The Journal of Systems and Software 164 (2020) 110546

Contents lists available at ScienceDirect

The Journal of Systems and Software

journal homepage: www.elsevier.com/locate/jss

In Practice

Requirements for adopting software process lines

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ARTICLE INFO

Article history:
Received 13 May 2019
Revised 7 February 2020
Accepted 11 February 2020
Available online 12 February 2020

Keywords:
Software Process Lines
Method Tailoring
Systematic Mapping Study
Empirical Study

ABSTRACT

A Software Process Line (SPrL) is potentially suitable for constructing software development methodologies by reusing core assets. However, adopting this approach without prior assessment of its suitability can lead to failure. The aim of this paper is to identify a set of requirements that can be used for deciding whether to adopt the SPrL approach in an organization. Identification of the requirements was accomplished in two stages: the characteristics important in method tailoring were first identified via a Systematic Mapping Study (SMS) that focused on analyzing 43 primary studies; the degree of importance of the identified characteristics was then determined using a questionnaire survey in which 31 experts participated. By analyzing the results of the SMS and the survey, we have identified 12 product-related, 22 project-related, and 10 organization-related requirements. In addition to these requirements, we have also identified two relevant requirements by studying previous research on Software Product Lines (SPL) and Business Process Lines (BPL). The requirements thus identified can help organizations decide on whether to adopt the SPrL approach: the more an organization satisfies the requirements, the more frequently method tailoring occurs in that organization, and hence, the more justified it is to adopt the SPrL approach.

1. Introduction

Constructing bespoke software development methodologies for specific project situations has become a crucial need in software development organizations (Agh and Ramsin, 2016). Method tailoring is an effective approach for constructing custom-built methodologies (Washizaki, 2006). Traditional tailoring approaches are deficient in various aspects, including in their support for identification of the regression process modifications to be performed if an object is removed, and also in supporting certain process modifications such as replacing or adding new objects; the Software Process Line (SPrL) approach is a relatively new method tailoring approach that aims to tackle these deficiencies (Jaufman and Münch, 2005).

Successful implementation of the SPrL approach is a situation-dependent issue. Organizations should first examine the suitability of the SPrL approach for their specific circumstances, otherwise they may fail to realize its potential benefits. Despite the importance of this issue, however, there has been no research effort on determining a comprehensive set of requirements to be considered when deciding on the adoption of the SPrL approach. Identifying these requirements could help organizations to successfully implement SPrLs.

The objective of this research is to provide software organizations with a comprehensive set of requirements to support them in deciding on whether or not to adopt the SPrL approach. To achieve this objective, it was necessary to identify the characteristics that are important for method tailoring, from both academic and industrial perspectives, and to then define SPrL requirements based on those characteristics. We first conducted a Systematic Mapping Study (SMS) (Petersen et al., 2015), through which we identified the characteristics of software products, projects, and organizations which should be considered throughout method tailoring, along with the types of methodologies and method areas which have been the subject of tailoring.

In order to validate the findings of the SMS from an industrial perspective, an online survey questionnaire was developed based on the findings of the SMS, and was sent to practitioners experienced in tailoring software development methodologies. This allowed us to collect self-reporting data from a large group of respondents (Kitchenham and Pfleeger, 2002; Lethbridge, 2005). By means of this survey, we identified the product, project and organization characteristics that necessitate the tailoring of methodologies in industrial settings.

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https://doi.org/10.1016/j.jss.2020.110546

Based on the results of the SMS and the expert survey, we defined a set of product-related, project-related, and organization-related requirements for adopting the SPrL approach. We also established two requirements related to method tailoring, based on research conducted on SPLs and BPLs.

The findings of this paper will contribute to the completion of the first phase of our proposed approach for model-driven development of SPrLs for organizations (Agh and Ramsin, 2017). This model-driven approach is performed in two phases: Domain Engineering and Application Engineering. Each of these phases includes three sub-phases: Analysis, Design, and Implementation. During domain engineering, the commonalities and variabilities among existing methodologies are analyzed to create a core process. During application engineering, bespoke methodologies are built by resolving the relevant variabilities in the core process. One of the tasks performed in the analysis activity of the domain engineering phase is to determine the suitability of the SPrL approach for the target organization. The requirements introduced in this paper will be used for that purpose.

The rest of this paper is organized as follows: Section 2 provides a survey of the related research; in Section 3, the research methodology that was selected is described; the findings of the SMS and its validation through conducting an expert survey are reported in Section 4; in Section 5, the set of requirements identified for SPrL adoption is presented; the summary and the limitations of this study are discussed in Section 6; and Section 7 presents the concluding remarks and suggests ways for furthering this research.

2. Background

This section provides concise backgrounds on method tailoring and SPrL Engineering (SPrLE).

2.1. Method tailoring

Method tailoring is the act of adapting a standard software development methodology to meet specific project/organization needs (Pedreira et al., 2007); the specific needs are described as method tailoring criteria. There are several studies on identifying the criteria to be considered during method tailoring (e.g., Clarke and O'Connor, 2012; Kalus and Kuhrmann, 2013); these studies provide a catalog of tailoring criteria that provide guidance to method engineers or project managers when selecting or tailoring a methodology for a specific situation.

There are several approaches for method tailoring which differ as to the size of the target organization, the degree of formalism expected in the target methodology, and the available tool support (Pedreira et al., 2007). One significant method tailoring approach is Situational Method Engineering (SME) (Henderson-Sellers et al., 2014). There are three prominent, high-level SME approaches, namely Paradigm-based, Assembly-based, and Extension-based (Henderson-Sellers et al., 2014). In these approaches, method tailoring criteria are first used for specifying the situation for which the target methodology should be built/improved. The methodology is then defined based on these criteria by either 1) instantiating or adapting a high-level standard methodology (paradigm-based SME), or 2) combining the different method fragments retrieved from a repository (assembly-based SME), or 3) using a methodology as an extension framework to extend incomplete processes into the desired methodology (extension-based SME). Although these approaches can be used to obtain a custom-built methodology, using them for this purpose is often a time-consuming and costly endeavor, especially when the assembly-based approach is adopted (Mirbel and Ralyté, 2006). Furthermore, in SME approaches, tailoring criteria are only used for defining the specific situation for which the target methodology should be built, and not for specifying the future needs of the organization. Therefore, SME approaches can be considered as reactive method tailoring approaches.

2.2. SPrLE

Software Product Lines (SPLs) have shown their usefulness in developing ranges of software products and software-intensive systems at lower costs, in shorter time spans, and with higher qualities (Pohl et al., 2005). According to (Northrop, 2002), a SPL is "a set of software-intensive systems that share a common, managed set of features satisfying the specific needs of a particular market segment and that are developed from a common set of core assets in a prescribed way".

Software development processes are essential in developing quality software systems, as they help transform user needs into a software product that meets those needs (Acuna et al., 2000). A SPrL is a specialized SPL in the context of method definition (Armbrust et al., 2009), which increases reuse opportunities and decreases the adaptation effort (Hurtado and Bastarrica, 2012). According to (Armbrust et al., 2009), "a software process line is a set of software development processes that share a common, managed set of features satisfying the specific needs of an organization and that are developed from a common set of core assets in a prescribed way". This definition is an adapted form of the SPL definition provided by (Northrop, 2002).

In a SPrL, common and variable parts of existing methodologies, and/or other types of variabilities specified according to future needs, are defined as a *core process*, also referred to as the *common architecture* and the *reference architecture* (Agh and Ramsin, 2017; Washizaki, 2006). Bespoke methodologies are then defined by resolving the variabilities defined in the core process. Future needs are usually determined by exploring combinations of method tailoring criteria that are sound based on the product portfolios of the organization; therefore, SPrL approaches can be considered as proactive method tailoring approaches. To manage the complexity involved in resolving the variabilities, SPrLE approaches define resolution rules by using method tailoring criteria; a combination of tailoring criteria specifies the situation in which each variation point of the SPrL can be resolved by a specific variant. This approach enables organizations to define their software development methodologies with less effort and in a shorter time (Hurtado et al., 2013). As an example, Fig. 1 shows the variable parts in the "Develop Change and Test Unit Capability Pattern", introduced in (Hurtado and Bastarrica, 2012); although this is a small-scale example, it clearly shows the typical structure of a process with constant and variable constituents.

3. Research design

We have used two different research methods: a Systematic Mapping Study, and an industrial questionnaire-based expert survey. An overview of the methods is shown in Fig. 2. The designs and results of these methods are explained in the following sections.

3.1. Systematic mapping study

The goal of this study was to specify the characteristics that are important for method tailoring. To carry out this systematic mapping, we followed the recommendations in (Kitchenham et al., 2015). In this section, we will present the plan for each step of the study, including the research questions, data sources and search strategy, as well as the classification and inclusion/exclusion criteria.

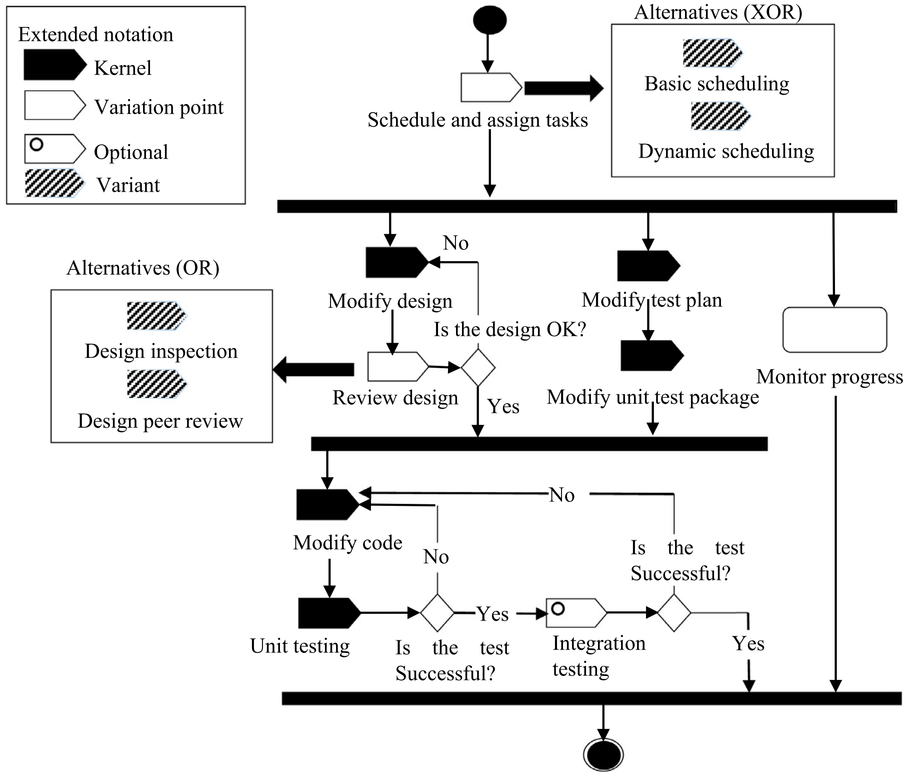

Fig. 1. Develop change and test unit capability pattern (adapted from (Hurtado and Bastarrica, 2012)).

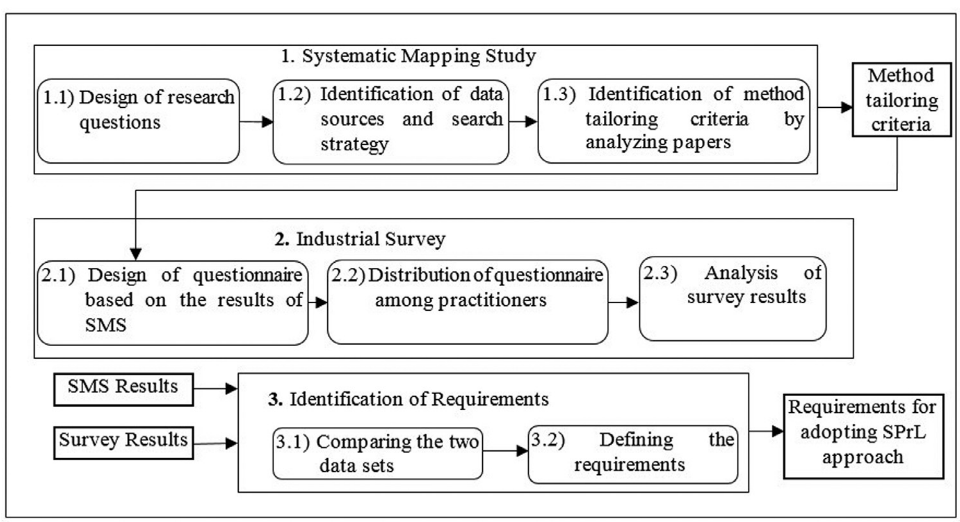

Fig. 2. Research process overview.

3.1.1. Research methods and questions

To achieve the goal of this study, we should specify product, project, and organization characteristics that are important for method tailoring. Hence, the research questions used in the SMS attempt to specify the specific aspects of the software product, software project, and software organization/company that should be considered throughout method tailoring. To specify these aspects, we produced six specific research questions, as shown in Table 1.

3.1.2. Data sources and search strategy

In an effort to answer the research questions, keywords had to be selected that would result in finding initiatives focused on *software process* and *tailoring*; these keywords were therefore joined by logical AND. Synonyms for the process part and tailoring part of the search string were also included in the search string by logical OR. The first part of the search string was thus formed as follows: "Software AND (process OR method OR methodology) AND (variability OR variant OR "variation point" OR tailoring OR flexibility OR customization OR customization OR adaptation OR adaption OR instantiation)". In order to find industrial research papers on method tailoring, the second part of the string was formed as follows: "¨software process tailoring" AND (practice OR experience OR organization)".

Including all the synonyms considered for the process and the tailoring keywords in the second part did not result in new re-

Table 1
Research questions of the systematic mapping study.

No.	Research question	Rationale for the RQ
RQ1	What is the profile of the papers that focus on method tailoring? This question is divided into three sub-questions: RQ1.1: what research methods have been used in research into method tailoring? RQ1.2: what types of publications or forums have addressed the issue of method tailoring? RQ1.3: what types of evaluation methods have been used in the primary studies?	Exploring whether the research works conducted in the domain of method tailoring are mature enough for defining requirements for SPrL adoption.
RQ2	Which characteristics of software products should be considered throughout method tailoring?	Identifying the product characteristics that are important for method tailoring.
RQ3	Which characteristics of software projects should be considered throughout method tailoring?	Identifying the project characteristics that are important for method tailoring.
RQ4	Which characteristics of software organizations/companies should be considered throughout method tailoring?	Identifying the organizational characteristics that are important for method tailoring.
RQ5	What types of methodologies have been considered for tailoring?	Specifying whether only specific types of methodologies (such as RUP) need to be tailored; this question helps us determine whether only organizations using specific methodologies need to consider SPrL creation.
RQ6	What method areas have been the subject of tailoring?	Determining whether only specific areas of the methodology need to be tailored and should therefore be considered in SPrL creation; otherwise, the methodology should be considered in its entirety.

Table 2
Summary of the search strategy.

Search strategy	
Academic databases searched	Scopus, ACM Digital Library, ScienceDirect, IEEEXplore, SpringerLink, Wiley InterScience
Target Items	Journal papers, conference papers
Search applied to	Title, abstract, keyword
Language	Papers written in English
Publication period	Until May 2018

sults; however, by considering the "software process tailoring" keyword along with special keywords for revealing industrial papers, we could retrieve new papers. The two parts were combined by logical OR as follows:

"(Software AND (process OR method OR methodology) AND (variability OR variant OR "variation point" OR tailoring OR flexibility OR customization OR customization OR adaptation OR adaption OR instantiation)) OR (¨software process tailoring" AND (practice OR experience OR organization))"

In order to evaluate the search string, we first conducted a limited manual search to see whether the results of that manual search actually show up in the results obtained by running the search strings. The two parts of the search string were run separately in some of the digital libraries because of the constraints set by those libraries regarding the length of search strings. Furthermore, the search string was adapted for use in different search engines; the forms of search string applied to different engines are provided in (Agh et al., 2019).

The search strategy is shown in Table 2. The search string was applied on the title, abstract, and keywords of the papers. As some databases such as SpringerLink do not separate these fields, the search string was applied on the full text of the papers. The publication period was not limited to a specific time frame; therefore, the end year is the point in time when the first researcher completed running the search strings. Backward snowballing (Wohlin, 2014) was also performed by examining the reference lists of the papers after the final filtering of the papers found by the automatic search.

3.1.3. Classification

The papers selected for analysis were classified according to the following criteria:

1.1) Type of research method, publication, and evaluation method: The selected papers are classified according to their profile, including:
   1.1.1) Research type: The categories mentioned in (Wieringa et al., 2006) and the rules recommended by (Petersen et al., 2015) are used to classify the primary studies (RQ1.1). These categories are as follows: Evaluation research, Solution proposal, Validation research, Philosophical papers, Opinion papers, and Experience papers.
   1.1.2) Publication type: This field is related to RQ1.2 and can be either journal paper or conference paper.
   1.1.3) Evaluation method: This field is related to RQ1.3 and can be any category mentioned in (Tonella et al., 2007), including Case study, Survey, Experiment, Observational study, and Experience report.

1.2) Product quality attributes: As the quality attributes mentioned in ISO/IEC 25010 (Usability, Security, Reliability, Portability, Performance efficiency, Maintainability, Functional suitability, and Compatibility) are widely used to measure the quality of software products, we used them to classify the selected papers (RQ2).

1.3) Project characteristics: This field is related to RQ3 and can be any project characteristic that emerges during the extraction of data from the papers, such as project duration.

1.4) Organization/company characteristics: This field is related to RQ4 and can be any organization/company characteristic that emerges during the extraction of data from the papers, such as organization maturity.

1.5) Type of methodology: This field is related to RQ5 and can be any type of software development methodology, such as RUP, that emerges during the extraction of data from the papers.

1.6) Method areas: This field is related to RQ6 and can be any area of software development lifecycle that emerges during the ex-

Table 3
Inclusion and exclusion criteria.

Type	Criteria
Inclusion criteria	Academic journal and conference papers Papers written in English Papers that address method tailoring/customization Papers that address process lines Papers that address variability, flexibility, and adaptation of methodologies Papers that address case studies about method tailoring in real software development companies
Exclusion criteria for title and abstract	Duplicate papers (only one copy is kept) Papers that focus on tools and notations for presenting the variability of methodologies, not the context information for resolving the variabilities Papers that only focus on product lines Papers available only in the form of abstracts or PowerPoint presentations Technical reports and white papers Graduation projects, Master's theses and PhD dissertations Textbooks, both print and electronic Studies in other domains of knowledge such as Civil Engineering.
Exclusion criteria for full text	Papers that do not specify the product/project/organization characteristics as the situation/context in which software development methodologies are tailored Papers that focus on agile transformation in specific domains

Table 4
Results of the search and the three-stage process.

		Total results	Results after the first stage	Results after the second stage	Results after the third stage
S1	IEEExplore	343	13	4	5
	ACM DL	1782	30	11	4
	Science Direct	560	10	6	7
	Springer	149	18	6	6
	Scopus	217	21	8	9
	Wiley InterScience	1843	29	6	7
Total		With duplication: 4894 Without duplication: 4809	121	41	38

traction of data from the papers. As there are many lifecycle models, different terms may be used for an area. Based on the information given in the papers, these terms are made consistent; for example, “analysis” is used for “requirements analysis”, “requirements engineering”, or “requirements management”.

3.1.4. Selecting primary sources, data extraction and synthesis

A three-stage process was performed to identify the primary studies: first, initial selection of papers based on the selection criteria defined in Table 3 by reading the title and abstract of the papers; at this stage, a paper is excluded if it meets one or more of the exclusion criteria defined for titles and abstracts. Second, reading the full text of the selected papers; at this stage, a paper is excluded if it meets one or more exclusion criteria defined for the full text. These two stages were performed by the first author of this paper. In the third stage, in order to reduce researcher bias, the results of the second stage were validated by the second and third authors of this paper; as a result of this stage, four papers that had been excluded in the second stage were chosen as primary studies. It should be noted that secondary studies that satisfied the selection criteria were not excluded for the following purposes:

1- Identifying the characteristics that were not mentioned in the primary studies included in our paper.
2- Identifying the characteristics that were mentioned both in the primary studies included in our paper and in one of the primary studies included in the secondary studies that was not included in our paper. As the number of research works that specify a characteristic as a method tailoring criterion is later analyzed to identify the requirements, analyzing the secondary studies in this way has a positive effect on the reliability of the results.

Table 4 shows the total number of the results retrieved through running the search string; it also shows the number of the results after each of the three stages. Results of the searches in different engines were combined so that only one copy of each paper was included in the end results. Due to the use of backward snowballing after the third stage, the total number of primary studies was increased from 38 to 43 papers. The data were extracted based on an extraction template, shown in Table 5; excerpts of excel sheets for data extraction are provided in (Agh et al., 2019).

In order to review the primary studies and conceptualize the characteristics important for method tailoring, the Grounded theory-based coding scheme was used, which provides an analytical approach for identifying, naming, and categorizing concepts through close examination of data (Strauss and Corbin, 1990). By using this approach, we identified, labelled, and grouped the related characteristics into general categories.

Data synthesis was performed by the first author, and a list of product/project/organization characteristics from the 43 papers was created. Initially, 13 product-related characteristics, 50 project-related characteristics, and 17 organization-related characteristics were identified. To minimize researcher bias and improve the validity of the identified characteristics, the first and second authors carefully reviewed each category; therefore, relationships between the categories were identified, and related categories were grouped into 13 product-related categories, 26 project-related categories, and 12 organization-related categories.

3.2. Data collection via questionnaire survey

Based on the findings of the SMS, an online survey questionnaire was developed to validate the findings from an industrial perspective.

Table 5
Data extraction template.

RQ	Extracted item	Type of data
General information	Title	Free text
	Venue	Free text
	Reference	Free text
RQ1	Research method used in research into method tailoring	Predefined list of existing types of research methods
	Type of the venue addressed the issue of method tailoring	Predefined list of venues considered in this paper
	Type of the evaluation method used in the primary study	Predefined list of existing evaluation methods
RQ2	Characteristics of software products considered throughout method tailoring	List of characteristics gradually completed by studying primary studies
RQ3	Characteristics of software projects considered throughout method tailoring	List of characteristics gradually completed by studying primary studies
RQ4	Characteristics of software organizations/companies considered throughout method tailoring	List of characteristics gradually completed by studying primary studies
RQ5	Types of methodologies considered for tailoring	List of methodologies gradually completed by studying primary studies
RQ6	Methodology areas which have been the subject of tailoring	List of methodology areas gradually completed by studying primary studies

3.2.1. Questionnaire design

A closed-ended questionnaire was developed by taking into account the product, project, and organization characteristics that had been identified as important for method tailoring (the SMS results). This questionnaire is provided in (Agh et al., 2019).

As the goal of the survey was to specify which of the characteristics identified through the SMS had already been considered in industrial settings for method tailoring, we sent the questionnaire to practitioners who were experienced in method tailoring. Open-ended questions were also used to collect other characteristics that are important in method tailoring from the practitioners' perspective. A six-point Likert scale was used to rate the importance of the characteristics identified; the values are: "Strongly Agree¨, "Agree¨, "Neutral¨, "Disagree¨, "Strongly Disagree¨, and "Not Sure¨.

The questionnaire was carefully reviewed and was sent to a practitioner to be pre-tested. As a result of this check, revisions were made to produce the final version. To ensure the confidentiality of data and information, participants were assured that the data would be used for academic and research purposes only.

3.2.2. Data sources

The questionnaire was sent to software companies who had used different variants of methodologies in their past projects, and it was answered by practitioners who took part in defining/refining the methodologies used. The participants were contacted via email and also through their colleagues. A total of 45 practitioners from Iran and Spain were invited to participate; we limited the respondents to these two countries because we had sufficient information about their knowledge on method tailoring. A total of 31 completed questionnaires were ultimately received, giving a response rate of 69%. All the respondents were experienced in method tailoring, and their responses were considered in the final evaluation. The majority of respondents (27 respondents) had more than 10 years' experience, two respondents had 6–10 years' experience, one respondent had 3–5 years' experience, and one respondent had 1–2 years' experience. The respondents had different roles, ranging from CEO, coach, and CTO to developers. The demographic information is provided in (Agh et al., 2019).

3.3. Analysis of SMS and survey data

A frequency analysis approach was used to identify the similarities and differences between the findings of the data sets. Frequency tables were used to present the frequencies and percentages of the data in the two data sets. Frequency analysis is a useful approach for analyzing variable groups and can be used for both ordinal and numeric data (Bland, 2015). To compare the two data sets, each characteristic was assigned a specific rank; characteristics were ranked according to their frequencies in the literature or the positive responses (strongly agree/agree) given to them by the practitioners. In other words, the highest rank is assigned to the characteristic with the highest frequency. If more than one characteristic has the same frequency, all of them are given the same rank. As an example, consider the four characteristics: A, B, C, and D, in descending order of frequencies with equal frequencies for B and C ($A > B = C > D$); based on the approach used, A is assigned the rank 1 and an average rank of 2.5 is assigned to characteristics B and C. Characteristic D has the next highest value and has therefore been given the rank of 4. This approach has already been used by other researchers for calculating rankings in similar research works (Khan et al., 2017; Rashid and Khan, 2017). In order to specify the significance of the similarity between the ranks of characteristics in the SMS and the ranks in the questionnaire survey, specific descriptive statistics were used, as explained in Section 4.4.

4. Results

In the following sections, the results of the SMS and the industrial survey are presented. Further details of the results and datasets have been provided in an Appendices file that has been made available on Mendeley Data (Agh et al., 2019).

4.1. Search results

The search process was performed to comply with the criteria and strategies explained in the previous section. The number of papers resulting from the automated search and the three-stage filtering process is shown in Fig. 3.

The distribution of primary studies according to publication year is shown in Fig. 4. There is no publication prior to 2003 that focuses on method tailoring. However, after 2003 there is at least one paper per year that focuses on method tailoring. This indicates that method tailoring is an active research area. 2008 and 2012 were the years with the highest amount of papers. The number of published papers in recent years has declined; this may be because of the shift in trend from method tailoring to agile transformation; we have excluded such studies from our list of primary studies, since they strictly focus on examining the challenges of applying agile methodologies in specific domains.

4.2. Answers to research questions

In this section, the findings from the data extraction and classification activities are analyzed. The answers to the research ques-

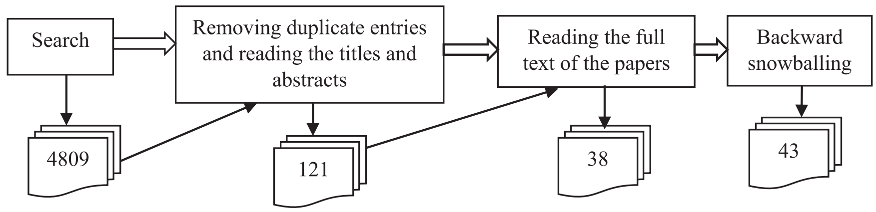

Fig. 3. Number of papers obtained from running the search process.

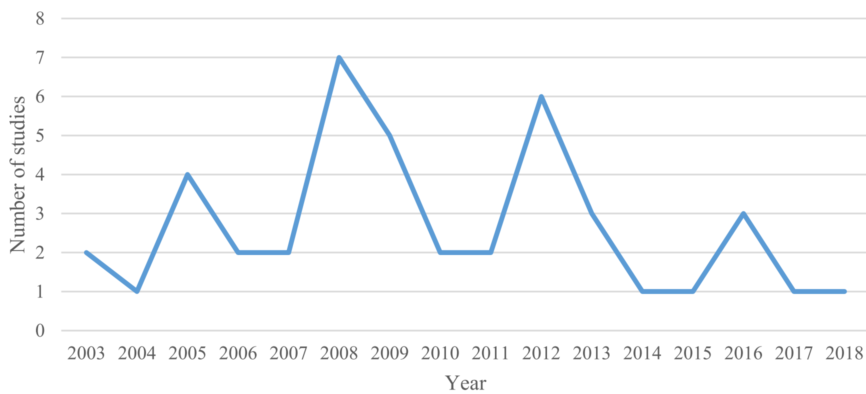

Fig. 4. Distribution of primary studies by year.

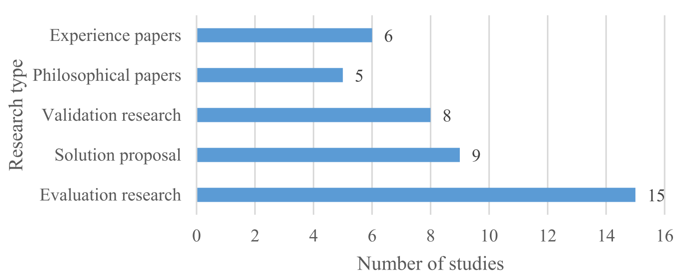

Fig. 5. Research methods addressed by primary studies.

Table 6
Distribution of primary studies by research method.

Research method	Studies
Evaluation research	[1,2,3,4,5,6,7,8,9,10,11,12,13,14,15]
Solution proposal	[16,17,18,19,20,21,22,23,24]
Validation research	[25,26,27,28,29,30,31,32]
Philosophical papers	[33,34,35,36,37]
Experience papers	[38,39,40,41,42, 43]

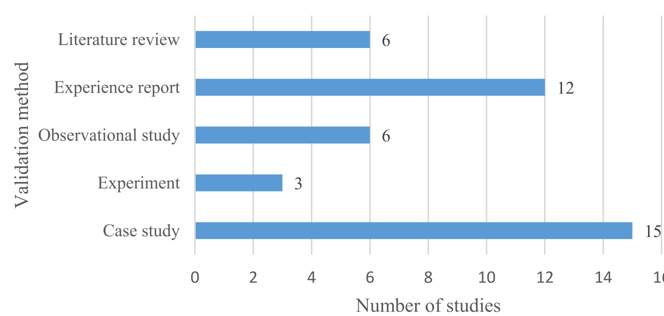

Fig. 6. Evaluation method used in primary studies.

tions mentioned in Section 3.1.1 are provided in the following subsections.

4.2.1. RQ1- What is the profile of the papers that focus on method tailoring?

This question is divided into three sub-questions, which will be explained below.

4.2.1.1. RQ 1.1- What research methods have been used in research into method tailoring?. Fig. 5 shows the classification of the primary studies according to their research type, and the number of primary studies in each category. This classification shows that a total of 29 primary studies have been categorized as evaluation research, validation research, and experience papers. This indicates that researchers are exploring the effects of method tailoring in developing software systems through empirical methods. Some of the papers in the solution proposal category claim that they have used case studies (Armbrust et al., 2008b; Fontoura and Price, 2008; He et al., 2008) as their validation method, but their validations are not reported in conformance with the guidelines mentioned in (Runeson et al., 2012); these papers were thus classified as solution proposals. Table 6 shows the details of the primary studies in each category. The numbers in the second column are indexes to the primary studies presented in Appendix A (Table A.1).

4.2.1.2. RQ 1.2- What types of publications or forums (venues) have addressed the issue of method tailoring?. The classification shows that 67% of the primary studies were published in peer-reviewed journals and 33% of them were published in conferences. This fact indicates that the research work reported in this area is mature enough. Table 7 shows the primary studies for each type of forum.

4.2.1.3. RQ 1.3- What types of evaluation methods have been used in the primary studies?. Several methods have been used for evaluating the primary studies, as shown in Fig. 6. As shown in this figure, most of the primary studies have been evaluated by conducting a case study or an experience report. Six papers were systematic literature reviews; their evaluation method was thus specified as literature review. Table 8 shows the primary studies that have used each type of evaluation method.

Table 7
Distribution of primary studies by the type of forum.

Type of forum	Studies
Journal	[2,3,4,5,6,7,8,11,12,13,14,15,21,23,24,26,27,28,29,30,33,35,36,37,38,39,40,41,43]
Conference	[1,9,10,16,17,18,19,20,22,25,31,32,34,42]

Table 8
Distribution of primary studies by the type of evaluation method.

Evaluation method	Studies
Case study	[3,4,6,10,11,15,24,26,28,29,30,31,40,41,42]
Experiment	[5,27,38]
Observational study	[7,8,13,25,32,39]
Experience report	[16,17,18,19,20,21,22,23,34,35,36,43]
Literature review	[1,2,9,12,33,37]

4.2.2. RQ2- Which characteristics of software products should be considered throughout method tailoring?

Out of 43 papers, a total of 22 primary studies (51%) have studied at least one of the quality attributes specified in ISO/IEC 25010. It is important to mention that in some papers, tailoring criteria have not been directly discussed; for example, the primary study (Anda et al., 2009) investigates the effects of resources and methodologies on software projects and products. Although our aim is to identify characteristics that influence the software methodology, we can conclude that if selecting a specific methodology affects a product quality such as usability, we should take usability into account during method tailoring. Furthermore, some of the papers proposed a technique or solution for method tailoring and did not mention tailoring criteria directly; for example, the primary study (Hurtado et al., 2013) proposes a model-driven approach for creating SPrLs, and evaluates the approach by conducting two industrial case studies; a specific stage of this approach focuses on the context information used for method adaptation. In primary studies such as (Hurtado et al., 2013), tailoring criteria are extracted by examining the context of the case studies.

Some of the primary studies focused on agile adaptation, and reported the challenges that agile approaches are faced with. These primary studies did not mention the tailoring criteria directly; we have therefore extracted the criteria by careful scrutiny of the papers. By way of example, the primary study (Cao et al., 2009) proposes a framework for adapting agile methods. This paper states that agile approaches do not have a formal design phase; hence, architectural scalability can be a serious concern for relatively large projects. Based on this information, we concluded that product maintainability and product size should be considered during process tailoring.

There are papers among the primary studies that mainly focus on defining tailoring criteria; two primary studies (Clarke and O'Connor, 2012; Kalus and Kuhrmann, 2013) are the most important ones in this regard. In (Kalus and Kuhrmann, 2013), 49 tailoring criteria have been identified by conducting a systematic literature review, and have then been related to a set of 20 tailoring actions. In (Clarke and O'Connor, 2012), a framework of situational factors affecting software development methodologies is proposed; the proposed framework consists of 44 factors that have been elicited by considering the literature in specific areas.

In addition to quality attributes, we have also included other product characteristics that have been mentioned in the papers as tailoring criteria, namely: criticality, product predictability (in predicting the requirements, project schedule, or project cost), product type, product complexity, and product size. The distribution of product characteristics is shown in Fig. 7. As shown in this figure, there is no paper among the primary studies that considers functional suitability as a tailoring criterion. The details of these primary studies are presented in Table 9.

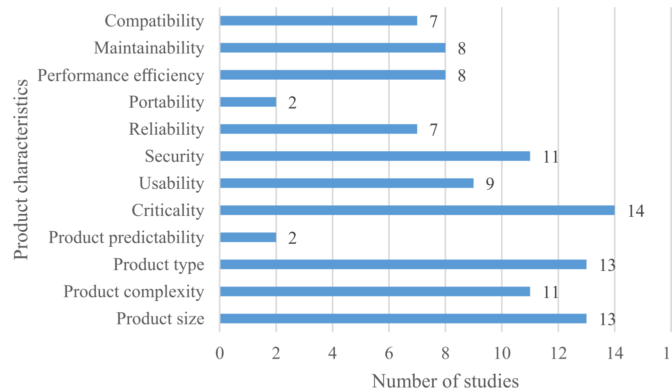

Fig. 7. Product characteristics addressed in the primary studies.

Table 9
Product characteristics considered by each primary study.

Product characteristic	Studies
Security	[1,4,5,7,17,20,34,35,39,40]
Maintainability	[3,4,7,20,36,38,39,41]
Usability	[3,5,9,17,20,36,39,41,43]
Performance efficiency	[1,5,7,24,34,37,39,40]
Compatibility	[1,7,28,29,35,39,41]
Reliability	[3,4,5,11,35,39,40]
Portability	[39,41]
Functional suitability	–
Criticality	[1,3,5,6,7,11,18,19,23,24,34,35,37,38]
Product predictability	[37,40]
Product type	[1,4,9,10,12,18,19,21,28,33,35,37,38]
Product complexity	[4,6,7,16,17,19,24,26,32,33,40]
Product size	[1,4,5,6,16,19,23,24,25,32,35,37,40]

4.2.3. RQ3- Which characteristics of software projects should be considered throughout method tailoring?

The project characteristics identified in the primary studies are presented in Table 10. While extracting the tailoring criteria, different names for the criteria were found in the literature; criteria with the same intention were hence combined by using the Grounded theory-based coding scheme. For example, five project characteristics that have been identified in the literature are related to the knowledge/skill level of team members, including: Team members' skill level, Application domain knowledge, Team members' technology knowledge, Team members' method knowledge, and Skill variety of team members; these characteristics have therefore been put together as Team members' knowledge/skill. All the combined characteristics have been presented in (Agh et al., 2019). Furthermore, there were criteria pertaining to customers, stakeholders, clients, and users that could be combined; in (Park et al., 2006), a semi-automated method tailoring approach is proposed that uses the artificial neural network-based learning theory to reduce the time expended on constructing a custom-built methodology. The effectiveness of the approach proposed in (Park et al., 2006) has been assessed by conducting an experiment in which the stakeholder cohesion/contention criterion is considered as a method tailoring criterion; as the roles of *customer*

Table 10
Project characteristics considered in the primary studies.

Project characteristic	Number of papers	Percentage (%)	Studies
Resource constraints	25	58	[1,3,5,6,7,10,11,12,13,16,17,18,23,24,25,26,29,32,33,35,37,40,41,42,43]
Team members' knowledge/skill	24	56	[1,3,4,5,6,8,9,10,11,14,16,18,22,23,26,27,28,29,30,32,35,37,40,43]
Project size/duration	23	53	[1,4,5,6,7,9,10,11,12,13,14,15,17,26,28,29,30,31,32,33,35,40,42]
Requirements characteristics	20	47	[1,5,6,7,8,11,12,13,15,18,19,24,26,32,33,35,37,40,41,43]
Team's physical characteristics	19	44	[1,3,4,7,11,14,16,18,24,26,27,29,30,32,33,35,37,40,41]
Project risk/complexity	19	44	[1,4,5,7,10,11,13,18,24,25,26,27,28,29,31,34,35,37,40]
Stakeholder characteristics	17	40	[1,4,5,6,9,11,13,15,17,18,26,27,32,35,39,40,43]
Team cohesion (distributed/collocated)	16	37	[1,4,6,7,11,13,14,15,18,19,23,28,33,35,37,41]
Project type (outsourced/insourced)	15	35	[1,7,11,12,13,14,20,25,27,29,30,31,33,35,43]
Application domain (e.g. e-commerce)	12	28	[5,9,10,11,12,21,22,25,28,30,35,40]
Technology-related issues	12	28	[1,3,7,10,11,15,21,22,35,36,40,41]
Team culture	11	26	[1,6,7,11,14,16,26,33,37,41,43]
Project contract characteristics	10	23	[1,3,7,8,10,14,15,28,37,42]
Type of development (new system development, existing system modification)	9	21	[1,7,17,21,29,30,32,35,39]
Turnover rate	9	21	[1,5,11,26,37,39,40,41,43]
Innovation level	6	14	[1,10,23,27,37,40]
Customer characteristics	6	14	[7,11,12,27,31,40]
Team productivity	5	12	[2,29,31,37,43]
Legacy system documentation	4	9	[1,29,30,36]
Application deployment profile	4	9	[35,37,40,43]
User-interface	3	7	[1,23,37]
Hardware development	3	7	[1,11,24]
End-user characteristics	3	7	[1,23,26]
Project opportunities	2	5	[1,37]
Measurement	2	5	[1,40]
Application reuse	2	5	[10,37]

Table 11
Organization characteristics considered in the primary studies.

Organization characteristic	Number of papers	Percentage (%)	Studies
Organization size	16	37	[7,8,9,10,11,13,28,29,30,31,33,35,36,37,39,40]
Organization structure/culture	15	35	[1,4,8,11,12,14,22,28,29,33,35,36,37,40,41]
Resource constraints	11	26	[1,11,12,13,16,20,22,31,33,36,37]
Organization maturity	10	23	[3,5,6,11,18,27,29,35,37,38]
Management-related characteristics	9	21	[1,9,11,18,26,33,37,38,40]
Business drivers	7	16	[2,10,11,26,36,37,41]
Organization standards /legal aspects	7	16	[1,12,15,20,23,35,36]
Business domain	6	14	[10,11,13,28,35,40]
Distribution of project organization	5	12	[7,10,27,33,35]
Organization stability	1	2	[37]
Level of innovation	1	2	[35]
External business dependencies	1	2	[37]

and *stakeholder* are the same in (Park et al., 2006), the stakeholder cohesion/contention criterion can be combined with the customer cohesion criterion. Furthermore, in some cases, it was not easy to distinguish among the different types of criteria, as different categories were mentioned for them in the papers. In such cases, the category with the most citations was selected. For example, characteristics related to the project team (e.g., team size) are categorized under the team category in (Hurtado and Bastarrica, 2012; Kalus and Kuhrmann, 2013), whereas we categorized these characteristics under the project category since in most of the other primary studies, the project category is selected for these characteristics.

4.2.4. RQ4- Which characteristics of software organizations/companies should be considered throughout method tailoring?

The organization-related characteristics are presented in Table 11. In this classification, there are also criteria with the same intention but with different names; these can therefore be combined. For example, both *organization facilities* and *resource constraints* refer to resource availability at the organization level; they were therefore combined as *resource constraints*; all the combined characteristics have been presented in (Agh et al., 2019).

Notice that the *level of innovation* mentioned in (Kruchten, 2013) is not the same *as degree of novelty*, which is mentioned as a project characteristic; level of innovation in an organization refers to the level of adoption/creation of new ideas and technologies in that organization, while degree of novelty in a project has to do with the new technologies or approaches used during the project. Also, *distribution of project organization* (an organization characteristic) and *team distribution* (a project characteristic) are different factors; team distribution refers to geographical distribution of teams that work on the same project, whereas distribution of project organization refers to geographical distribution of organization sections that may be working on different projects. In (Bass, 2016), tailoring agile methodologies to meet the needs of large-scale offshore software development programmes is studied; distribution of project organization is one of the main characteristics considered in (Bass, 2016) as a method tailoring criterion.

Some of the primary studies particularly focus on tailoring reference standards such as ISO/IEC 12207 or the German V-Modell XT to build company-specific standards. In these studies, the number of organization characteristics used for tailoring the method is greater than the product/project characteristics. In (Armbrust et al., 2008a), experiences of adapting and deploying the V-Modell XT in

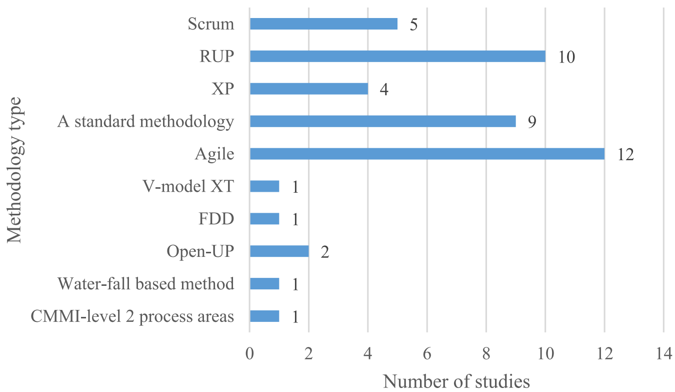

Fig. 8. Distribution of the primary studies by the type of methodologies.

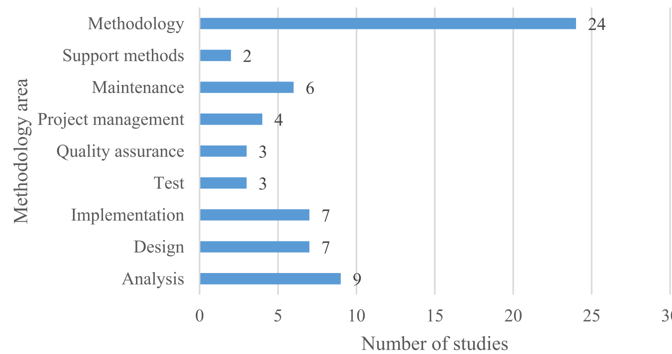

Fig. 9. Distribution of primary studies by method area.

Table 12
Methodology types considered by each primary study.

Methodology type	Studies
CMMI-level 2 process areas	[13]
Water-fall based method	[5]
Open-UP	[29,42]
FDD	[7]
V-model XT	[38]
Agile	[2,8,11,12,14,15,24,31,33,35,40,43]
A standard methodology	[3,16,19,20,21,26,30,36,41]
XP	[4,6,7,18]
RUP	[7,9,10,17,18,22,26,27,28,29]
Scrum	[6,7,23,25,39]

a specific company are reported; organization maturity and management commitment are the organization characteristics used for tailoring in (Armbrust et al., 2008a).

4.2.5. RQ5- What types of methodologies have been considered for tailoring?

Fig. 8 shows the distribution of the primary studies according to the type of methodologies they have considered for tailoring. Some of the papers focused directly on tailoring a specific methodology type; for example, in (Fitzgerald et al., 2006), customization of XP and Scrum methodologies with software practices is discussed. However, some of the papers concentrate on tailoring agile methodologies in general (e.g., Campanelli and Parreiras, 2015; Campanelli et al., 2018) and do not mention any specific methodology. Some of the papers first propose an approach for method tailoring and then evaluate it by applying the approach on a specific methodology. In these papers, adequate justification is provided for the selection of the methodology for tailoring; hence, we have elicited methodology type information by considering the type of methodology used for evaluation. For example, in (Park et al., 2006), a semi-automated technique is proposed for method tailoring. The effectiveness of the approach is evaluated by conducting a case study that focuses on tailoring the RUP methodology; RUP has been targeted for tailoring because the organization under study considers it as an off-the-shelf methodology that should be tailored to be applicable in a specific project. RUP's type was therefore determined as the methodology type for (Park et al., 2006).

Some of the primary studies do not concentrate on a particular methodology type (Clarke and O'Connor, 2012; Kalus and Kuhrmann, 2013). These research papers propose a set of criteria for method tailoring, but they neither focus on a particular methodology type, nor evaluate their framework by an evaluation method. Table 12 shows the primary studies for each methodology type. Some of the papers (e.g., Anda et al., 2009; Armbrust et al., 2008b) have addressed the tailoring of methodologies that are designated as standard methodologies in a specific organization; a standard methodology includes best practices that should be selected based on the characteristics of project situations. As shown in Fig. 8, various types of methodologies have been subjected to tailoring. This indicates that organizations using any type of methodology can examine whether they should adopt the SPrL approach.

4.2.6. RQ6- What methodology areas have been the subject of tailoring?

Fig. 9 shows the distribution of the primary studies in terms of the method areas they consider. Table 13 presents the details of the primary studies. There are papers that did not focus on any particular method area; these studies have therefore not been included in this classification. For example, (Clarke and O'Connor, 2012) presents a framework of situational factors affecting the methodology, but does not provide details (for example, by means of a case study) on the method areas that the situational factors are used for.

The method areas that appear in the primary studies are grouped into nine main blocks, namely: analysis (requirements analysis (Mishra and Mishra, 2011; Ocampo et al., 2005; Pereira et al., 2007), requirements engineering (Hurtado et al., 2014; Ortega et al., 2012), requirements management (Niazi and Babar, 2009)), design, implementation, test, quality assurance, project management (measurement and analysis (Niazi and Babar, 2009), project planning (Hurtado and Bastarrica, 2012; Niazi and Babar, 2009), project assessment and control (Hurtado and Bastarrica, 2012; Niazi and Babar, 2009)), support methods (configuration management (Niazi and Babar, 2009), support process (Martínez-Ruiz et al., 2011)), and methodology. As shown in Fig. 9, most of the primary studies focused on tailoring a methodology in its entirety (24 primary studies). This is not surprising, as to achieve the full benefits of tailoring, all the areas of a methodology should be tailored in accordance with the project situation. Fig. 9 shows that all the areas of the methodology, from analysis to maintenance, need to be tailored and should therefore be considered throughout SPrL creation.

4.3. Survey results

In this section, which aims to validate the findings of the SMS from an industrial perspective, the data received from the 31 participants of the questionnaire survey is analyzed. A summary of the responses given to questions on the degree of importance of the product, project, and organization characteristics is provided in (Agh et al., 2019).

The responses have been classified into four main categories, namely: positive responses, negative responses, neutral, and not sure (undecided). Positive responses (i.e., strongly agree and agree) indicate that the listed characteristics do influence method tailor-

Table 13
Method areas considered by each primary study.

Area	Studies
Analysis	[3,13,21,22,29,30,32,34,40]
Design	[3,16,21,25,29,34,40]
Implementation	[16,21,25,29,32,34,40]
Test	[16,25,34]
Quality assurance	[13,20,25]
Project management	[13,16,27,40]
Maintenance	[5,29,32,36,39,41]
Support methods	[13,20]
Methodology	[4,6,7,9,10,11,12,14,15,17,18,19,23,24,26,28,31,33,35,38,39,41,42,43]

Table 14
Comparison of product characteristics in the two data sets.

	Occurrence in SMS ($N = 43$)		Positive occurrence in survey ($N = 31$)	
	%	Rank	%	Rank
Criticality	33	1	68	7.5
Product type	30	2.5	55	10
Product size	30	2.5	52	11.5
Security	26	4.5	74	4
Product complexity	26	4.5	74	4
Usability	21	6	65	9
Maintainability	19	7.5	84	1
Performance efficiency	19	7.5	74	4
Compatibility	16	9.5	52	11.5
Reliability	16	9.5	74	4
Portability	5	11.5	42	13
Product Predictability	5	11.5	74	4
Functional suitability	0	13	68	7.5

ing, whereas negative responses (i.e., disagree and strongly disagree) assert that a particular characteristic does not influence the method tailoring activity (as perceived by the respondents).

The positive percentage for all product characteristics, except for “Portability” (42%), is above 50%. The positive percentage for all project characteristics, except for “Application domain” (32%), “Turnover rate” (35%), and “Hardware development” (39%), is above 50%. Furthermore, the positive responses for all organization characteristics, except for “External business dependencies” (48%), are above 50%. These values indicate that all the characteristics identified in the literature have influenced method tailoring in industrial settings.

4.4. Comparison of the two data sets

In this section, the findings of the SMS and the questionnaire survey are analyzed by considering the frequency of mentions of the characteristics in the literature and the positive responses given to the characteristics in the survey. The purpose of this comparison is to identify product, project, and organization characteristics that should be considered for defining a set of requirements for SPrL adoption. Table 14, Table 15, and Table 16 present the product, project, and organization characteristics in the two data sets, respectively. As shown in the tables, each characteristic has a specific rank. As mentioned before, certain open-ended questions have been added to the questionnaire to elicit additional characteristics from the practitioners' perspectives. Of all the replies received, there were only two answers in response to the open-ended questions on product characteristics. However, the characteristics mentioned in these responses are covered by the characteristics identified for project and organization aspects. For example, one of the respondents replied to certain product and project factors with the following comment:

“*Other attributes that may affect method tailoring, among others, are the desired/required time-to-market (*e.g.*, in startup products), business/financial criticality (*e.g.*, in banking systems), and confidentiality and mission criticality (*e.g.*, in military systems)*”.

“Time to market”, two types of “criticality”, and “confidentiality” are the characteristics mentioned in this comment. “Time to market” has already been specified as a project characteristic, and the reason the practitioner has mentioned this particular characteristic may very well be because the practitioners have filled the questionnaire section by section: they have first completed the section related to product characteristics, then project characteristics, and finally organization characteristics. “Criticality” as a product characteristic refers to the different types of criticality usually encountered, encompassing *Mission criticality*, and *Business/financial criticality*. “Confidentiality” is also covered by “Security”. The total number of product characteristics in the two data sets (SMS and survey) has thus remained the same, as shown in Table 14.

In order to specify the significance of the similarity between the rank of characteristics in the SMS and the ranks in the questionnaire survey, a correlation analysis test has been performed. Table 17 presents the Spearman's rank-order correlation results for the SMS and the survey. Spearman's rank-order correlation has been selected to perform the correlation analysis test since it is a nonparametric measure of dependency between two paired samples (with no assumptions on the distribution of data) and is based on the ranks of the paired data.

As shown in Table 17, the Spearman's correlation coefficient (r_s) for product characteristics is −0.046; this value indicates the negative correlation between the ranks obtained from the SMS and the questionnaire survey; in other words, the higher the rank of a product characteristic identified via the SMS, the lower its rank in the questionnaire survey, and vice versa. In addition, the value of p ($0.882 > 0.05$) shows that Spearman's rank-order correlation is not statistically significant. One reason for having negative correlation between the results of the SMS and the questionnaire survey may be that particular attention has been given to product characteristics in the literature, while from the practitioners' perspec-

Table 15
Comparison of project characteristics in the two data sets.

	Occurrence in SMS ($N = 43$)		Positive occurrence in survey ($N = 31$)	
	%	Rank	%	Rank
Resource constraints	58	1	57	18.5
Team members' knowledge/skill	56	2	84	2.5
Project size/duration	53	3	77	6
Requirements characteristics	47	4	81	4
Project risk/complexity	44	5.5	77	6
Team's physical characteristics	44	5.5	84	2.5
Stakeholder characteristics	40	7	74	8.5
Team cohesion	37	8	71	11
Project type	35	9	57	18.5
Application domain	28	10.5	32	26
Technology-related issues	28	10.5	77	6
Team culture	26	12	74	8.5
Project contract characteristics	23	13	94	1
Type of development	21	14.5	71	11
Turnover rate	21	14.5	35	25
Customer characteristics	14	16.5	68	14
Innovation level	14	16.5	68	14
Team productivity	12	18	71	11
Legacy system documentation	9	19.5	55	20
Application deployment profile	9	19.5	52	21.5
End-user characteristics	7	22	65	16.5
Hardware development	7	22	39	24
User-interface	7	22	52	21.5
Project opportunities	5	25	68	14
Measurement	5	25	65	16.5
Application reuse	5	25	45	23

Table 16
Comparison of organization characteristics in the two data sets.

	Occurrence in SMS ($N = 43$)		Positive occurrence in survey ($N = 31$)	
	%	Rank	%	Rank
Organization size	37	1	65	6.5
Organization structure/culture	35	2	84	2
Resource constraints	26	3	71	4.5
Organization maturity	23	4	90	1
Management-related characteristics	21	5	71	4.5
Business drivers	16	6.5	57	8
Organization standards /legal aspects	16	6.5	74	3
Business domain	14	8	52	10.5
Distribution of project organization	12	9	55	9
Organization stability	1	11	52	10.5
Level of innovation	1	11	65	6.5
External business dependencies	1	11	48	12

Table 17
Correlation ranks across the data of SMS and questionnaire survey.

			SMS	Survey
Spearman's rho for product characteristics	SMS	Correlation coefficient	1	−0.046
		Sig. (2-tailed)	–	0.882
		N	13	13
	Survey	Correlation coefficient	−0.046	1
		Sig. (2-tailed)	0.882	–
		N	13	13
Spearman's rho for project characteristics	SMS	Correlation coefficient	1	0.566
		Sig. (2-tailed)	–	0.003
		N	26	26
	Survey	Correlation coefficient	0.566	1
		Sig. (2-tailed)	0.003	–
		N	26	26
Spearman's rho for organization characteristics	SMS	Correlation coefficient	1	0.702
		Sig. (2-tailed)	–	0.011
		N	12	12
	Survey	Correlation coefficient	0.702	1
		Sig. (2-tailed)	0.011	–
		N	12	12

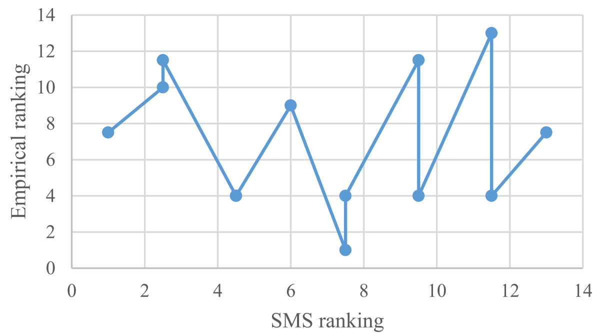

Fig. 10. Systematic mapping study and survey correlation scatter graph of product characteristics.

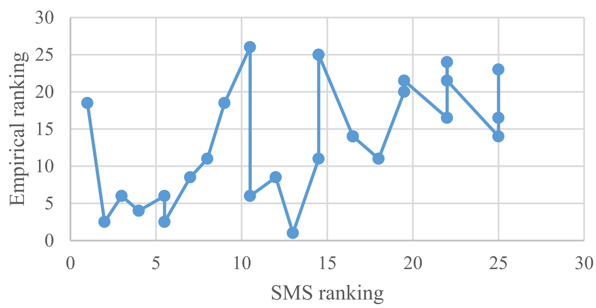

Fig. 11. Systematic mapping study and survey correlation scatter graph of project characteristics.

tive, some product characteristics do not have a considerable effect on method tailoring; for example, "product size" has rank 3 in the SMS, while its rank in the empirical study is 11.5. This issue has been brought up by one of the practitioners:

> "*for most of the product attributes (*i.e. *security, reliability, performance, maintainability, functional suitability, and compatibility), I think the aforementioned method tailoring is usually manifested mainly in the form of code reviews (and brain-storming sometimes); it cannot be considered a significant method tailoring.*"

The value of R_s for project characteristics is 0.566, indicating the positive correlation between the ranks; the value of p in this analysis ($0.003 < 0.05$) demonstrates that this correlation is statistically significant. Positive correlation indicates that the higher the rank of a project characteristic identified via the SMS, the higher its rank in the questionnaire survey, and vice versa. The correlation coefficient for organization characteristics is 0.702, and shows the positive relationship between the ranks; the value of p in this analysis ($0.011 < 0.05$) indicates that this correlation is statistically significant.

To analyze the correlation between the results of SMS and the questionnaire-based empirical study, scatter plots of the ranks of product, project, and organization characteristics in the two data sets have been shown in Figs. 10 –12, respectively. As seen in these figures, there is no linear pattern in the points in the scatterplots; this illustrates that there are more differences than similarities between the ranks of product, project, and organization characteristics in the two data sets.

In addition to Spearman's rank-order correlation, the independent t-test has been performed to calculate the mean differences between the SMS and the empirical study, as shown in Tables 18 and19. The independent t-test has been selected since it is commonly used to test statistical differences between the means of two independent groups with a normal distribution (approximately) of the dependent variable for each group; based on the group statistics shown in Table 18, the two data sets have a normal distribution. The independent t-test also requires the assumption of homogeneity of variance; the Levene's test has therefore been performed for the homogeneity of variance.

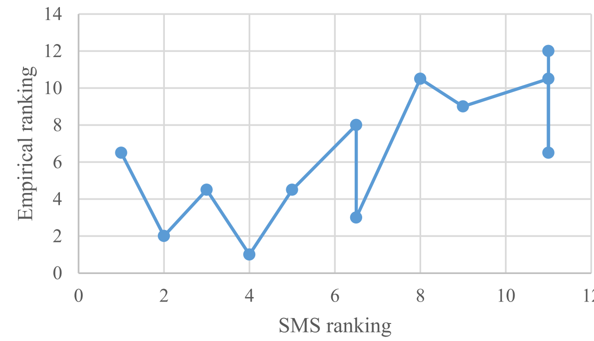

Fig. 12. Systematic mapping study and survey correlation scatter graph of organization characteristics.

As shown in Table 19, the Levene's test for product factors is not significant ($1>0.05$); the option "Equal variances not assumed" has therefore been considered. Based on this assumption, the t-test results are $t = 0$ and $p = 1 > 0.05$, which demonstrates that there is no significant difference between the findings of the SMS and the questionnaire. The results of the test for project and organization characteristics have also shown that there are no significant differences between the results of the SMS and the questionnaire. These results have been obtained because the values of the mean in the two data sets are equal, thereby demonstrating the level of agreement between academic and industrial perspectives on the average degree of importance of tailoring criteria.

In addition to the above statistics, the median values have been calculated for the results of the questionnaire, which are provided in (Agh et al., 2019).

The results show that the general agreement on the importance of product, project, and organization characteristics is greater than the median value (3) except for certain characteristics, for which the score is 3, including *Portability, Application domain, Turnover rate, Hardware development, Application reuse, External business dependencies*. This general baseline value indicates that practitioners agree that the identified characteristics should be considered as tailoring criteria.

5. Requirements for adopting SPrLs

In this section, a set of requirements are presented that can be used for deciding about implementing the SPrL approach in organizations. These requirements have been identified with reference to the results obtained from the SMS and the empirical study. To identify these requirements, we should specify the product, project, and organization characteristics that have a considerable effect on method tailoring. The following criterion has been used for this purpose:

> "A characteristic is considered as a critical factor in method tailoring if the percentage of its citation in the literature is greater than or equal to 50%, or if the positive percentage of responses to the characteristic in the questionnaire survey is greater than or equal to 50%."

Based on this criterion, which has been successfully applied in previous research efforts (Akbar et al., 2011; Rainer and Hall, 2002), a set of characteristics which are considered of greatest importance in method tailoring have been identified (shown in Table 20). Although we use this criterion for identifying the characteristics critical to method tailoring, practitioners can define their own criterion in order to decide the importance of a characteristic.

Table 18
Group statistics.

	Group	N	Mean	Std. deviation	Std. error mean
Product factors	SMS	13	7	3.88	1.07
	Survey	13	7	3.77	1.05
Project factors	SMS	26	13.5	7.63	1.50
	Survey	26	13.5	7.63	1.50
Organization factors	SMS	12	6.5	3.57	1.03
	Survey	12	6.5	3.59	1.04

Table 19
Independent samples *t* -test.

		Levene's test for equality of variances		*t*-test for equality of means				95% Confidence interval of the difference	
		F	Sig	t	Df	Sig (2-tailed)	Mean difference	Lower	Upper
Product factors	Equal variances assumed	0	1	0	24	1	0	−3.094	3.094
	Equal variances not assumed	–	–	0	23.986	1	0	−3.094	3.094
Project factors	Equal variances assumed	0.005	1	0	50	1	0	−4.249	4.249
	Equal variances not assumed	–	–	0	50	1	0	−4.249	4.249
Organization factors	Equal variances assumed	0	1	0	22	1	0	−3.031	3.031
	Equal variances not assumed	–	–	0	22	1	0	−3.031	3.031

In the third column of Table 20, the requirements that are important for adopting SPrLs have been presented. It should be noted that the requirements in the organization category are related to organizations that have headquarters in different locations, such as multi-national or international companies, while other requirements are meaningful for any type of software company. Hence, we have excluded the "Distribution of project organization" characteristic from the organization category, since this particular characteristic refers to the geographical distribution of organization units, and it should already be true when we consider organization-related requirements for creating SPrLs.

As shown in Table 20, there are characteristics related to methodologies that form a SPrL portfolio; these methodologies will be used in constructing the core process/common architecture of a SPrL, or will be instantiated from the SPrL. These characteristics are as follows:

- **Structural similarity**: This characteristic refers to the degree of similarity in the structure of methodologies that form the SPrL portfolio. Structural similarity has already been used in the domain of the software product line, to enable developers to reuse components across a range of different products (Schmid and Verlage, 2002). In (Alves et al., 2008), similarities between requirements in requirement specification documents have been analyzed to construct the feature model of an SPL. Structural similarity is also used in the context of BPLs for different purposes, such as searching for process models stored in a repository that are similar to each other (Schoknecht et al., 2017; Yan et al., 2010).
- **Method type similarity**: Product line scoping is an essential activity in the context of software product line engineering (Schmid and Verlage, 2002; Van der Linden, 2002) and refers to the products, technical areas, and functionalities that a product line should support. This characteristic is also important for creating a SPrL and has to do with the type of methodologies that will be part of the SPrL. Classifying methods as agile and predictive is a typical classification for methodology management approaches.

Table 20 presents the general requirements that should be considered when deciding about SPrL creation. However, the level of importance of these requirements may not be the same in different contexts. Furthermore, when applying these requirements in a specific context, a threshold should be defined that determines the minimum score to be satisfied by the organization in order to be suitable for creating the SPrL. For example, let us consider that for a specific domain, the levels of importance of the requirements have already been specified by conducting one or more case studies, as shown in the second column of Table 21. The threshold specified for this domain is also set to 20. Suppose that an organization developing products in this domain is interested in creating a process line. The evaluation of the requirements in this organization is shown in the third column of Table 21. The level of satisfaction of requirements for this organization can be calculated by multiplying each cell of the second column by its corresponding cell in the third column, and summing up the results; the fourth column in Table 21 shows the results for our example. As shown in this table, the total score is 24; therefore, based on the threshold value of 20, this organization is a suitable candidate for creating a SPrL.

6. Summary and limitations

A short summary of the research will be provided in this section, followed by a discussion on the threats to its validity.

6.1. Research overview

The aim of this research was to identify the requirements that should be considered for deciding about creating a SPrL. The ultimate goal of this research is to develop a framework for creating SPrLs in organizations (Agh and Ramsin, 2017).

In order to specify the requirements, we first conducted a systematic mapping study; this study focused on identifying method tailoring criteria. A set of tailoring criteria, including product, project, and organization characteristics, was specified by analyzing 43 papers selected through the SMS.

Table 20
Requirements for adopting SPrLs.

	Characteristic	Requirement for adopting SPrL
Product	Criticality	Significantly different criticality levels in different products
	Product type	Significantly different product types produced
	Product size	Significantly different product sizes produced
	Security	Significantly different security levels in different products
	Product complexity	Significantly different complexity levels in different products
	Maintainability	Significantly different maintainability needs in different products
	Usability	Significantly different usability needs in different products
	Performance efficiency	Significantly different performance efficiency levels in different products
	Compatibility	Significant difference in the level of compatibility with organization laws/standards, or with existing systems, in different products
	Reliability	Significantly different reliability needs in different products
	Product Predictability	Significantly different complexity levels in predicting the requirements/project schedule/project cost in different products
	Functional suitability	Significantly different levels of rigidity in meeting stated and implied needs of products
Project	Resource constraints	Significantly different levels of resource constraints in different projects
	Team members' knowledge/skill	Significant difference in the level of team members' skill/knowledge in different projects
	Project size/duration	Projects of significantly different sizes/durations undertaken
	Project risk/complexity	Significantly different risk/complexity levels in different projects
	Teams' physical characteristics	Significant difference in the number or size of teams in different projects
	Requirements characteristics	Significant difference in changeability, understandability, or feasibility of user/system requirements in different projects
	Stakeholder characteristics	Significant difference in the level of stakeholder involvement, number of stakeholders involved, and/or background/knowledge level of stakeholders in different projects
	Team cohesion	Significant difference in team cohesion (Distributed/Collocated) in different projects
	Project type	Significantly different project types undertaken (i.e., outsourced and insourced)
	Technology-related issues	Significant difference in technological environments (tool infrastructures, test environments, COTS products) and/or architectural decisions in different projects
	Team culture	Significant difference in the level of cooperation, cooperation history, and/or disharmony among team members, in different projects
	Type of development	Variable types of development (developing new systems /modification of existing systems) undertaken in different projects
	Project contract characteristics	Significant difference in contract types (fixed date/fixed price) and/or the level of interaction between contractor and developers in different projects
	Customer characteristics	Significant difference in customer cohesion and/or customer variety in different projects
	Innovation level	Significant difference in the degree of novelty and/or the level of technology emerging in different projects
	Team productivity	Significantly different productivity levels in the teams involved in different projects
	Legacy system documentation	Significant difference in the availability of legacy system information in different projects
	End-user characteristics	Significant difference in the level of end-user variety, their availability, and/or their experience with the system in different projects
	Application deployment profile	Significant difference in the number of deployed versions of applications, or the number of deployed applications in different projects
	User-interface	Significant difference in importance of user interface in different projects
	Project opportunities	Significant difference in the rate at which emergent opportunities occur in different projects
	Measurement	Significant difference in the importance of status information for the top management in different projects
Organization	Organization size	Significant difference in sizes of distributed organizations
	Organization structure/culture	Significant difference in structure/culture of distributed organizations
	Organization maturity	Significant difference in maturity levels of distributed organizations
	Resource constraints	Significantly different levels of resource constraints in different organizations
	Management-related characteristics	Significant difference in the level of commitment, support, expertise, availability, accomplishment, and/or continuity among the managers
	Business drivers	Significantly different crucial forces behind the successful development of a project in different organizations
	Business domain	Significantly different product types in different organizations
	Organization standards /legal aspects	Significant difference in standards or legal aspects
	Organization stability	Significantly different stability levels in different organizations
	Level of innovation	Significantly different innovation levels in different organizations
Methodology	Structural similarity	Specific level of similarity as to the structure of methodologies
	Method type similarity	Similarity in type of methodologies

The results of the SMS were then analyzed by designing a questionnaire and distributing it among practitioners who had experience in method tailoring. We applied Spearman's correlation analysis to the ranks of method tailoring criteria in the two data sets; the results of this analysis indicated that there are more differences than similarities between the rankings specified in the SMS and the empirical study. However, the results of the *t*-test illustrate that there is no difference between the means of the rankings; that demonstrates that there is a level of agreement between the literature and the industrial environments on the average degree of importance of tailoring criteria; the median values calculated for each characteristic also confirmed this result.

To specify the requirements for adopting the SPrL approach, we first identified the tailoring criteria that are most critical; a tailoring criterion was considered as a critical factor if it had a frequency ≥50%, either in the literature or in the empirical study. Require-

Table 21
An example of application of requirements for deciding about creating the process line.

Requirement	Level of importance [0–10]	Satisfaction by organization (Yes = 1, No = 0)	Score
Significantly different criticality levels in different products	3	1	3
Significantly different product types produced	2	1	2
Significantly different product sizes produced	1	1	1
Significantly different security levels in different products	0	1	0
Significantly different levels of resource constraints in different projects	5	0	0
Significant difference in the level of team members' skill/knowledge in different projects	4	0	0
Projects of significantly different sizes/durations undertaken	5	1	5
Significantly different risk/complexity levels in different projects	2	1	2
Organization size	4	1	4
Organization structure/culture	0	1	0
Organization maturity	2	1	2
Resource constraints	1	0	0
Management-related characteristics	8	0	0
Specific level of similarity as to the structure of methodologies	2	1	2
Similarity in type of methodologies	3	1	3
			Sum = 24

ments for adopting the SPrL approach were then defined, based on the specified tailoring criteria. Furthermore, two requirements related to methodologies themselves were also established by studying the research work on SPL and BPL, including: Structural similarity, and Method type; these characteristics show that a degree of similarity should exist in the structure and type of the methodologies that form the SPrL portfolio.

6.2. Threats to validity

There are several threats to the validity of this study, including:

- **Internal validity**: The first threat to internal validity of the SMS is that in some publications, some tailoring criteria have not been explicitly mentioned; we handled this threat by carefully analyzing the case studies, experiments, and other empirical studies conducted in those publications. The second threat to internal validity of the SMS pertains to the validity of research questions; we dealt with this threat by evaluating the search strings through conducting a limited manual search to see whether the results of that manual search actually show up in the results obtained by running the search strings. The third threat to internal validity of the SMS is the accuracy of the extracted data: it was not possible to involve multiple researchers for extracting the data; hence, data extraction was conducted by the first author. However, sessions were held with the other authors of this paper in order to resolve the ambiguities that arose during the data extraction stage. As for the questionnaire study, one possible internal threat to its validity is the potential lack of experience in the respondents; we mitigated this risk by sending the questionnaire to practitioners who had a good deal of experience in method tailoring.
- **Construct validity**: One of the potential threats to construct validity is incompleteness of the SMS; the results of an SMS depend on the keywords used, as well as on the limitations of the search engines. We dealt with this threat by using alternative synonyms to build the search string, and by using different digital databases to reduce the limitations of the existing search engines. The second possible threat to construct validity of the SMS is related to the selection of the papers; we mitigated this threat by performing a three-staged filtering process to select the related papers, and also by using the snowballing technique. With respect to the questionnaire survey, the potential threat to construct validity is the misunderstanding of the questions; to deal with this, we added explanations to the tailoring criteria in the questionnaire. A pre-test was also conducted before sending the questionnaire, to ensure that it was comprehensive and understandable. The third threat to construct validity of the SMS is the inclusion of secondary studies; to mitigate this threat, the overlaps between primary studies of the secondary studies and primary studies of the SMS were examined. If a characteristic was mentioned in a primary study that was simultaneously included in our paper and in a secondary study, only the primary study was cited (not the secondary study) as the reference used for extracting the characteristic.
- **Conclusion validity**: One of the potential threats to conclusion validity is low statistical power. The scope of the SMS was limited to six digital libraries (namely: Scopus, ACM Digital Library, ScienceDirect, IEEEXplore, SpringerLink, Wiley InterScience). However, there are other related digital libraries that were not considered in the study. Furthermore, as the goal of the survey was specifying method tailoring criteria that were empirically used in industrial settings, we did not use a randomized sampling strategy; instead, we sent the questionnaire to practitioners who were experienced in method tailoring. For the mentioned reasons, the number of primary studies in this research is 43 and the number of respondents is 31. Nevertheless, we believe that our results are comprehensive and can be used by practitioners interested in method tailoring or creating SPrLs as well as by researchers interested in conducting research in the fields of method tailoring or SPrL.
- **External validity**: One inherent limitation of a questionnaire study is its external validity. We sent the questionnaire to 45 practitioners, and received 31 completed questionnaires (69%); the response rate is therefore acceptable. However, we may not be able to generalize the findings of the empirical study, since the questionnaire was sent only to Iranian and Spanish companies. Nevertheless, a questionnaire survey is a suitable type of research for understanding trends from an industrial perspective (Lethbridge, 2005). Hence, in our opinion, the results of this study provide practitioners with a reasonable list of requirements for adopting SPrL approaches based on academic and industrial practices.

7. Related work

The aim of this research is to provide software organizations with a comprehensive set of requirements to support them in deciding on whether or not to adopt the SPrL approach. There is no previous research work on identifying requirements for adoption of SPrL approaches. However, as part of this research, we conducted an SMS to identify the method tailoring criteria reported in the literature. Therefore, systematic literature reviews or mapping studies on method tailoring can be considered as works that are related to this research.

Kalus and Kuhrmann (2013) conducted an SLR to provide a catalog of tailoring criteria documented in the literature and to then analyze the impact of these criteria on project-specific methodologies. Akbar et al. (2011) analyzed the different approaches to methodology improvement and tailoring; as many approaches lack proper methodologies and are not properly validated, they have concluded that for method tailoring to be applicable in the IT industry, tailoring methods should be of a more formal and applied nature. Pedreira et al. (2007) conducted a systematic review, seeking to identify the approaches, methodologies, and support tools proposed for method tailoring; the authors identified two problems as the most important issues in method tailoring: creating a general framework for method tailoring that is applicable to organizations of different sizes, and compliance with standards such as ISO/IEC 15504. Martínez-Ruiz et al. (2012) conducted an SLR to identify requirements for method-tailoring notations; the authors concluded that tailoring notations are not mature enough to be consistent with industry requirements.

SLRs have also been conducted on agile method tailoring. In particular, Campanelli and Parreiras (2015) carried out an SLR to analyze the approaches adopted for agile method tailoring, as well as the criteria used for agile practice selection. The results of this study show that method engineering is the most widely-used approach for agile method tailoring; in addition, they also show that internal environmental criteria (e.g., project type) and objective criteria (e.g., degree of innovation) are the main criteria used for selection of agile practices. Dikert et al. (2016) conducted an SLR to analyze large-scale industrial agile transformations. The main focus of this research is to find the reported challenges and success factors of such transformations.

A few mapping studies have also been conducted on agile method tailoring. In particular, Diebold and Dahlem (2014) carried out a mapping study to identify the agile practices that are used in industry under different circumstances; the results of this study show that the domain influences the selection of agile practices.

The literature reported above consists of SLRs or systematic mapping studies conducted on method tailoring. Although method tailoring criteria have been considered in these research works, they cannot be directly used for defining a set of requirements for SPrL adoption since the criteria mentioned in these studies are not validated from an industrial perspective. In particular, there are three main differences between the work presented here and the research works conducted on method tailoring:

1- We have validated the criteria extracted via the SMS from an industrial perspective.
2- By analyzing the results of the SMS and the survey, we have specified the importance level of criteria from both academic and industrial perspectives.
3- We have defined a set of requirements for adopting the SPrL approach based on the results of the SMS and the survey.

Although there is no previous research work on identifying requirements for adoption of SPrL approaches, there are specific works on supporting SPL adoption (e.g., Bastos et al., 2017). Since a SPrL is a specialized SPL in the context of method definition, it is worth to compare these works with ours, as to both content and methodology. Bastos et al. (2017) have used a multi-method research approach to collect empirical evidence on SPL adoption in Small to Medium-sized Enterprises (SMEs). The methods used in their research are Systematic Mapping Study, Case Study, and Expert Survey. In the first stage (Bastos et al., 2011), a mapping study has been carried out in order to investigate state-of-the-art SPL adoption, synthesize available evidence, and identify gaps between the required strategies, organizational structures, maturity level and existing adoption barriers. In the second stage (Bastos et al., 2015), an industrial case study has been conducted in a small to medium-sized organization to gain a better understanding of SPL adoption in SMEs; in this study, the four perspectives considered in the mapping study (adoption strategies, organizational structures, adoption barriers, and organizational maturity level) have been investigated; in the third stage, based on the two previous studies, a survey involving SPL experts has been performed to characterize SPL adoption in SMEs based on expert opinion. In a separate work (Bastos et al., 2017), the authors have integrated the results of the three methods to propose transition strategies that can be used by SMEs to move from single system development to product line engineering, organizational structures that may facilitate or hinder effective and efficient SPL engineering, adoption barriers (e.g., Projects sponsors and customers view, organization and development groups' view), and the specific level of maturity that an organization should achieve before considering SPL adoption.

In comparison, from a methodological point of view, we have similarly used a multi-method approach (SMS and Expert Survey) to identify a set of requirements for SPrL adoption; furthermore, we too have used the overall results of the SMS and expert survey to achieve the goals. When comparing the two works as to content, both works share "organizational structure" and "organizational maturity" as factors. In Bastos et al. (2017), organizational structures and organizational maturity levels suitable for SPL adoption have been specified. We have similarly identified “Organization structure” and “Organization maturity” as two organization-level requirements for adopting SPrL approaches; however, in Bastos et al. (2017), two specific research questions have been designed to specify organizational structures and maturity levels, whereas in our work they have been identified as two requirements (out of 46). Furthermore, we have mentioned that the requirements in the organization category (including “Organization structure” and “Organization maturity”) are related to organizations that have headquarters in different locations, such as multi-national or international companies, whereas Bastos et al. (2017) have specified organizational structures and maturity levels that may facilitate or hinder effective and efficient SPL engineering in a general sense.

The similarities between our approach and Bastos et al. (2017) can be summarized as follows:

1) Both research works have investigated the adoption of approaches that can potentially result in improvements in product quality, and time-to-market reductions;
2) Both research works have specified conditions that an organization should satisfy before adoption of the new approach; in our approach, those conditions have been specified by identifying a set of requirements, whereas in Bastos et al. (2017), maturity level and organizational structure are the conditions that should be considered;
3) Both research works have used a multi-method approach to achieve their objectives.

The differences between our approach and Bastos et al. (2017) can be summarized as follows:

1) Our approach is focused on SPrL adoption, whereas Bastos et al. (2017) is concerned with SPL adoption;
2) In Bastos et al. (2017), transition strategies and adoption barriers have been investigated, whereas they have not been addresses in our approach, since our approach is specifically focused on the requirements that should be considered prior to SPrL adoption.

8. Conclusions and future work

Defining a specific methodology for each project situation has become a crucial need in software development organizations. SPrL approaches help construct bespoke software development methodologies according to the specifications of the project at hand through the reuse of methodology assets. However, organizations should examine the suitability of this approach before accepting it. There is therefore motivation to identify a list of requirements that can be used for deciding about adopting SPrL approaches. We have used two approaches to identify these requirements: A Systematic Mapping Study (SMS) and a questionnaire survey. By comparing the results of the SMS to the survey results, we identified 12 product-related requirements, 22 project-related requirements, and 10 organization-related requirements. We also pinpointed 2 requirements related to the methodologies themselves.

As stressed before, in order to apply the results of this research in real-world projects, it is necessary to determine the level of importance of each requirement, along with an acceptance threshold (minimum total score), for the target domain; typically, these values are determined through conducting case studies or experiments; therefore, the requirements identified herein provide a basis for future research in this regard. Furthermore, the method tailoring criteria specified in the literature have been empirically validated by the expert survey; practitioners can therefore consider them as a set of criteria that have empirically influenced method tailoring. Researchers can also consider these characteristics as a basis for identifying additional tailoring criteria, and thereby eliciting additional requirements for SPrL creation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Halimeh Agh: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - original draft. **Félix Garcia:** Validation, Investigation, Resources, Writing - review & editing, Supervision. **Mario Piattini:** Resources, Writing - review & editing, Supervision, Project administration. **Raman Ramsin:** Writing - review & editing.

Acknowledgments

This work was supported by the Ministry of Science, Research, and Technology of Iran; BIZDEVOPS-Global [grant number RTI2018-098309-B-C31], Ministerio de Economía, Industria y Competitividad (MINECO) y el Fondo Europeo de Desarrollo Regional (FEDER); G3Soft [grant number SBPLY/17/180501/000150 Model Engineering for Government and Management of Global Software Development] and GEMA (Generation and Evaluation of Models for dAta Quality), Consejería de Educación y Ciencia, Junta de Comunidades de Castilla-La Mancha.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jss.2020.110546.

Appendix A. Primary Studies

Table A.1 shows the primary studies considered in the SMS.

Table A.1
List of primary studies.

No.	Title	Author(s)/Year	Venue
[1]	Criteria for Software Process Tailoring: A Systematic Review	(Kalus and Kuhrmann, 2013)	International Conference on Software and System Process
[2]	Agile methods tailoring–A systematic literature review	(Campanelli and Parreiras, 2015)	Journal of Systems and Software
[3]	Variability and reproducibility in software engineering: A study of four companies that developed the same system	(Anda et al., 2009)	IEEE Transactions on Software Engineering
[4]	A framework for adapting agile development methodologies	(Cao et al., 2009)	European Journal of Information Systems
[5]	Tailoring the software maintenance process to better support complex systems evolution projects	(Donzelli, 2003)	Journal of Software: Evolution and Process
[6]	Customising agile methods to software practices at Intel Shannon	(Fitzgerald et al., 2006)	European Journal of Information Systems
[7]	Artefacts and agile method tailoring in large-scale offshore software development programmes	(Bass, 2016)	Information and Software Technology
[8]	The impact of tailoring criteria on agile practices adoption: A survey with novice agile practitioners in Brazil	(Campanelli et al., 2018)	Journal of Systems and Software
[9]	Tailoring and introduction of the rational unified process	(Hanssen et al., 2007)	European Conference on Software Process Improvement
[10]	Tailoring RUP to a defined project type: A case study	(Hanssen et al., 2005)	International Conference on Product-Focused Software Process Improvement
[11]	Strengths and barriers behind the successful agile deployment—Insights from the three software intensive companies in Finland	(Pikkarainen et al., 2012)	Empirical Software Engineering
[12]	Global software engineering and agile practices: A systematic review	(Jalali and Wohlin, 2012)	Journal of Software: Evolution and Process
[13]	Identifying high perceived value practices of CMMI level 2: An empirical study	(Niazi and Babar, 2009)	Information and Software Technology
[14]	Modified agile practices for outsourced software projects	(Batra, 2009)	Communications of the ACM
[15]	Agility in context	(Hoda et al., 2010)	ACM Sigplan Notices
[16]	Building software process lines with CASPER	(Hurtado and Bastarrica, 2012)	International Conference on Software and System Process
[17]	A systematic method for process tailoring based on knowledge reuse	(He et al., 2008)	International Conference on Software Engineering and Knowledge Engineering
[18]	Systematic approach to risk management in software projects through process tailoring	(Fontoura and Price, 2008)	International Conference on Software Engineering and Knowledge Engineering
[19]	Scoping software process models-Initial concepts and experience from defining space standards	(Armbrust et al., 2008b)	International Conference on Software Process
[20]	Managing process diversity by applying rationale management in variant rich processes	(Martínez-Ruiz et al., 2011)	International Conference on Product-Focused Software Process Improvement
[21]	Software process commonality analysis	(Ocampo et al., 2005)	Software Process: Improvement and Practice
[22]	A systematic approach to process tailoring	(Pereira et al., 2007)	International Conference on Systems Engineering and Modeling
[23]	A pattern-based model-driven approach for situational method engineering	(Agh and Ramsin, 2016)	Information and Software Technology
[24]	An agile development methodology applied to embedded control software under stringent hardware constraints	(Cordeiro et al., 2008)	ACM SIGSOFT Software Engineering Notes
[25]	Customization of Scrum methodology for outsourced e-commerce projects	(Hong et al., 2010)	International Asia Pacific Software Engineering Conference
[26]	Using process tailoring to manage software development challenges	(Xu and Ramesh, 2008)	IT Professional
[27]	A semi-automated filtering technique for software process tailoring using neural network	(Park et al., 2006)	Expert Systems with Applications
[28]	Tailoring software development methodologies in practice: A case study	(Lycett et al., 2008)	Journal of Computing and Information Technology
[29]	MDE software process lines in small companies	(Hurtado et al., 2013)	Journal of Systems and Software
[30]	MDE-based process tailoring strategy	(Hurtado et al., 2014)	Journal of Software: Evolution and Process
[31]	A framework of software process tailoring for small and medium size IT companies	(Akbar et al., 2012)	International Conference on Computer & Information Science
[32]	A tool for modeling software development contexts in small software organizations	(Ortega et al., 2012)	International Conference of the Chilean Computer Science Society
[33]	Challenges and success factors for large-scale agile transformations: A systematic literature review	(Dikert et al., 2016)	Journal of Systems and Software
[34]	Quality attribute techniques framework	(Chiam et al., 2009)	European Conference on Software Process Improvement
[35]	Contextualizing agile software development	(Kruchten, 2013)	Journal of Software: Evolution and Process
[36]	Process Diversity and how practitioners can manage it	(Caivano and Visaggio, 2004)	Upgrade, the European Journal for the Informatics Professional
[37]	The situational factors that affect the software development process: Towards a comprehensive reference framework	(Clarke and O'Connor, 2012)	Information and Software Technology
[38]	Experiences and results from tailoring and deploying a large process standard in a company	(Armbrust et al., 2008a)	Software Process: Improvement and Practice
[39]	An industry experience report on managing product quality requirements in a large organization	(Mohagheghi and Aparicio, 2017)	Information and Software Technology
[40]	Complex software project development: Agile methods adoption	(Mishra and Mishra, 2011)	Journal of Software: Evolution and Process
[41]	Latitudinal and longitudinal process diversity	(Siebel et al., 2003)	Journal of Software: Evolution and Process
[42]	The introduction and use of a tailored unified process-a case study	(Westerheim and Hanssen, 2005)	International EUROMICRO Conference on Software Engineering and Advanced Applications
[43]	Effects of agile practices on social factors	(Law and Charron, 2005)	ACM SIGSOFT Software Engineering Notes

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