Risk Management in Software Product Lines: An Expert Opinion Survey

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Abstract. *Software Product Line (SPL) Engineering is a software development paradigm focused on systematic reuse, which provides companies with several benefits, such as improved quality of delivered products and reduced time to market. However, major investments and considerable risks are also inherent. In this context, managing the risks and providing strategies to avoid and mitigate them are mandatory tasks during software development. In this study, we present the results of an expert survey, carried out with the aim to figure out how the SPL experts have been worked with Risk Management (RM) in their projects. We observed that experts do not always address the RM activities during real world project development, what can be justified that RM is an open issue when related to SPL.*

1. Introduction

Software Product Line (SPL) Engineering can be defined as a set of software systems sharing a common and managed suite of features that satisfy a particular market, or mission's needs, developed in a prescribed way [Clements and Northrop, 2001]. The SPL goal is to exploit commonalities and variabilities among the applications, in order to achieve large-scale reuse, reduced time to market, improved quality and minimized costs, key aspects for software companies interested in improving their productivity [Schmid, 2002]. The benefits of SPL are evident and there is an increasing number of companies adopting such a development paradigm, based on its economic and strategy benefits, as points out a relevant list of success stories [Weiss et al., 2006].

However, the SPL development is particularly complex, raising specific and advanced engineering and management challenges. Adopting a SPL demands a considerable effort, once is necessary to develop the assets that will be part of the product line, in order to define the domain in which the SPL will be developed [Clements and Northrop, L. 2001; Schmid, 2002; Lobato, 2012]. Indeed, because of its inherent characteristics, the adoption involves major investments and many risks can be associated with it. The potential risks may vary widely over different domains and projects [Schmid, 2002]. Thus, is important to consider Risk Management (RM) practices in SPL projects. In case of an improper risk management along a SPL project, the expected success might not be achieved. However, despite the success stories in

SPL adoption [Gacek et al., 2001; Linden et al., 2007] and the relevance of RM to develop SPL projects [Schmid, 2002], there is few evidence that support assumptions on RM reports about SPL industrial practices, as identified in our preceding investigation [Lobato, 2012]. Schmid (2002) identified that most approaches do not address risk evaluation in SPL. Even ten years after, this scenario is still true. We observed a reduced number of approaches addressing RM practices in SPL, and also a lack of industrial assessment of the existing ones. Moreover the approaches addressing RM in SPL, usually do not present detailed results about how the approach was applied and no details about the study performed.

In our previous research [Lobato, 2012], we observed that the lack of information regarding SPL management, specifically in terms of risk analysis, is a gap in this research field since the software industry does not seem to follow a model to analyze and control the risks through the development of their products.

Despite that expert survey is not a new idea in the SPL research topic, unfortunately, we cannot find any study that investigates experts' opinion on RM practices in SPL engineering. However, knowing what experts think about this topic might lead to a better understanding on the potential issues related to management in SPL could run into. Thus, we selected some studies that contributed to the conduction of this research. In this sense, in order to contribute with more empirical studies about RM in SPL, in this paper we presented a survey based on experts' opinion carried out with the following goals: i) identify insights about their experience in SPL projects, regarding RM practices; ii) validate previous identified risks, which were collected from earlier investigations – literature reviews [Lobato, et al. 2012a] and cases studies on RM practices [Lobato, et al. 2012b]; and iii) describe the most common risks, and associate them to the SPL essential activities: Core Asset Development (CAD), and Product development (PD) and Management (M) [Northrop, 2002].

The remainder of this paper is organized as follows: Section 2 presents related work. Section 3 describes the research method used. Section 4 details the survey questionnaire, and presents the gathered data. Section 5 presents the analysis of the results. Section 6 addresses the main findings and the threats to validity. Finally, Section 7 draws concluding remarks.

2. Related Work

Ahmed and Capretz (2007) presented a quantitative survey, applied to software companies working with SPL, to gather information from practitioners. It aimed at gathering insights on practices commonly applied in the SPL development from a management point of view. They found out that companies have to cope with multiple key business factors to improve the overall performance of the business and to improve their efforts during software development (related to optimize the development and provide quality about the services).

Apart from SPL related studies, we also found another set of related studies that, although bearing no relationship to SPL, hold importance to our survey, especially in terms of lessons learned, and insights about RM practices, which are briefly summarized next.

Ropponen and Lyytinen (2000) presented a survey focused on identifying RM practices in traditional software engineering. The questions involved risks and presented

scenarios in which the subjects needed to define an occurrence rate to the risks, based on what they faced during their projects. Thus, a risk list was defined based on the expertise of these managers. Additionally, Li et al. (2008) surveyed RM in the development of Commercial Off-The-Shelf (COTS) components. They investigated existing RM activities and their correlations with the occurrences of typical risks in COTS development. The results indicated that several factors, such as project characteristics, cultural, and human aspects, have to be investigated to deal with possible risks.

Despite that these are studies related to RM on practices in traditional software engineering, we used them as lessons learned in order to identify insights that can be used to develop a survey about RM focused on SPL. One of the most important issues is related to consider the core assets development during the SPL engineering, where different risks can be associated. In this sense, we defined some research questions that reflect SPL practices.

3. Research Method

Kitchenham and Pfleeger (2008) state that surveys are probably the most commonly used research method to gather opinions from experts. Fink (1995) shows that a survey is not applied only as an instrument for gathering information, but also to provide a way to compare or share the knowledge. *Experts' opinions* or judgments are series of scientific endeavors, employed to interpret data, anticipate system's behaviors, and evaluate uncertainties [Li and Smidts, 2003]. This kind of study is performed through a research applied to people who are considered experts in a field, in order to identify speculations, guesses and estimates, which may serve as a cognitive input in some decision process [Chhibber et al., 1992].

We designed this work by combining guidelines for surveys [Kitchenham and Pfleeger, 2008] and the best practices of expert opinion [Li and Smidts, 2003]. Additionally, Cruzes and Dybå, (2010) presented the survey method as a set of structured closed-ended questions to extract data that will be aggregated in further analysis, where qualitative and quantitative evidence are synthetized in order to identify relevant data. This section is structured according to set of activities performed.

3.1. Setting the Objectives

A survey should address the objectives defined in the research to guarantee the achievement of the expected outcomes [Kitchenham and Pfleeger, 2008]. In this survey, we aim at identifying the risks that experts have already identified in SPL projects. Our interests also include the factors that influence the risks occurrence and which mitigation and contingency strategies might be applied to avoid and solve them.

3.2. Survey Design

Different survey designs encompass distinct objectives, so that it is relevant to define a concise survey design in order to clearly set all the specific goals. Two purposes can be distinguished from the survey design [Fink, 1995]: *the experimental design* is characterized by arranging to compare two or more groups, at least one of which is experimental, and *descriptive design* produces information on groups and phenomena that already exist.

In this survey, we used the *experimental design*, comparing answers from academic and industrial experts. The *descriptive design* was also followed, since we validated the risks identified in a previous research, to provide new information regarding SPL activities which risks were commonly associated with, given their occurrence. This survey was performed as a *self-administered questionnaire* available in the Internet. It was performed between August and September, and we asked the participants to give a feedback within a period of 2 months. Hence, by the end of November we collected all data for analysis. We believe that such a decision could motivate more experts to participate in our study.

3.3. Developing the Survey Instrument

The main information sources to propose our questions were based on the research presented by Ropponen and Lyytinen (2000) and Ahmed and Capretz (2007). The questions were organized into topics, according to Kitchenham and Pfleeger (2008) guidelines, where each topic addresses a specific goal.

The questionnaire was also developed following the experience obtained from previous investigation on the topic [Lobato et al., 2012a; Lobato et al., 2012b]. We refined the questions according to our experience [Neto, et al. 2012]. For validation purposes, the questionnaire was analyzed by a small group of researchers and practitioners of Software Engineering from the RiSE research group[1]. The disagreements about which questions were relevant were discussed among three SPL experts, the research group members and the authors.

In order to collect the insights, the questions were mapped into key drivers. These were adapted from the SEI (2009), which are key factors steering a program towards success or failure of the practical approach to RM. Thus, we addressed the use of the SEI Risk Taxonomy-Based Questionnaire (TBQ) supplemented with risks from the practice areas of the SEI framework. The TBQ is used as a way to consider possible sources of risk. We considered six categories of drivers, and defined how the standard drivers for software-intensive programs mapped to the drivers [Lobato, 2012].

The questionnaire was composed of nine personal questions, twelve closed questions, and seven open questions. The closed questions were formulated to validate our achievements in previous research studies. The open questions were built to collect the experts' experiences. In addition, we presented a checklist with risks for validation. The purpose of this validation is to identify in which SPL essential activities the risks occur in order to provide insights that can be followed by risk managers (or stakeholders) during software development. From this perspective, a checklist is expected to help us identifying the most hazardous and harmful risks to the project, in order to aid management.

3.4. Evaluating the Survey Instrument

Once the survey instrument is designed, it is necessary to evaluate it, in order to check whether is enough to address the preliminary stated goals. This encouraged evaluation may be called *pre-testing*, stated with a set of goals that must be analyzed [Kitchenham

[1] RiSE (Reuse in Software Engineering) is a research group involved in SPL engineering aspects. More information can be found at http://labs. rise.com.br.

and Pfleeger, 2008]. Thus, it is possible to carry out a *pre-testing* to identify misleading questions and/or poor instructions within the survey, as an opportunity to solve them before the main survey takes place. This may also contribute to reliability assessment, since it is performed using the same procedures as the survey, but, in this case, the survey instrument is applied to a smaller sample.

Two common ways to organize a survey evaluation are *focus groups* and *pilot studies* [Kitchenham and Pfleeger. 2008]. In order to validate whether the questions were sufficient to achieve our goals and calibrate our questionnaire, we performed the *pilot study* with a *focus group*. We had four rounds until achieving the appropriate questions configuration. This pilot study was performed with seven students, which are Ph.D. and M.Sc. students in Software Engineering, and three Ph.D. professors, which are experts in SPL engineering.

The main improvements in the questions were related to their organization, since the order that the questions are placed matters [Kitchenham and Pfleeger, 2008]. Personal data were considered an important aspect for our research. Further improvements were related to the open questions in place of closed questions, as we would like to capture the experts' feelings without influencing their answers. Besides, the questions should not demand much effort to be completed. This survey ended up with a questionnaire with both qualitative and quantitative questions. The qualitative were designed to identify which risks and practices the experts have already applied in their projects. The quantitative questions were asked in order to assess the application of RM during the projects and validate the risks collected in our previous studies.

3.5. Obtaining Valid Data

In order to obtain valid data about the experts' answers, some strategies can be used to motivate the experts. *Motivation* can be accomplished by giving reasons for conducting the exercise [Chhibber et al., 1992]. Thus, a brief overview of the RM importance to SPL and the research goals were presented to the experts, since there is little work in the literature that provide reliable findings about RM in SPL projects.

3.6. Expert Opinion

An important step to the survey is looking for expert judgments, since an expert is a knowledgeable authority on the research domain [Chhibber et al., 1992]. Regarding the appropriate sample size, Fowler (2002) suggests that there is no equation to exactly determine the sample size. The basic idea is to ensure the adequate sample sizes of the smallest important subgroups in the population. The subjects should be chosen based on the most relevant expertise, most accurate estimates or judgments. However, as presented by Li and Smidts (2003), there is not a known standard involving how it can be achieved.

In this way, we followed a number of criteria to systematize the selection process of the experts in this work, recognizing the merit of expertise and the diversity of opinions: Experts should have demonstrated experience through publications, and consulting or managing research in the areas related to the issues of the study; They should have experience in software development and be able to address several issues, considering how these could be used in RM to SPL; They should have been worked in universities, consulting firms, or companies that develop software, following SPL.

After selecting the target population, it is necessary to use a rigorous sampling method. We employed the *non-probabilistic* method [Kitchenham and Pfleeger, 2008], in which the participants were chosen because they are representative to the population of SPL experts. In addition, we used *known-expert judgment* [Chhibber et al., 1992], since the experts' names are showed in order to increase the confidence of our research. We selected twenty-eight SPL experts, as potential candidates. However, three of them did not receive the invitation emails, and sixteen did not answer our invitation. Thus, we had nine experts that participated in this survey. As showed in Table 1, the experts present experiences in academics (two) and industry (three), and some of them have experience in both (four). For the purpose of describing the results and personal opinions and assumptions, we omit their names related to each question, and associate a numbered ID to each one. We only present the experts names, in order to keep the confidence about the results presented in this paper, however their names are not presented related to the IDs. The goal here is to show that the SPL experts are people that have been involved in the SPL community, and, in this case, the association of the answer to each expert was not the relevant point.

Table 1. Experts selected

Name	Area	Name	Area	Name	Area
David Weiss	AI	John D. McGregor	AI	Paul Clements	A
Frank van der Linden	I	Juha Savolainen	I	Paul Gruenbacher	A
Isabel John	AI	Lawrence G. Jones	I	Ronny Kolb	AI
Legend: A – Academic; I – Industrial; AI – Academic and Industrial					

As the experts are from different regions (countries and continents), they can follow different approaches during the project development and have different rules related to the company, which can influence the number and risks type.

3.7. Analyzing the data

After designing and running the survey, the next step was to analyze the collected data. The main analysis procedure was to check all responses, in order to identify new findings about RM to be applied during SPL projects, and verify the risks classification presented by the experts.

4. Results

In the next sub-section, the experts' answers are discussed and analyzed, in details, being the answers presented by the questions type.

4.1. Personal Questions – PQ

The **PQ1**, **PQ2** and **PQ3** collected, respectively, the expert name, information about his/her work experience and the business domain. We also collected the roles in which the experts have been worked in the last five years (**PQ4. Role in the SPL Project)**. It is worth mentioning that it was possible to have a subject matching more than one role in the project, thus the number of roles exceeds the number of experts. The final data set consisted of: two Project Managers (22,22%), no Risk Manager, one System Analyst (11.11%), three Software Architect (33.33%), one Software Engineer (11.11%), three Requirements Analyst (33.33%). Two subjects (22,22%) also marked the option Other

and answered: Angel (E5) and Researcher (E11). As RM is the main focus of this survey, it should be highlighted that there was no Risk Manager, which is a threat to our research.

The respondents present experiences in different roles, which might lead to the report of different views. It is a positive point, since we have evidence on how the risks are observed. The distribution of roles is as follows: all of them have experience as a Consultant; two as a Project Manager; one as a System Analyst; three as a Software Architect; one as a Software Engineer; and three as a Requirement Analyst. An observation is that no respondents presented experience as a Risk Manager. Table 2 presents the roles distribution considering the academic and industrial background.

Table 2. Work experience vs Expert roles

ID	Work Experience		Roles								ID	Work Experience		Roles							
	A	I	C	PM	RM	SA	S	SE	RA	O		A	I	C	PM	RM	SA	S	SE	RA	O
E2	✓	✓	✓				✓				E10		✓	✓							
E4	✓	✓	✓								E11	✓		✓							✓
E5	✓	✓	✓	✓			✓		✓	✓	E12		✓	✓							
E8	✓		✓								E13	✓	✓	✓					✓	✓	
E9		✓	✓	✓		✓	✓		✓												

Legend: *Work Experience:* A-Academic; I-Industry. *Roles*: C-Consultant; PM-Project Manager; RM-Risk Manager; SA-System Analyst; S -Software Architect; SE -Software Engineer; RA-Requirement Analyst; O-Other

In **PQ5. Expertise Area**, we had the following results: seven chose Scoping as their expertise area, which represents a rate of 77.78% out of the total; six in Requirements (66.67%), eight in Architecture (88.89%), one in Implementation (11.11%), three in Testing (33.33%), three in Risk Management (33.33%), seven in Project Management (77.78%), and three experts in Configuration Management (33.33%). The respondents did not choose any other area and it may indicate a bias, since the areas addressed by the subjects were only the ones suggested by our study.

It is an important aspect since the subjects have experience with the development of different activities and can answer the questions with more confidence about the relevance of RM to SPL, regarding their experience in academy and industry. It is worth mentioning that, despite the lack of experts that have worked as Risk Manager during SPL projects, some of them had experience with risk management in SPL. Thus, we could observe that, although there is little research in these fields, RM in SPL has been applied in some projects and it is an essential activity.

In order to verify the expertise of the respondents, we defined the question **PQ6. How long have you been involved in Software Engineering?** All of them have more than five years of experience in SE projects. Regarding **PQ7. How long have you been involved in SPL?** All respondents pointed that have more than five years working with SPL. Indeed, we should have considered a different range of time (not only more than five years). This is a known issue that could be avoided since all respondents are experts in SPL and have worked a long time in this area.

In the question: **PQ8. How long have you been involved in RM?**, two experts (22.22%) reported as having less than one-year involvement in RM, and seven (77.78%) as having more than five years. Regarding RM in SPL, we defined the question: **PQ9. What was the importance given to RM in the organization?** Two experts (22.22%)

reported low importance, three pointed to medium (33.33%), and four experts (44.44%) indicated high importance to RM during SPL projects. Just one subject commented this question: *"It is hard to distinguish among these. Why would you do something of low importance? (E5)"*. Despite none of the experts had assumed the role of Risk Manager, we observed that RM has been applied in SPL projects.

Considering the **PQ10. How often are the risks monitored in the SPL projects?**, we had the same number of experts monitoring risks daily, weekly and monthly (33.33% each). Five (55.56%) commented about this question: E4 *"Risk Board only meet weekly but data is collected daily. Not certain what "monitored" means in this case"*. *E5 "vary with time and risks"*. E10 *"this is my guess, as I was not actively involved"*, E12 *"part of a weekly status briefing"*, E13 *"not at all"*. By analyzing the answers, we can see that we should have considered the option *"I don't know"* to this question, since this was addressed in the comments option.

4.2. Closed-ended Questions – CQ

We analyzed the answers to the scoping and requirements SPL disciplines since these are the focus of our research and also as a way to limit the size of the study. Whenever, RM is applied at the beginning of the project, most risks can be avoided earlier, and some of them can be visualized before becoming a problem to the whole project. Next, we present the closed questions defined, and discuss the findings of each one.

CQ1. Was the scoping phase in the SPL projects well understood? The majority of the answers pointed to positive results, with six answers *Yes* (66.67%), one answer *No* (11.11%), and two answers *Uncertain* (22.22%). This is relevant since the scoping is an essential discipline to SPL and, as such, should be considered.

CQ2. Was the scope sufficiently defined to meet the SPL project requirements? Three experts (33.33%) answered *Yes*, and six (66.67%) *Uncertain*. This result indicates the need of well defining the SPL scope, to limit what it can or cannot encompass, i.e., what should be out of scope. As the scoping is the first discipline to carry out in a SPL, all decisions taken in this discipline might impact the whole project.

After investigating the importance of RM to SPL projects, we also verified whether RM is performed or not**: CQ3. Was RM performed during the SPL project?** Seven (77.78%) experts pointed to *Yes*, one (11.11%) to *No*, and another one to *Uncertain* (11.11%). Despite all the experts reported as inexperienced in the role of Risk Manager, they have considered RM practices in their SPL projects.

CQ4. Did the organization apply RM strategies in all SPL phases? Two experts (22.22%) pointed to *Yes*, saying that RM is applied during the whole project, three (33.33%) answered *No*, and four (44.44%) were not sure about it, and answered *Uncertain*. Although the importance of applying RM in SPL projects, this practice is not commonly used. However, a considerable number of experts were not sure about this question. A possible reason is for project confidentiality. Thus, the collected data are not informed since they might be confidential.

CQ5. Were organizational and political conditions facilitating completion of RM activities to SPL? Only two experts (22.22%) mentioned *Yes*. Two experts (22.22%) answered *No*, and five (55.56%) did not have confidence about providing an

answer. This scenario shows a drawback concerning the attention of the company to the RM issues, since we had only two answers Yes. The ideal scenario is that the company should provide ways to facilitate the execution of RM during SPL projects.

CQ6. Had the staff received training on SPL practices prior to the project start? Four experts (44.44%) answered *Yes*, and another four as *Uncertain*. Only one (11.11%) answered *No*. However, this situation should be changed as the experts can start the project after the training sessions or even if the staff presents a mature knowledge about the domain and the SPL practices.

CQ7. Were SPL activities within each team coordinated appropriately? We had four answers *Yes*, four answers *Uncertain*, and one answer *No*. This question refers to the previous one, as the training can influence the execution of the activities.

CQ8. Were there specific stakeholders allocated for RM in the organization? Four experts (44.44%) answered *Yes*, two (22.22%) *No*, and three (33.33%) *Uncertain*. It is a serious problem since we identify that the risks related to users are the most common ones in the project, and sometimes the most dangerous as well, as we earlier discussed (Lobato et al., 2012a) (Lobato et al., 2012b). Thus, the stakeholders should be allocated to deal with risk management during the whole project development (Lobato, 2012).

CQ9. Were RM strategies performed effectively and efficiently? The experts did not have confidence about the correct application of RM strategies during the SPL projects, with six answers *Uncertain* (66.67%). Only two experts answered *Yes* (22.22%), and one expert said that RM strategies were not used during the projects. These findings are not good to the RM field, since RM should be a mandatory activity to the SPL project since the project success can be compromised by the lack of this type of management (Northrop, 2002).

CQ10. Were the risks identified and mitigated during the SPL phases? Six experts (66.67%) answered *Yes*, one (11.11%) *No*, and two (22.22%) *Uncertain*. Despite only two experts have marked Yes in the CQ9, which mentioned that RM strategies were performed during the project in an effective and efficient way, six experts pointed, in CQ10, that the risks were mitigated during the projects. It indicates that RM cannot be systematically performed during SPL projects. The risks are analyzed in the projects, however, the planning to manage them is not previously planned and followed accordingly.

CQ11. Were there any method/methodology/approach/tool used to manage the risks during SPL projects? We had three answers to both *Yes* and *Uncertain* (33.33%) options. Two participants (22.22%) said that none of these were used to manage the risks, and one (11.11%) did not answer the question.

CQ12. Was the RM capable of identifying and managing potential events and changing circumstances of the SPL development? Four experts (44.44%) did not know about the RM benefits. Three experts (33.33%) mentioned that RM was useful to the SPL projects, and one (11.11%) answered *No*. One expert did not answer this.

As observed, the number of answers "*Uncertain*" was large, considering that the participants came from experts in SPL projects. As suggestions, we supposed that the experts do not have access to all project information, due to confidential constraints. This can be a threat to our research, since it affects the findings because some risks can

be not identified. The idea behind using RM in a project is that, through its application, eventual risks can be identified, assessed, monitored and solved, and situations of mistakes can be avoided [Lobato, 2012]. Thus, despite that some experts are involved in industrial projects, it is also likely that they did not answer this question with a Yes, and decided to choose other answers because they are not aware about the use of the RM in the projects that they participated, since they are not the Risk Manager.

Based on the answers from the closed questions, we noticed that experts should give more attention to RM, because only a small number of them reported experience in applying RM during their projects, since no systematic management is performed and continually analyzed to the whole SPL. Thus, RM should be treated as any other project management activity. Moreover, people involved with SPL, such as managers and researchers, should raise the awareness of the RM importance, providing training to the stakeholders before starting a new project, in order to solve emerging problems.

4.3. Open-ended Questions – OQ

We designed a set of open-ended questions to enable respondents to present additional information about their experiences, addressing other issues than the listed before. Next, we present every question and discuss the findings:

OQ1. Describe the main risks and mitigation/contingency strategies related to the last SPL project you were involved in. Eight experts (88.89%) mentioned about the main risks that they have faced and the strategies used to avoid and resolve these risks. Only one expert (11.11%) did not answer the question. Table 3 presents the answers related to the risks the experts reported, as well as mitigation and contingency strategies used. In addition, we mapped these risks to the ones previously identified [Lobato et al, 2012a], [Lobato et al., 2012b]. The results show that just a few new risks were added, if compared to a preceding list. This contributes to the relevance of our preliminary studies, since most of the risks presented in this survey already had been previously identified in [Lobato, 2012].

Table 3. Risks and strategies identified

Expert ID	Risk	Strategy	Risks already identified
E2	Lack of experienced/skilled resources for SPL	To bring in outside consultants	R62. Absence of domain experts R64. Absence of SPL experts
	Lack of architectural knowledge	Provide training	R65. Centralized knowledge in few stakeholders R77. Difficulties in acquiring knowledge
E4	Used continuous risk management	Include changing a schedule, assigning more or different people to a task	R54. Inadequate project monitoring R70. Inadequate risk management
E5	Communication among different sites	Clear, specific documentation	R33. Inadequate communication
	Lack of understanding of the process	Good documentation, careful review, selection of good people	R82. Lack of project understanding
E8	Risk of schedule not being met because core assets not ready in time.	Core assets should be ready in time	R46. Missed schedule
E10	Not enough capacity fulfillment of application requirements	Introduction of agile, distributed development involving the application representatives	R9. Failure in requirements identification
	Security hazard	To have a single responsible for security	R36. Security and privacy issues
E11	-	-	-
E12	Schedule	Reduce scope of deliveries for increments	R46. Missed schedule
	Customers focus on individual products rather than product line	Reduce rigor of SPL implementation	R23. No products focus R18. Difficulties in introducing SPL

E13	Taking or not taking the SPL approach	-	R33. Inadequate communication

An assumption regarding the small amount of risks informed can be due to the time, since it is necessary a considerable time to answer a survey to the number of questions defined. Thus, the subjects might have become bored to complete the questionnaire, especially to answer open questions where more time is required. Another assumption may refer to any kind of constraints in the projects the experts have worked on, namely since some of the projects are developed in-house, sometimes under non-disclosure agreements, it is likely that such data might not be spread out, as justified by E11 that said: *"cannot share this information due to NDA"*. In addition to the supposed assumptions, as already presented, the subjects did not present the role of Risk Manager, and can be that they do not know details about RM, consequently, they do not know which are the most common risks in SPL projects.

OQ2. Which were the activities used to manage the risks during SPL project development? In this question, we suggested some RM activities to manage the risk and gave the option for respondents to add other activities that are used in their projects, and were not listed in this question. Nine experts (99%) applied the activity Risk Identification. After this, the most addressed activities were the Risk Analysis and Risk Monitoring, with seven experts (77.78%) addressing them. Regarding Risk Prioritization and Risk Evaluation, six (66.67%) experts pointed them. Five experts (55.56%) addressed the Risk Documentation, and four (44.44%) Risk Planning. Only one expert (11.11%) mentioned another activity, named *"Frequent communication and intra-site visits (E5)"*. However, it was considered as a mitigation strategy to solve the risk instead of a new RM activity.

The scenario about the number of experts that addressed each RM activity was expected beforehand, since in previous questions, we observed that the execution of RM activities was not considered as a common practice. One important point is about the small occurrence of Risk Planning activity, since it should be the first activity to increase the chances of RM success in a project.

OQ3. In which SPL disciplines (e.g. scoping, requirements, and so on) the mentioned risks occurred? The most common disciplines are Scoping, Requirements and Architecture, with seven answers (77.78%). Five experts (55.56%) said that risks were identified in the Test discipline. Two experts (22.22%) presented comments about this question. E5 suggests adding Implementation as another discipline to consider.

We observed that RM has been performed in the initial SPL disciplines. Indeed, if risks were analyzed at the beginning of a project, the chances of success are higher and most risks are likely to be avoided before they become real to the project.

4.4. Validation of Findings – VF

To validate the risks, the experts had to assess a provided list of risks, detailed in Lobato (2012), and listed in Table 4. Since a risk might assume different likelihood and impact in different projects, it was convenient that the experts thought of a single SPL, when evaluating the risks. The priority was to consider the latest SPL project that they have been enrolled, once that a same risk can assume different values to different projects.

As our survey had a considerable number of risks (88), the risks were not assessed regarding their relevance to a project, and as a result we did not adopt or

present solutions to measure the risks in this paper. Instead, we asked experts to assess and classify the risks based on the SPL essential activities (CAD, PD, and M) [Clements and Northrop, 2001]. The risks names are presented followed by the number of experts that addressed them to each SPL activity. One risk could be classified in more than one SPL activity.

Based on Table 4, the analysis of risks indicates that RM needs to be performed during the whole SPL development, since all the risks occurred in the three SPL activities. There is no risk classified by the experts within a same SPL activity, since we did not have all nine respondents answering one risk to the same SPL activity. Eight experts addressed one risk to one SPL activity. This implies that a considerable number of experts agreed with the occurrence of the risks R1, R2, R4, R9, R10, R21, R24 to the respective SPL activities. As a means of prioritizing the most dangerous risks to the project, in a specific SPL activity, the manager can look at these results and verify which risks the experts associated to each SPL activity, and then analyze the most referred ones.

Table 4. Risks to be validated

ID	Risk Name	SPL activities			ID	Risk Name	SPL activities		
		CAD	PD	M			CAD	PD	M
R1	Immature domain	8	5	4	R45	Delayed validation of artifacts	5	5	2
R2	Immature process (scoping)	8	3	7	R46	Missed schedule	5	4	6
R3	Absence of non-functional features	6	5	3	R47	Slow process of change	4	5	5
R4	Inadequate features definition	8	5	4	R48	Tight schedule for client	3	5	5
R5	Core assets instability	6	6	5	R49	Tight schedule for the Project	6	5	7
R6	Inadequate core assets traceability	6	5	5	R50	Absence of test	4	5	2
R7	Unexpected project scope expansions	5	4	7	R51	Inaccurate of changes estimation	4	5	4
R8	Customer requirements not stable	7	7	5	R52	Inadequate continuous process improvement	5	5	6
R9	Failure in requirements identification	8	7	4	R53	Inadequate process	4	4	6
R10	Immature requirements	8	7	3	R54	Inadequate project monitoring	4	4	6
R11	Immature architecture	7	7	4	R55	Inadequate system performance	4	6	2
R12	Lack of architecture documentation	5	4	3	R56	Inadequate technical documentation	6	4	2
R13	Implementation errors	7	7	2	R57	Lack of documentation standards	4	4	4
R14	Platform not Mutable	5	4	3	R58	Inadequate technology, methods and process	5	5	7
R15	Pollution of the platform (gold plating)	5	4	3	R59	Lack of support tools for RM	4	4	4
R16	Inadequate quality of the artifacts	7	6	7	R60	Third-party components not certified	5	4	2
R17	Unnecessary Variability	6	6	4	R61	Bad practices in management	3	3	7
R18	Difficulties in introducing SPL	4	4	7	R62	Absence of domain experts	7	5	3
R19	Immature SPL	7	6	6	R63	Absence of scope experts	5	3	4
R20	Project complexity	4	3	6	R64	Absence of SPL experts	7	5	6
R21	SPL complexity	8	6	7	R65	Centralized knowledge in few stakeholders	6	4	3
R22	Lack of SPL background	7	6	7	R66	Failure to include new tasks	4	3	5
R23	No products focus	7	5	6	R67	Failure to prioritize artifacts	5	4	5
R24	Test complexity	8	8	4	R68	Inadequate configuration management	4	4	3
R25	Inaccurate cost estimation	4	4	7	R69	Inadequate planning	5	5	6
R26	Absence of metrics	4	4	5	R70	Inadequate risk management	4	4	5
R27	Deliver fewer functions than promised	6	7	5	R71	Lack of risk management	3	3	4
R28	Inappropriate reuse	6	7	4	R72	Lack of training	5	5	4
R29	Usability problems	5	7	2	R73	Lack of planning	3	3	4
R30	Ignoring past experience	6	5	7	R74	Client understanding of SPL	3	5	4
R31	Inadequate resource allocation	5	4	6	R75	Inadequate training	6	5	5
R32	Rework	6	6	3	R76	Customer dissatisfaction	3	6	5
R33	Inadequate communication	6	6	8	R77	Difficulties in acquiring	4	4	2

						knowledge			
R34	Inadequate system integration	5	5	3	R78	Inadequate team size	5	4	4
R35	Legacy system integration issues	7	5	3	R79	Instability of staff productivity	4	4	3
R36	Security and privacy issues	5	4	4	R80	Lack of customer involvement	5	4	3
R37	Bureaucracy issues	5	5	7	R81	Lack of expertise in management	3	3	7
R38	Cultural barriers	6	6	7	R82	Lack of project understanding	4	4	4
R39	Immature organization	6	6	6	R83	Lack of team commitment	5	5	4
R40	Infrastructure unavailability	5	5	4	R84	Not qualified staff	6	6	5
R41	Limited development resources	5	5	4	R85	Staff turnover	6	6	5
R42	Project is discontinued	4	4	6	R86	Team expertise diversity issues	3	3	3
R43	Delay in time-to-market	2	6	4	R87	Working remotely	4	4	5
R44	Delayed inspection rounds	4	6	4	R88	Workload on experts	7	6	5
Legend: CAD: Core Asset Development; PD: Product Development; M: Management.									

5. Limitations

Despite the number of non-respondents, the experts that participated are significant to our study. Two respondents sent us emails with improvement suggestions to our survey. However, these feedbacks were relevant but, unfortunately, were not used in this survey, since the questionnaire had already been sent to all experts and some of them had already answered. The feedbacks, as the suggestions to the questionnaire, were useful as lessons learned and can be used in further research.

Two experts reported that they felt uncomfortable with the fact that their name was required in the questionnaire, being this another threat since we could had have more answers if the name was hidden. A survey-based research is not a simple research method. It requires time and effort to understand the basis methodology, as well as to create, validate and manage a survey instrument.

We next list the main threats to the validity of this study: **Internal validity:** As the experts' profiles were not anonymous, one possible negative effect was the modification of the answers. The subjects may have changed their answers, and sometimes selected the answers at their convenience, because they were afraid of being identified. The sample size is a threat to internal validity, since the number of subjects was small when applying statistical inference-based analysis methods. The sample size is a consequence from the fact that there are few researchers with experience in RM to SPL, besides their availability. **External validity:** Experts from different countries composed our sample. In this sense, some of them may have let organizational problems or country rules interfere in their feelings about the risks. **Construct validity:** This threat addresses whether our questions are sufficient to identify the main issues about RM to SPL. As a way to improve our questions, we conducted pilot tests, which led us to modifications in the questionnaire to improve both the content and construct validity. We asked experts to consider the SPL project in the last five years that they have participated to assess the risks, thus relevant evaluation may have been lost, and since the risks assumed values based on one single SPL project. The decision by considering projects in the last five years considers a time span in which the respondents were more likely to remember the facts. Indeed, such a threshold value was not based on any formalized evidence. **Conclusion validity:** Given that experts worked in totally different projects, the risk assessment may present different values to each project, since it was based different development scenarios. However, we asked experts to consider facts from recent projects, namely developed in the last five years, since their knowledge about the project is more recent and consequently more insights could be provided.

6. Concluding Remarks

This study presented a survey performed with the aim of collecting insights about RM in SPL projects based on experts' opinion. To the best of our knowledge, this is the first study that uses the survey strategy to address this topic. This survey was performed to understand how the risks influence SPL projects, and which RM strategies can be used in order to avoid and solve them. By analyzing the findings of this survey, some points already identified in our previous research [Lobato, 2012] were reinforced.

As a way to highlight the focus in SPL engineering, we analyzed the risks according to the essential activities proposed by the SEI. Thus, it is possible to know, for each SPL activity, which are the possible risks that can be faced and the most dangerous to the project.This study enabled us to validate the risks identified beforehand in an earlier investigation, and endorse the need of further research in RM in SPL engineering, since few new insights were collected by the expert's answers. The RM activities need to be more executed during the SPL project development, and more attention should be given to the risks identification, analysis and monitoring. We suggested that the Risk Manager should follow a systematic approach to perform RM in SPL projects. Thus, these results are important as input to the approach that will be developed in the context of our work.

As a future work, we are conducting an study using multi-method as methodology, analyzing the results identified in our previous studies [Lobato et al., 2012a; Lobato et al., 2012b] with this survey to identify the main findings about RM in SPL (related to the risks, mitigation strategies, risks likelihood and impact, and severity of the risks related to the SPL activities). We believe that these complementary sources of evidence will be very important to increase the understanding of this area.

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