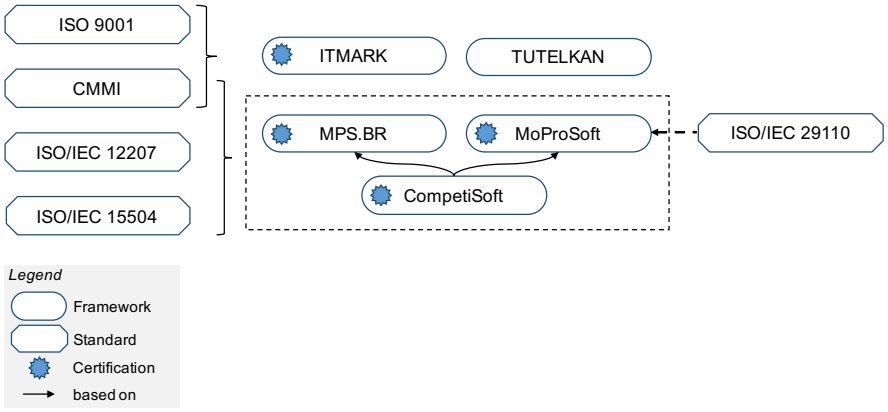

Fig. 7.3 Relations between frameworks and standards.

pass EFQM and ISO/IEC 27001. Each framework has its own reference and assessment model, and approaches to their implementation that includes automated tools. Consequently, almost all of them have mechanisms for their certification. However, Tutelkan is a framework that does not provide certification. It allows SMEs to become aware of their level of compliance with international standards, since each reusable asset contains information about the specific CMMI practices, ISO 9001 clauses and COMPETISOFT activities that it conforms to. On the other hand, MoProSoft has been selected by the authors of the ISO/IEC 29110 standard in order to quickly achieve initial products. This standard aims to address the difficulties of SMEs by developing profiles and by providing guidance for conformance with ISO/IEC software engineering standards. This framework attempts to ease the use of ISO/IEC 12207 processes and ISO 9001, and reduce the conformance obligations by providing VSE profiles. The ISO/IEC 29110 standard has a series of Deployment Packages (DPs) and Implementation Guides that have been developed to define guidelines and explain in more detail the processes defined in the ISO/IEC 29110 profiles. Although a DP is not a process reference model, packages are designed such that a VSE can implement its content without having to implement the complete framework. A DP also includes mapping to other standards or models, such as the CMMI.

Regarding the adoption of the 10 SPI approaches outlined in Table 7.6, by the end of 2013, after 10 years, the MPS-SW of MPS.BR surpassed the 500 assessments in companies located in Brazil's five regions, mostly including micro, small and medium-sized enterprises. The LAPPI technique has evolved through 42 industrial cases conducted during 1999-2011 in 31 different companies. The official website of Itmark[1] point out a list of 155 certified companies in 17 countries around the world. Accordingly to NYCE[2], more than 400 organizations have been assessed un-

[1] Available from: `http://it-mark.eu`

[2] Available from: `http://www.nyce.org.mx/moprosoft`

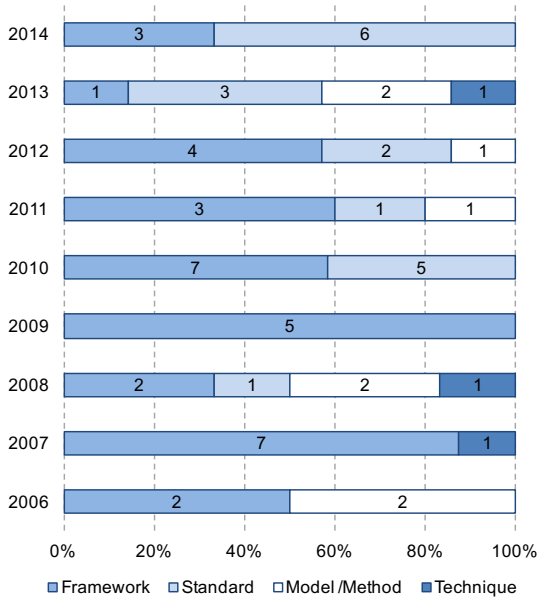

Fig. 7.4 Number of publications by type per year.

der the standard NMX-I-059/02-NYCE, best known as MoProSoft, and there are 11 certified companies under basic profile of the ISO/IEC 29110 standard. The selected papers about COMPETISOFT describe some case studies and 5 certified companies in Peru.

In 2008, OWPL reported an experience concerned to 93 evaluations of 86 different organizations in 3 countries (Wallonia, Quebec and France). Finally, the selected papers about MARES, Tutelkan, iFlap shows quiet few case studies carried out in order to validate their proposal.

7.3.3.3 Research Trends

In this section, we describe the main research trends of the SPI in SMEs revealed from this SLR. In relation to the number of publications, Fig. 7.4 shows that lately there is an increasing interest on the ISO/IEC 29110 standard which overcomes the other types of initiatives (models/methods, techniques, and frameworks). Nevertheless, the initiatives have given experience and knowledge in the field of SPI so its usefulness extends to practitioners and researchers. In fact, the distribution of publications on SPI initiatives (Fig. 7.5) also shows that MPS.BR, MoProSoft and COMPETISOFT correspond to more than 50% of the papers, which is in accordance with the aforementioned adoption data. The SPI approaches have evolved through the collaborations among academy and software industry during 1997-2014 in different kinds of SME around the world. However, the SPI initiatives are primar-

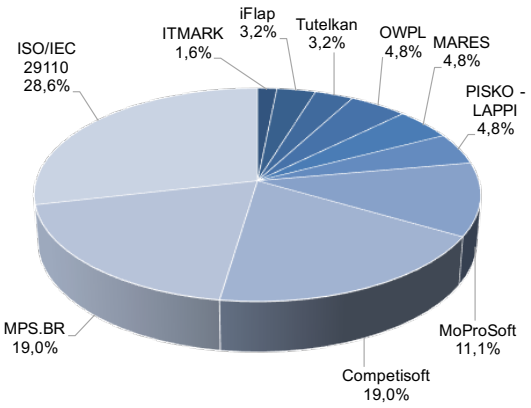

Fig. 7.5 Distribution of publications by software process improvement initiative.

ily located in Europe and America where the strength of local government support for these initiatives has been in large. It also has been a key factor affecting their dissemination. In addition, the development of mechanisms such as automated tools or deployment packages to facilitate the implementation of the initiatives is important and necessary to achieve their adoption among SMEs.

7.3.3.4 Limitations of Current Research

Regarding the search string, we attempted to collect all the strings that were representative of the SPI approaches identified and the three research questions. Based on the results obtained, the search strings were refined on several occasions in order to maximize the selection of papers related to the SLR. Then, we ensured that the studies with which we were familiar were in the results.

Another potential weak aspect is that there are very few papers related to this topic. This aspect is normal in the SME context, where the tendency is to maximize the product quality as a mean to achieve the best quality in use. Therefore, SPI approaches are rarely deployed. We argue that this is not the best way to work and we advocate another way to apply them: first, establish what they actually do or could potentially do; and later on, ensure the SME stability and address an SPI initiative.

7.4 Conclusions

A main objective of the SLR was to investigate specific SPI initiatives. We have investigated the current evidence of SPI initiatives in the context of SMEs. Due to our

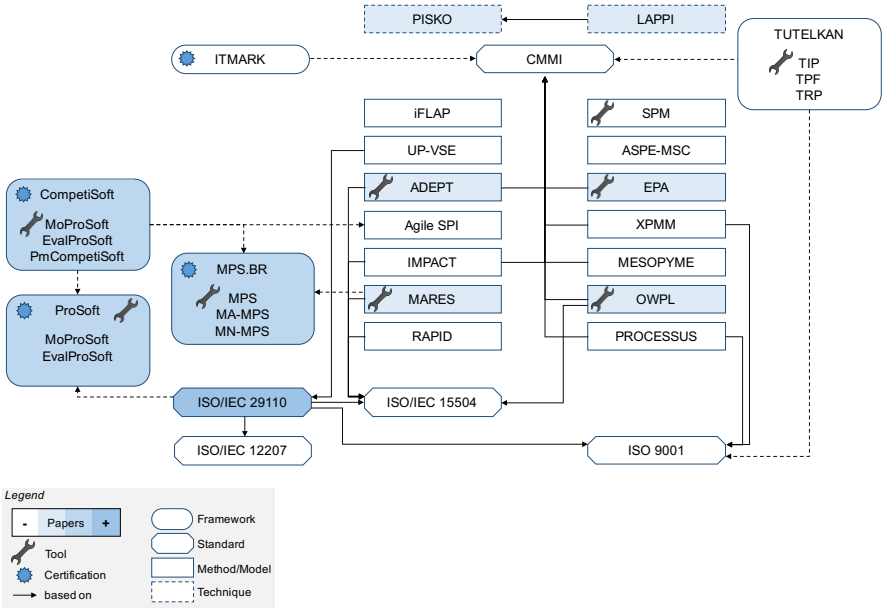

Fig. 7.6 Relations between software process improvement initiatives and the standards: CMMI, ISO/IEC 12207, ISO/IEC 15504, ISO 9001, and ISO/IEC 29110.

inclusion/exclusion criteria, the number of relevant studies found was small but the overall search process was very comprehensive, and following the protocol defined performed it. As a result, 90 papers were chosen and a total of 21 SPI approaches were studied from these papers, although only 63 are pertinent for this SLR. The rest of the papers are about less known and consequently less used initiatives. A full list of papers is shown in Sect. 7.6.

Regarding the categories in which the SPI approaches can be divided, we found 5 frameworks, 13 models/methods, 2 techniques, and 1 standard (see Fig. 7.6). Many of the publications are focused on frameworks (40% out of the total) but the ISO/IEC 29110 has lately received a lot of attention (20%). However, the current work is revealed by 3 methods/models (iFlap, OWPL and MARES), 5 frameworks (MoProSoft, COMPETISOFT, MPS.BR, ITMark, Tutelkan) and the ISO/IEC 29110 standard. However, the MoProSoft, COMPETISOFT and MPS.BR work with their own reference and assessment models and offer their own certifications. Although two techniques were found in this topic, they are only one approach because LAPPI extends Pisko.

There is quite few information about the results of the above SPI initiatives in terms of case studies, lessons learned, and number of certified SMEs. Therefore, it is difficult to determine the actual scope of such initiatives and their success. That means that more dissemination and support is necessary. These factors strongly influence the number and the period in which the adoption appears: very few contributions were found before 2006. Consequently, a growing increase appears in the

last ten years. In addition, we have found novel approaches, such as ArSPI model, which by its nature could become more relevant in the coming years.

It is worth mentioning that most of the SPI initiatives are based on CMMI, ISO/IEC 12207, ISO/IEC 15504 and ISO 9001 standards (Fig. 7.6), the relations between them and the framework are displayed in Fig. 7.3. Additionally, there is a strong tendency for use of the ISO/IEC 29110 standard for instance UP-VSE model is based on it.

Considering the rich variety of software development settings, the route to SPI in SMEs depends on the amount of resources, effort and objectives of each one. On one hand the ease of use (automated tools), lightweight and low cost are important features. On the other hand the support of local governments and international institutions such as ISO is an important part of the key.

7.5 Further Reading

This paper discusses SPI methods, models and frameworks for SMEs from a comparative perspective. The most related work has been developed by Mishra and Mishra [72, 71], who reviewed and compared various SPI methodologies on different significant attributes supported by various studies. Additionally, there are four systematic literature reviews (SLRs) on this topic: three of them [55, 96, 135] identified the SPI approaches but did not focus on understand their evolution, and the last one [125] is focused on web companies.

This book chapter extends previous work in a substantial way because we are considering a measure of the impact of publications by means of a systematic literature review of each SPI identified approach (method, model, and framework) from previous reviews. Therefore, a rigorous and up-to-date literature review with the latest related references has been included.

Recommended literature for further information about this topic is available in the proceedings from conference series such as *International Conference on Software and System Process* (ICSSP; [43]), *European System & Software Process Improvement and Innovation* (EuroSPI; [11, 68]) and *International SPICE Conference* (SPICE; [73, 146]) as valuable information resources for researchers. Furthermore, recommended literature for aditional information about ISO/IEC 29110 is available: `http://29110.org` and there is a Public Site of the ISO Working Group Mandated to Develop ISO/IEC 29110 Standards and Guides for Very Small Entities involved in the Development or Maintenance of Systems and/or Software References. Recommended literature for further information about MoProSoft: `http://www.nyce.org.mx/moprosoft` and recommended further reading regarding ArSPI is available from [50, 51].

7.6 List of SLR Papers

This section gives an overview of the reviewed papers and provides a classification. Furthermore, the acronyms and abbreviations used in this chapter are explained.

Table 7.7 Summary and classification of the papers of the systematic literature review.

Type	Iniatiative	References
Framework	COMPETISOFT	[61, 98, 90, 139, 28, 92, 29, 100, 99, 97, 62, 101]
	ITmark	[56]
	MoProSoft	[136, 110, 36, 8, 37, 1, 38]
	MPS.BR	[74, 22, 111, 118, 32, 13, 116, 117, 46, 112, 143, 33, 75, 76]
	Tutelkan	[133, 132]
Model/Method	Adept	[64, 66]
	ASPE/MSC	[142, 41]
	EPA	[59, 67, 145, 144, 60]
	iFlap	[95, 94]
	IMPACT	[122]
	MARES	[140, 148, 7, 141]
	MESOPYME	[17]
	OWPL	[40, 149, 23]
	PROCESSUS	[113, 42]
	RAPID	[18, 19, 20]
	SPM	[108, 107]
	XPMM	[79, 34, 80]
Standard	ISO/IEC 29110	[85, 104, 137, 105, 63, 6, 52, 16, 53, 106, 86, 87, 15, 89, 83, 54, 70, 127]
References	LAPPI	[103]
	PISKO	[3, 5, 119, 134, 4]

Table 7.8 Current SPI approaches.

Abbreviation	Name
Prosoft	Programme for the Development of the Software Industry (Programa para el Desarrollo de la Industria del Software)
↪ MoProSoft	Process Model for the Software Industry (Modelo de Procesos para la Industria de Software)
↪ EvalProSoft	Process Assessment Method for Software Industry (Método de Evaluación de Procesos para la Industria del Software)
MPS.BR	Brazilian Software Process Improvement (Melhoria de Processos do Software Brasileiro)
↪ MA-MPS	MPS Assessment Method (Método de Avaliação para Melhoria de Processo de Software)
↪ MN-MPS	MPS Business Model (Modelo de Negócio para Melhoria de Processo de Software)
SIMEP-SW	Colombian Software Development Process Improvement System (Sistema Integral para el Mejoramiento de los procesos de Desarrollo de Software en Colombia)
COMPETISOFT	Process Improvement for Promoting Iberoamerican Software Small and Medium Enterprises Competitiveness
RAPID	Rapid Assessments for Process Improvement for software Development
MARES	Methodology for Software Process Assessment (Método de Avaliação de Processo de Software)
EPA	Express Process Appraisal
AFSP	Agile Framework for Small Projects
OWPL	Walloon Observatory for Software Practices (Observatoire Wallon des Pratiques Logicielles)
ASPE/MSC	Approach for Software Process Establishment in Micro and Small Companies
ASPEI/MSC	Approach for Software Process Establishment and Improvement in Micro and Small Companies
iFlap	improvement framework utilizing lightweight assessment and planning
SPM	Software Process Matrix
XPMM	eXtreme Programming Maturity Model
Agile SPI	Agile Software Process Improvement
Tutelkan	
↪ TIP	Tutelkan Implementation Process
↪ TPF	Tutelkan Process Framework
↪ TRP	Tutelkan Reference Process
LAPPI	Light-weight Technique to Practical Process Modeling and Improvement Target Identification
Automotive-adept	Lightweight assessment method for the automotive software industry
UP-VSE	Unified Process for Very Small Entities
ArSPI	Artifact-based Software Process Improvement & Management

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