# How do Agile Organizations Manage Risks: An Analysis of the State of Practice in Brazil

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## ABSTRACT

The use of agile methods tends to keep risks under control in software projects, due to their inherent characteristics of small increments, work visibility and expectation management. Thus, explicit risk management in agile projects has often been neglected, as the use of agile methods, with a focus on rapid value delivery, tends to lead to implicit risk management. However, software projects that use agile methods also can fail and implicit risk management may often not be sufficient for certain contexts. This has sparked research interest in the possible need for explicit risk management in software organizations that use agile methods. Motivated by the lack of information about risk management in agile software development contexts, in this work a comprehensive survey is carried out to understand how software development organizations that use agile methods are managing risk. We conducted an online survey with a statistically significant sample of 273 agile professionals in Brazil. Our findings indicate that although most organizations engage in some form of explicit risk management, a significant proportion consider agile methods insufficient for comprehensive risk mitigation. We also observed a set of 15 explicit risk management practices in agile contexts, with some agile ceremonies, notably daily and sprint planning meetings, emerging as conducive to the integration of explicit risk management practices. We also verified a statistically relevant association between these agile ceremonies and risk management processes.

## CCS CONCEPTS

• **Software and its engineering** → *Risk management*; *Agile software development*; Software development techniques.

## KEYWORDS

risk management, agile, practices, survey

## 1 INTRODUCTION

Software development is subject to several inherent risks related to deadlines, budget and schedule estimates, technological evolution and stakeholder expectations, among others [13, 20]. Although software project risks cannot be completely eliminated, the impact of these risks can be reduced through proper management [43].

In traditional plan-driven software development methods, risk management is carried out explicitly, following practices defined in process reference models or standards, such as PMBOK [32], ISO 31000 [22], IEC 80001 [24], ISO 14971 [21] or IEC 62304 [23]. Risk management practices allow to prevent the direct and indirect costs of potentially occurring events, supporting the company's long-term sustainability and ensuring the achievement of expected business value [14]. Therefore, companies realize that part of their projects are more vulnerable without implementing appropriate risk management methods [47].

On the other hand, in agile methods, risk management is usually performed implicitly [7, 29]. Agile methods adopt practices such as small increments, work visibility and expectation management that tend to be good risk mitigation strategies [7]. Thus, the use of agile methods tends to reduce risks in projects [1], which is one of the main reasons for their adoption in software organizations [11].

However, in some contexts the lack of project management competence and also the absence of explicit risk management can lead software projects that use agile methods to fail [10, 11, 40, 42, 49]. Despite its importance, explicit risk management is often overlooked in agile software development methods as their focus is on rapid value delivery [17].

In this sense, the explicit application of risk management in agile contexts consists of inserting, risk management principles and practices into already used life cycle management practices [49]. Thus, risks can be identified, analyzed and managed during each software development iteration [32].

Thus, due to its importance, the introduction of explicit risk management practices in organizational contexts that use agile methods has attracted recent attention from the software engineering research community, both from the point of view of literature review [15, 43] and from the state of practice in different countries such as Palestine [13], India [10] and Pakistan [17]. However, to the best of our knowledge, there is no study of this type involving Brazilian software development organizations.

With the aim of understanding "how software development organizations in Brazil are managing risks in agile contexts", a survey was carried out with professionals from software development companies, following the methodological approaches proposed by [33] and [28]. The study is conducted with a probabilistic stratified sampling of 273 agile professionals in Brazil.

The main contributions of this study are twofold: (i) for Software Engineering researchers we present an extensive survey, to the best of our knowledge, of the state of the practice of how software organizations manage risks with agile methods; (ii) for practitioners that are seeking to include explicit risk management practices in agile methods we provide insights on how other organizations are doing this.

This paper is organized as follows: the next section presents a brief background about risks managed in traditional and in agile methods (2), followed by the related works (3), a section on methods (4), the study definition (4.1), study design (4.2), implementation (5), execution (5.1), data analysis (6), and discussion (7). Finally, threats to validity (8) and the conclusion section (9) summarizes the key findings.

## 2 BACKGROUND

Risk Management (RM) is a fundamental aspect of project management [32]. Projects are carried out in contexts of restrictions and assumptions, responding to the expectations of interested parts that can be conflicting and changeable [32]. In this sense, project risk management improves team awareness, communication and shared skills to deal with project uncertainties [1]. However, project risk management practices differ in terms of processes, amount of documentation, adaptability to changes, roles and life cycle [5]. Next sections present an overview on how project risk management has been applied in traditional and agile methods.

### 2.1 Traditional Risk Management

Project risk management has been a relevant interest for software engineering [4]. Managing project risks typically involves applying the processes of risk management planning, risk identification, qualitative and quantitative risk analysis, prioritization, response and control of risks [32].

*Risk management planning* is the process of defining how to conduct the risk management activities of a project. The main benefit of this process is to ensure that the degree, type and visibility of risk management are proportional to the risks and importance of the project to the organization and stakeholders [32].

*Risk identification* is the process of identifying the causes of individual and overall project risks and documenting their properties. The main advantage of this process is the documentation of all existing risks and the project's general sources of risk [22].

*Qualitative risk analysis* is the process of prioritizing individual project risks and making additional analyzes or measurements evaluating their likelihood and impact, as well as other characteristics. The main advantage of this process is that it focuses on high priority risks [22, 32]. *Quantitative risk analysis* is the process of numerically analyzing the impact of identified individual risks along with other sources of uncertainty on project goals. The main advantage of this process is that it can quantify the overall risk exposure of the project and provide additional quantitative risk information to assist with response planning [22, 32].

*Risk prioritization* is the process that allows to determine which candidate risks are the most important and should be addressed first [4].

*Risk response planning* is the process of devising strategies to mitigate risks that may affect the project. This process identifies the most appropriate ways to address project risks [22, 32].

*Risk control* involves risk monitoring and resolution [4, 22]. Risk monitoring is the process of overseeing the implementation of agreed risk response plans, monitoring identified risks, identifying and analyzing new risks, and evaluating the effectiveness of the risk process as the project progresses [32].

### 2.2 Agile Risk Management

Even with the recognized advantages of using agile methods and their own implicit processes for handling risks [1], agile methods alone can be insufficient in certain contexts, leading to the need to define explicit risk management practices that fill the gaps left by agile methods [6, 16, 26, 37, 44].

In agile environments, with high variability, risk management is difficult. The risk identification process is the most effortful process during the life cycle of a project. Furthermore, risk monitoring is also a costly process. However, visible development costs tend to receive more attention than intangible ones, which can leave risk management helpless [30].

Nonetheless, projects that adopt agile methods can use frequent reviews within each development cycle and cross-functional project teams to accelerate knowledge sharing and ensure that risks are understood and managed. Thus, risks can be tacitly identified, analyzed and managed during each iteration [32].

Risk management in agile methods is usually conducted with a focus on the software development activities, which leaves other activities of the life cycle without risk assessments and mitigation strategies [9]. However, in agile methods, risk management practices can be incorporated strategically. In literature some works bring explicit risk management practices to incorporate in agile methods.

Hammad and Inayat [16], inserted two brainstorming sessions into Scrum, one following the Sprint planning meeting to identify potential risks, and another during the Sprint review meeting for risk documentation purposes.

Ribeiro et. al. [35] propose risk analysis practices within the XP method to reduce risks of user story overload by providing alternative plans to enhance negotiations between different stakeholders. The approach fosters a deeper comprehension and aids in selecting a development plan with the highest likelihood of timely implementation [35].

Dorca, Munteanu and Popescu [12] propose a risk management practice to fit Kanban workflow. Identified risks are distributed to team members with defined roles, offering transparency regarding each individual's tasks and responsibilities concerning risk management.

Agile risk management in software projects has even attracted the application of Machine Learning aiming to identify or predict risks before project development starts [38].

## 3 RELATED WORKS

As software development organizations have increasingly adopted agile methods, studies have analyzed the state of practice on risk management within agile contexts from different perspectives.

Hammad, Inayat and Zahid [17] carried out an online survey with 54 agile practitioners, seeking to understand the risks faced by organizations and the mitigation strategies they used. The results indicate that the most frequently observed risks are related to project deadlines and unstable requirements. Regarding risk management strategies, the results indicate that, in general, risk management practices are followed in a non-systematic way by agile organizations. The study is related to this present research by seeking to identify the state of practice in agile risk management in a developing country. However, the sampling used is not statistical, representing a limitation in the generalization of results and, therefore, making it difficult to compare them with Brazil.

Hayat et. al. [18] applied a survey-based research methodology which encompasses over 30 software organizations in a developing country. The applied questionnaire addresses two key aspects: the

impact of agile on software project management and the knowledge areas of software project management. As a result, risk management emerges as an important concern among respondents. The findings suggest that organizations embracing agile methods experience a mitigated level of risk compared to those operating without any of them. Survey results also indicate that project risks may persist throughout various stages, but the Scrum framework is able to handle the risks. Besides the limitation to generalize the results, the work does not address any risk faced by practitioners nor explicit risk management practices.

Elzamly, Hussin, and Salleh [13] investigate software risk factors and management techniques across the software development life cycle within Palestinian software development organizations. Conducting a survey with 76 software project managers, they collected data on 50 software risk factors and 30 risk management techniques. The findings highlights the importance of all identified risks, particularly emphasizing the processes of analysis, planning, maintenance, design, and implementation. The study identifies the top ten software risk factors and corresponding techniques for further analysis and offers valuable insights into the prioritization of software risk factors and management techniques. Nonetheless, the study did not provide any contextual information about the surveyed projects nor organizations.

Recent secondary studies have also been carried out seeking to understand the use of risk management in agile methods in industry. Garcia, Hauck and Hahn [15] selected 23 primary studies that applied risk management with agile methods in industrial case studies, adapting agile practices such as daily meetings and iteration planning meetings to manage risks related to schedule and communication. Tavares, Silva and Souza [43] analyzed 129 primary studies on agile methods and discovered 127 risk management practices, that were categorized and ranked. Vieira, Hauck and Matalonga [46] identified 18 primary studies that applied risk management within agile methods, with positive results such as improved communication, improved product quality, cost reduction, improved team efficiency and time-to-market reduction. None of these secondary studies were focused on primary studies carried out in Brazil.

To the best of our knowledge, there is no comprehensive survey, using a relevant statistical sample, seeking to identify the state of practice of risk management in software development agile contexts in Brazil.

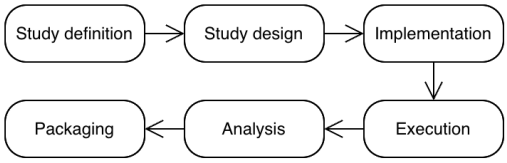
# 4 METHODS

The main research question of this study is: "how software development organizations in Brazil are managing risks in agile contexts". By agile context, we understand the organizational context, such as employees, culture, climate and policies, etc, where agile values and practices are adopted [19, 34].

In order to answer this research question, a survey study is conducted. Survey is a collection of information of different types, such as characteristics, actions and opinions of a group of people who represent a population [31].

The survey is carried out following the approaches proposed by Punter et al. [33] and Molléri, Petersen and Mendes [28]. Thus, the methodological steps followed are: study definition, study design, implementation and execution, analysis, and packaging (results report). Figure 1 shows the survey steps sequence.

**Figure 1: Survey steps**




Each of these methodological steps is presented below. The study definition and design steps are presented as subsections of this section, while subsequent steps are presented in the following sections.

This research project was approved by the Human Research Ethics Committee of the Federal University of Santa Catarina (number 55851622.8.0000.0121).

## 4.1 Study definition

Along with the main research question, this study aims to discover how explicit risk management practices are applied (or not) and how agile ceremonies and risk management processes are carried out. Thus, we derived 7 specific research questions (RQ) from the main research question, that are presented in Table 1.

**Table 1: Research questions.**

| Question | Description |
|---|---|
| RQ1 | How many companies manage risks and what is their organizational context? |
| RQ2 | Are agile methods sufficient for risk management? |
| RQ3 | What risk management practices are introduced in agile methods? |
| RQ4 | In which ceremonies are risk management practices introduced? |
| RQ5 | Does the organizational context influence the practices introduced? |
| RQ6 | Does the organizational context influence the ceremonies in which risks are managed? |
| RQ7 | Does the organizational context influence the risk management processes that are used? |

## 4.2 Study design

This step includes defining the target population and sample and developing a data collection instrument. The target population of this study are, in general, professionals who work for software development organizations in Brazil. The data collection instrument chosen to answering the RQs is a questionnaire supported by an online form.

*4.2.1 Sampling.* In order to carry out a research that is adequately representative of the state of practice in relation to the use of risk management in agile contexts in Brazil, it is necessary to define

a sample that is statistically significant and adequately represents this geographically distributed population.

Thus, in order to balance the sample between regions of the country and achieve statistical relevance, a probabilistic stratified sampling [3] was chosen. The population of interest is defined based on data from the Brazilian Association of Software Companies (ABES) report [2], which presents the number of software development organizations in Brazil and the respective number of employees in each organization. Thus, it was possible to determine that the size of the population is approximately 514,303 professionals who work for software development organizations. Also, the ABES report presents the distribution of software organizations within the Brazilian territory in the following proportion: 2.58% in the northern region, 7.07% northeast region, 11.88% mid-west region, 13.60% south region and 64.87% in the southeast region.

Therefore, to calculate the sample size, a margin of error of 5% and a confidence level of 90% were defined. Based on these limits, it was determined that a statistically significant sample must have 273 respondents [3], properly balanced between the country's regions according to the proportion of the software development organizations [2].

The inclusion and exclusion criteria for participants in the sample are presented in Table 2.

**Table 2: Participant inclusion and exclusion criteria.**

| | |
|---|---|
| **Inclusion Criteria** | |
| SCI1 | Have direct or indirect involvement in the management of software projects |
| SCI2 | Works for a software development organization that uses agile methods |
| SCI2 | Have experience with applying agile methods |
| **Exclusion Criteria** | |
| SCE1 | Under 18 |
| SCE2 | Works for a software development organization that is not located in Brazil |

*4.2.2 Data Collection Instrument Definition.* To answer the research questions, we prepared a questionnaire with 8 closed questions (closed-ended or multiple choice) and 3 open questions (essay) as the data collection instrument. Table 3 shows the questions available in the questionnaire. Column "RQ" of Table 3 presents the mapping of the questionnaire questions to our Research Questions defined in Section 4.1.

## 5 IMPLEMENTATION AND EXECUTION

In this step, we implemented the questionnaire using Google Forms as a tool and piloted it to ensure that the survey could be carried out effectively.

To evaluate the quality and reliability of the data collection instrument, we carried out a pilot application with ten professionals from ten different software development companies, who met the inclusion and exclusion criteria, selected based on proximity. The selected professionals occupy positions of CTO, Product Manager and Project Manager. All ten invited professionals answered the online form and were then interviewed in person to collect their evaluation of the use of the questionnaire. Some small wording improvements in questions were identified by the respondents and were corrected in the final version of the questionnaire.

**Table 3: Questionnaire questions.**

| # | Type | Question | RQ |
|---|---|---|---|
| 1 | Closed ended | In which region of Brazil is the headquarters of the company you work for? | RQ1 |
| 2 | Closed ended | What is your role in the team you work in? | RQ1 |
| 3 | Essay | How long (in years) have you been working with software development? | RQ1 |
| 4 | Essay | Approximately how many employees does your organization have? | RQ5, RQ6, RQ7 |
| 5 | Multiple choice | For which domain areas does your organization develop software? | RQ5, RQ6, RQ7 |
| 6 | Multiple choice | What agile methods does your team use? | RQ5, RQ6, RQ7 |
| 7 | Multiple choice | In which typical agile method ceremonies do you apply risk management? | RQ4, RQ6 |
| 8 | Closed ended | Do you use risk management in your team(s) or in your organization, even informally? | RQ1 |
| 9 | Closed ended | Do you consider existing practices in agile methods sufficient for risk management? | RQ2 |
| 10 | Multiple choice | What risk management processes do you typically carry out? | RQ1, RQ7 |
| 11 | Essay | In addition to the typical practices of agile methods, do you use any additional practices to manage risks? If so, which ones? | RQ3, RQ5 |

In order to assess the reliability of the data collection instrument the Cronbach's alpha coefficient [8] was calculated using the pilot application data. The Cronbach's alpha coefficient is used to measure the correlation between the answers given by participants in a questionnaire, analyzing the consistency of answers between questions. It is calculated from the variance of the individual items and the variance of the sum of the items for each respondent in a questionnaire.

The Cronbach's alpha value obtained for the 10 responses was 0.73, which indicates a good level of reliability of the data collection instrument [41].

### 5.1 Execution

We randomly invited participants remotely using the [1]LinkedIn platform. The procedure for selecting the participants consisted of using the LinkedIn platform for filtering professionals from software companies located in Brazil that met all the inclusion and

[1]https://www.linkedin.com/

exclusion criteria. For each professional found in the search, a direct message was sent, through the platform, with an invitation to participate in the survey. This procedure was repeated until the minimum sample size was reached, always maintaining a proportional balance between the invited participants from the regions of Brazil when making the invitations. Thus, 1,042 professionals from software companies located in Brazil were invited.

In the invitation message to participate in survey, the objective of the research was clearly presented to participants. Furthermore, on the form page created in Google Forms, a free and informed consent was requested electronically. All data were collected without participant identification to ensure confidentiality and privacy.

Participants answered the questionnaire remotely, using the Google Forms platform. The form was kept open for a period of 4 months and was answered asynchronously, without the need for researcher supervision.

Among the 1,042 invitations, 309 professionals responded the questionnaire, resulting in a response rate of 29.65%. However, due to sample balancing, 36 responses were randomly eliminated, leaving 273 valid responses.

The raw data collected are available at [2]Mendeley Data [45].

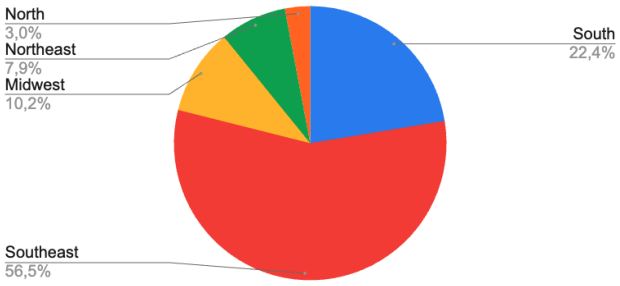
## 6 ANALYSIS

In this section, the main findings are presented. Initially, demographic data is presented and then each of the research questions is analyzed based on the data collected.

### 6.1 Demographics

The respondents work for companies in all regions of Brazil, as shown in Figure 2. The percentages of participants by region are equivalent to the distribution of software companies in Brazil according to an ABES report [2].

**Figure 2: Answers by region of Brazil**




There are respondents with various levels of experience and who work in different positions. Below, Figure 3 and Figure 4 present the positions and experience of the respondents, respectively. Most participants (48.4%) have more than 10 years of experience, while 28.2% have up to 5 years of experience. The most common positions held by respondents are Team leader (29.7%), Product Manager (17.9%) and Scrum master (13.6%), .

[2]https://data.mendeley.com/

**Figure 3: Respondents' positions**

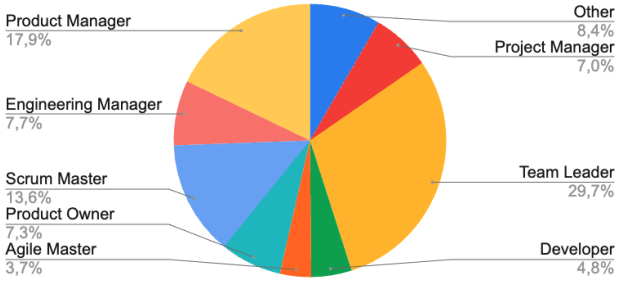
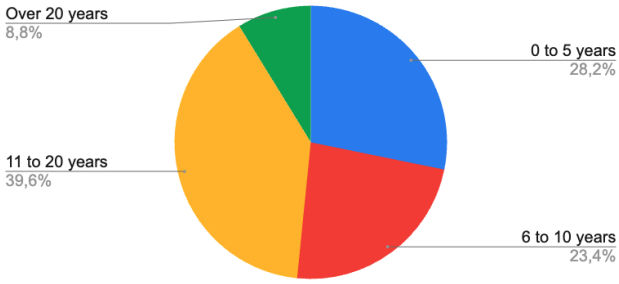
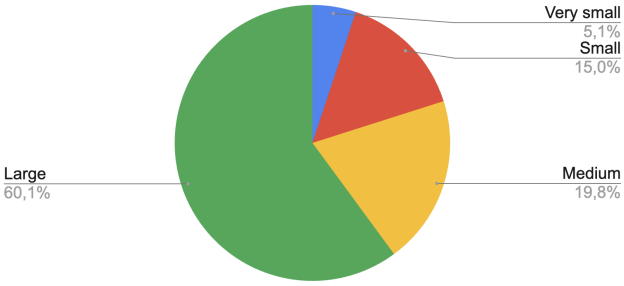



**Figure 4: Respondents' experience time**




In addition, data was also collected about the organizations in which the respondents work. Figure 5 and Table 4 show the characteristics of the respondents' organizations. To categorize the size of companies, the number of employees was used as a criterion, following the [2] classification. It is possible to observe that the majority of companies (60.1%) are large companies.

**Figure 5: Size of respondents' organizations**




In relation to the organizations' software business domain, 48.72% of participating organizations develop software for the Financial domain, followed by E-commerce with 41.39% (Table 4). Each respondent could indicate more than one domain.

### 6.2 Research Questions Analysis

Next, each of the research questions is analyzed based on the collected data.

**RQ1 - How many companies manage risks and what is their**

**Table 4: Business domain of respondents' organizations.**

| Area | Number of respondents |
|---|---|
| Construction | 19 (6,96%) |
| E-commerce | 113 (41,39%) |
| Education | 10 (3,66%) |
| Financial | 133 (48,72%) |
| Management | 3 (1,10%) |
| Government | 41 (15,02%) |
| Military | 2 (0,73%) |
| Health | 56 (20,51%) |
| Streaming | 17 (6,23%) |
| Telecommunications | 47 (17,22%) |
| Transport | 33 (12,09%) |
| Others | 76 (27,84%) |

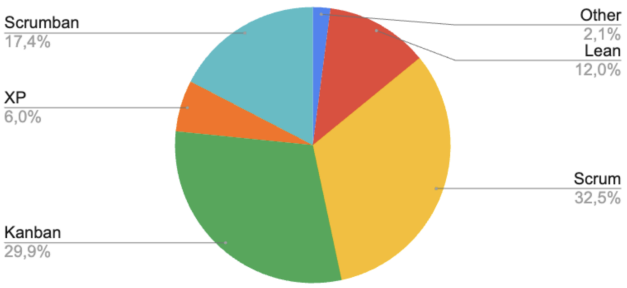
**organizational context?**

In total, 239 (87.55%) respondents reported that their organizations carry out some kind of risk management, even if they do not use explicit risk management practices.

Among the many possible characteristics of the organizational context, we chose to collect some that have been related in the literature to agile risk management: agile methods used, application domain and size of the organization [15, 46]. The percentages represented in next charts (Figures 6 and 8) are related to the 239 responses of the organizations that perform risk management, rather than the total number of responses.

Figure 6 illustrates the agile methods that are used by organizations. It was possible to notice that many companies use more than one agile method.

**Figure 6: Agile methods used by organizations that manage risks**




Confirming the global trend [11], Scrum is the most used agile method among respondents with 32.5%. Respondents' organizations also widely adopt Kanban (29.9%) and Scrumban (17.4%), also fitting in the global trend [11].

Figure 7 presents the application domain of organizations that manage risks in agile contexts. It can be seen that the majority of organizations that manage risks operate in the Financial (48.72%) and E-commerce (41.39%) sectors. Some respondent organizations develop software for more than one application domain.

**Figure 7: Application domains of organizations that manage risks**

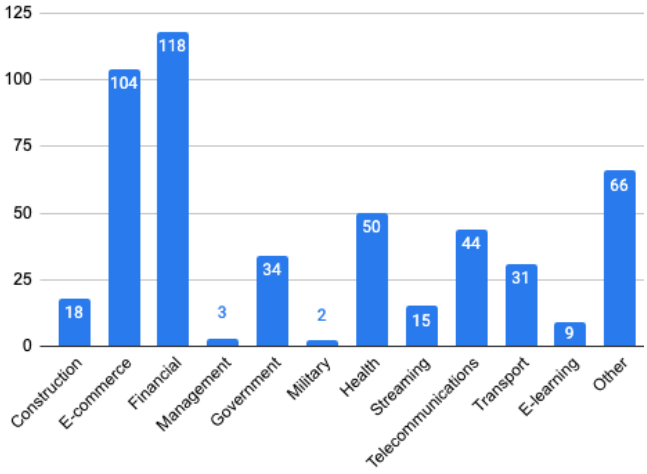
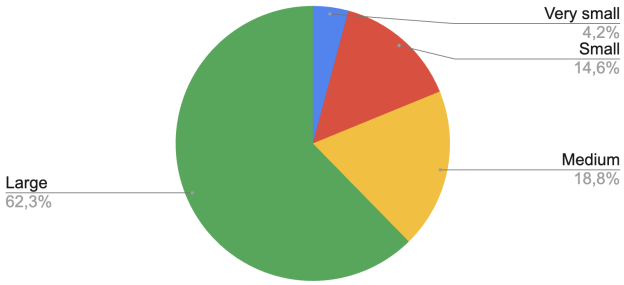



Figure 8 shows the size of organizations that manage risks. It can be noted that the vast majority (81.1%) of organizations that manage risks in agile contexts are medium (18.8%) to large (62.3%) companies, which largely differs from the distribution of software organizations sizes in Brazil [2] (see section 8).

**Figure 8: Size of organizations that manage risks**




**RQ2 - Are agile methods sufficient for risk management?**

The purpose of this research question is to understand whether there is a need to introduce new risk management practices in agile methods. According to the survey, 57% of respondents reported that they do not consider agile methods sufficient for risk management.

**RQ3 - What risk management practices are introduced in agile methods?**

As the form question that identifies the risk management practices used is an open question, to answer this research question, the risk management practices were analyzed using the open coding [39] approach. This means that practices were grouped in a unstructured way, allowing categories to emerge naturally from the data collected [25]. In this way, it was possible to identify different types

of practices and relate them to the risk management strategies used by the organizations, with all the steps detailed in [45]. The open coding approach allowed for a flexible and comprehensive analysis, enabling the discovery of new insights and patterns that might not have been found in a non-systematic approach.

Thus, the risk management practices introduced in agile methods in software development organizations are presented in Table 5, ordered by the frequency of occurrence.

**Table 5: Risk management practices.**

| # | Practices | Occurrences |
|---|---|---|
| 1 | Application of project management frameworks | 10 |
| 2 | Metrics/data driven decisions | 9 |
| 3 | Customized/extra meetings | 3 |
| 4 | Risk matrix | 2 |
| 5 | Ishikawa | 2 |
| 6 | Feedbacks | 2 |
| 7 | RACI Matrix | 1 |
| 8 | Decision tree | 1 |
| 9 | Risk Review | 1 |
| 10 | Outsource | 1 |
| 11 | PDCA | 1 |
| 12 | A3 | 1 |
| 13 | SWOT Matrix | 1 |
| 14 | Strategic roadmap | 1 |
| 15 | Post Mortem | 1 |

The term "Application of project management frameworks" in the context of our open coding refers to the utilization of comprehensive frameworks or principles such as PMBoK, traditional management methods, or Lean Six Sigma.

The answer to this question also involved identifying which traditional risk management processes are covered by the practices introduced in agile methods. The questionnaire listed traditional risk management processes proposed in the literature [32]: Identification, Qualitative analysis, Quantitative analysis, Prioritization, Monitoring and control, Management planning and Response planning. For each process, three options were presented to respondents: the process can be fully implemented, partially implemented, or not implemented at all. The answers are described in Table 6.

**Table 6: Implemented risk management processes.**

| Process | Fully | Partially | Not impl. |
|---|---|---|---|
| Qualitative analysis | 038 | 127 | 108 |
| Quantitative analysis | 035 | 127 | 111 |
| Identification | 080 | 151 | 042 |
| Monitoring and control | 072 | 125 | 076 |
| Management planning | 043 | 128 | 102 |
| Response planning | 054 | 133 | 086 |
| Prioritization | 089 | 115 | 069 |

With this, it is possible to conclude that the most used risk management processes are prioritization and identification.

**RQ4 - In which ceremonies are risk management practices introduced?**

This question is to understand which agile ceremonies are used to introduce explicit risk management practices. Respondents reported that the most used agile ceremonies to manage risks are the *sprint* planning meeting (69.6%) and the daily meeting (54.21%). The complete list of ceremonies is presented in Table 7.

**Table 7: Ceremonies that risk management is introduced.**

| Ceremony | Implement | Not impl. |
|---|---|---|
| Sprint planning meeting | 190 | 083 |
| Sprint retrospective meeting | 110 | 163 |
| Sprint review meeting | 094 | 179 |
| Daily meeting | 148 | 125 |
| Weekly meeting | 119 | 154 |
| None of the above | 018 | 255 |

To help identify which risk management practices (RQ3) are most applied in which ceremonies (RQ4), we grouped practices according to traditional risk management processes [32] and applied statistical correlation analysis to this data. The correlation and regression analysis tool is an efficient method to measure the existence of a association between two variables (a dependent variable and an independent variable) [27]. The correlation coefficient determines the degree of association between the variables. To verify this and the following associations in this study, we subjected the data to chi-square tests [48], which are widely used to verify the dependence between qualitative variables.

Chi-square was applied considering ceremonies as independent variables and processes as dependent variables [45]. The values 0.0, 0.5 and 1.0 were used in columns as "does not implement", "partially implements" and "fully implements" respectively. Values 0.0 and 1.0 are used in lines to indicate the presence (1.0) or not (0.0) of the risk management in the meeting.

**Figure 9: Cross tab planning meeting x identification**

| Identifies Risks<br>Manages Risks in Planning Meeting | 0.0 | 0.5 | 1.0 |
|---|---|---|---|
| 0.0 | 29 | 41 | 13 |
| 1.0 | 13 | 110 | 67 |

**Figure 10: Cross tab planning meeting x prioritization**

| Prioritizes Risks<br>Manages Risks in Planning Meeting | 0.0 | 0.5 | 1.0 |
|---|---|---|---|
| 0.0 | 36 | 29 | 18 |
| 1.0 | 33 | 86 | 71 |

When analyzing the cross tabs of the planning meeting with the risk identification and prioritization processes, respectively presented in Figure 9 and Figure 10, it is possible to verify a large

variation between the two rows of the tables in columns 0.5 and 1.0, which indicates that these processes are related to the fact that the ceremony is carried out. Furthermore, the *p* value equal to 0.0068 and 0.0032, respectively, indicates a correlation between the risk management processes and the ceremony on both occasions.

**Figure 11: Cross tab daily meeting x identification**

| Identifies Risks<br>Manages Risks in Daily Meeting | 0.0 | 0.5 | 1.0 |
|---|---|---|---|
| 0.0 | 33 | 59 | 33 |
| 1.0 | 9 | 92 | 47 |

**Figure 12: Cross tab daily meeting x prioritization**

| Prioritizes Risks<br>Manages Risks in Daily Meeting | 0.0 | 0.5 | 1.0 |
|---|---|---|---|
| 0.0 | 46 | 42 | 37 |
| 1.0 | 23 | 73 | 52 |

When analyzing the contingency tables of the daily meeting with the risk identification and prioritization processes, respectively illustrated in Figure 11 and Figure 12, it is possible to verify that there is also variation between the two rows of the table in columns 0.5 and 1.0, which indicates that the fact that these processes are carried out are also related to the fact that the daily meeting is held. And, in this case, the *p* value of 0.0030 and 0.0018, respectively, also indicates a correlation between the risk management processes and the ceremony on both occasions.

Therefore, in response to this research question, it is possible to conclude that **the most commonly used ceremonies to apply risk management practices are daily and sprint planning meetings**, applying the processes of **identification** and **risk prioritization**.

**RQ5 - Does the organizational context influence the practices introduced?**

As there are several variables related to organizational context and several variables related to practices, for this and the next research questions, a separate analysis was carried out for each combination of the organizational context and the variable to be analyzed.

Thus, the chi-square test was applied to evaluate the association between context variables, such as agile method, domain of activity, company size, among others, and the risk management practices reported by respondents [45].

After carrying out the analyzes using the chi-square test considering the organizational context variables as independent and the risk management practices as dependent variables, the results showed that **there was no significant association between the majority of context variables and risk management practices** reported by respondents (See Table 8). This result means that, according to the data analyzed, it is not possible to state that the characteristics of the organizations directly influence the risk management practices adopted. Table 8 shows the 10 best associations among the 285 analyzes carried out between context variables and the risk management practices (Table 4).

**Table 8: Chi-square between context variables and practices**

| Index | Independent (Context variables) | Dependent (Practices) | p value |
|---|---|---|---|
| 110 | Agile Method XP | Practice 6 | 0.008291 |
| 126 | Company Size | Practice 7 | 0.034392 |
| 101 | Application Domain Health | Practice 6 | 0.055449 |
| 235 | Application Domain Construction | Practice 13 | 0.090170 |
| 112 | Agile Method Lean | Practice 6 | 0.121695 |
| 131 | Agile Method Lean | Practice 7 | 0.121695 |
| 188 | Agile Method Lean | Practice 10 | 0.121695 |
| 202 | Company Size | Practice 11 | 0.128297 |
| 259 | Company Size | Practice 14 | 0.128297 |
| 113 | Agile Method Other | Practice 6 | 0.130101 |

It is important to highlight that the result of the analysis with the chi-square test does not mean that there are no associations between the variables, but rather that these associations are not statistically significant to be detected from the data collected from the sample.

**RQ6 - Does the organizational context influence the ceremonies in which risks are managed?**

The objective of this question is to investigate whether risk management ceremonies are influenced by the organizational context in which they are applied. In this case, for the chi-square test, the context variables were defined as independent and the variables related to the ceremonies as dependent [45].

Table 9, presents the 10 pairs with the best degree of association. It is possible to observe that **most of the variables did not demonstrate a relevant degree of association**. From the results it is possible to observe that the context domain variables are predominant and variables related to the agile method also appear, but only this first 10 presented in Table 9, show a slightly relevant degree of association, considering the 114 context analyzes carried out.

**RQ7 - Does the organizational context influence the risk management processes that are used?**

The objective of this question is to investigate whether the application or not of risk management processes is influenced by the organizational context. The question seeks to understand whether factors such as the application domain, agile method used or company size can affect the choices and use of risk management processes.

**Table 9: Chi-square between context variables and ceremonies**

| Independent (Context variables) | Dependent (Ceremonies) | p value |
|---|---|---|
| Application Domain Other | Manages Risk in Sprint Retrospective | 0.000845 |
| Application Domain Telecommunication | Manages Risk in Weekly Meeting | 0.001207 |
| Company Size | Manages Risk in Unlisted Ceremony | 0.003084 |
| Application Domain E-commerce | Manages Risk in Weekly Meeting | 0.021985 |
| Application Domain Government | Manages Risk in Weekly Meeting | 0.023544 |
| Application Domain Health | Manages Risk in Sprint Planning | 0.033477 |
| Application Domain Construction | Manages Risk in Weekly meeting | 0.043062 |
| Application Domain E-commerce | Manages Risk in Sprint Retrospective | 0.045888 |
| Company Size | Manages Risk in Sprint Planning | 0.047203 |
| Application Domain Other | Manages Risk in Sprint Review | 0.058073 |

In Table 10, the 10 pairs with the best degree of association are presented. In this case, **most of the variables did not demonstrate a relevant degree of association**. The application domain variables are once again predominant and variables related to the agile method also appear, but only these 10 presented in Table 10, show a relevant degree of association, considering the 133 analyses performed.

**Table 10: Chi-square between context variables and risk management processes**

| Independent (Context variables) | Dependent (Risk Management Processes) | p value |
|---|---|---|
| Application Domain Health | Qualitative Analysis | 0.006028 |
| Application Domain Health | Control and Monitoring | 0.009063 |
| Application Domain Transport | Qualitative Analysis | 0.012658 |
| Application Domain Health | Identification | 0.015806 |
| Application Domain Health | Management Planning | 0.020141 |
| Application Domain Telecommunication | Control and Monitoring | 0.021457 |
| Application Domain Telecommunication | Prioritization | 0.029339 |
| Agile Method Kanban | Quantitative Analysis | 0.032958 |
| Agile Method Kanban | Qualitative Analysis | 0.044893 |
| Application Domain Construction | Control and Monitoring | 0.053294 |

# 7 DISCUSSION

In relation to demographic data, it is interesting to highlight the scope and balance of the sampling approach used for the survey. The alignment with the data from ABES report [2], suggests that the survey was able to capture a representative sample of the Brazilian software development landscape in relation to the use of risk management in agile contexts. Moreover, the diversity in respondents' levels of experience and job roles offers a multifaceted perspective on risk management practices within agile organizations. The prevalence of experienced professionals, with nearly half having over a decade of experience, indicates a wealth of industry knowledge contributing to the insights gleaned from the survey.

The results of the survey revealed that the majority of software development organizations in Brazil (~88%) carry out some kind of risk management, even if not explicitly. This suggests that companies recognize the importance of risk management for successfully conducting agile projects. Furthermore, the analysis of risk management practices introduced in agile methods demonstrated a diversity of approaches, from the application of project management frameworks to more specific practices, such as quantitative and qualitative risk analysis.

The majority of respondents (57%) also consider that agile methods are not sufficient to fully address risk management. This may indicate that, despite the predominance of agile methods, there is still room for the incorporation of explicit risk management practices, with the aim of improving the approach to identifying, analyzing and mitigating risks.

A closer look at agile ceremonies and risk management practices revealed significant associations between certain ceremonies and specific practices. Daily and sprint planning meetings were identified as the most conducive to introducing risk identification and prioritization practices. This finding suggests that these ceremonies provide opportunities to manage risks in a more regular basis, without threatening the organizational agile values or the project life cycle with the introduction of new risk-related ceremonies.

When analysing the possible influence of the organizational context on the adoption of risk management practices, it was observed that the majority of associations were not significant. This indicates that, despite the different characteristics of organizations, such as domain, size and agile method used, these factors do not necessarily directly influence the choices of risk management practices. However, some relevant associations were identified, such as the agile method used and the size of organizations with certain practices, such as the Risk Identification Matrix and the Ishikawa Diagram respectively.

Despite variations in organizational context, there is limited evidence of significant associations between contextual variables and agile ceremonies. This indicates that while certain ceremonies may be more prevalent in specific contexts, the association is not deterministic, highlighting the complex interplay between contextual factors and ceremony selection in agile risk management.

The analysis suggests that contextual factors have limited influence on the adoption of specific risk management processes. Specific application domains such as "Health" have relevant associations with the processes of qualitative analysis, monitoring and control, identification and planning. However, the overall impact is

not statistically significant, underscoring the need for a nuanced understanding of how organizational context shapes the implementation of risk management processes.

Based on the results, it is possible to observe that risk management is a concern in software development organizations in Brazil that use agile methods. However, research indicates that there is room for improvement in integrating specific risk management practices into the agile context.

## 7.1 Comparison with Related Works

Comparing this study with similar surveys (see Table 11), it is possible to observe that the sampling of this study is more comprehensive and focused on Brazil, with the participation of a large number of respondents with management positions and with greater experience.

**Table 11: Comparative Analysis of Surveys**

| Criteria | Hammad, Inayat and Zahid [17] | Hayat et. al. [18] | Elzamly, Hussin, and Salleh [13] | This study |
|---|---|---|---|---|
| Sampling | Convenience | Convenience | Convenience | Probabilistic stratified |
| Respondents | 54 | 21 | 76 | 273 |
| Country | Various | Pakistan | Palestine | Brazil |
| Experience | Software developers (66%), < 3 years (53%) | - | Project managers | Management (79.5%), > 10 years (48.4%) |
| Context | Scrum (80%) | Scrum (52,4%) | - | Scrum (32,5%), Kanban (29,9%) |
| Risk Management | 44,44% | 85,7% | - | 87.55% |

Regarding the context (Table 11), all studies show a predominance of Scrum, with a greater dominance in [17]. Regarding the application of risk management in agile methods, study [18] shows similar results to this study, with more than 85% of participants indicating that they apply some form of risk management, while [17] shows a much lower application. Other aspects investigated in this study were not addressed by the related works.

Comparing the results of this study with those observed in secondary studies, Garcia, Hauck, and Hahn [15] indicate the predominance of the use of Scrum with risk management, in a similar way to this study. Notably, in [15], the daily and sprint planning meetings were identified as key agile ceremonies for risk identification and monitoring, which is confirmed in this study. The risk identification process also emerges in [15] and in this study as the most used risk management process integrated into agile methods.

# 8 THREATS TO VALIDITY

In this section we describe the potential threats to validity observed and how we tried to minimize their possible impacts.

Regarding internal validity, a possible threat is related to the interpretation of open-ended questions, such as in the description of risk management practices. To minimize this threat, the open coding [39] technique was adopted to analyze the data in the most impartial and objective possible way, cross-checking between authors at all stages of coding.

Regarding external validity, one of the main typical threats to validity for survey studies is a possible selection bias. In our study a probabilistic stratified sampling was used in which a category is chosen to stratify the sample. We chose to balance the sample across all geographic regions of Brazil, aiming a general view that was not biased by a region where a greater number of software companies are concentrated. This represents a possible threat related to the adequate representation of other stratus such as the different sizes of software companies or software development domains.

Furthermore, this study is based exclusively on professionals who are active on the LinkedIn platform. It's important to note that this limitation may influence the results due to the omission of responses from professionals who are not on LinkedIn. This factor tends not to be a strong threat as, with more than 51 million active users in Brazil, LinkedIn accounts for 65% of the economically active population in Brazil [36].

# 9 CONCLUSION

This paper presents a survey of the state of practice on explicit risk management in agile software development organizations in Brazil. The study was conducted using a stratified probabilistic sample with 273 professionals, according to the distribution of software organizations in Brazil [2], using an online form to collect data.

Respondents' diverse experience levels and profiles offer varied insights into risk management in agile contexts. Results indicate that more than a half of the respondents believe that agile methods alone are insufficient to manage risks, with the majority of the organizations applying some kind of additional risk management practice. According to the participants, daily and sprint planning meetings are key events for risk identification and prioritization.

Organizations' contexts have limited influence on risk management practices and ceremonies, with associations observed in specific cases, such as the agile methods and organization's size influencing the adopted practices. However, overall impact remains statistically insignificant, emphasizing the need for nuanced understanding. While risk management seems to be a concern in Brazilian software development organizations, there's scope for enhancing specific practices within agile methods.

Moving forward, our findings unveil the importance of further research and targeted interventions to enhance the integration of explicit risk management practices within agile methods.

# ARTIFACT AVAILABILITY

The raw collected data, the dataset and open coding carried out in this study, and the form questionnaire used are available at Mendeley Data repository [45].

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# REFERENCES


[1] Aalaa Albadarneh, Israa Albadarneh, and Abdallah Qusef. 2015. Risk management in Agile software development: A comparative study. In *2015 IEEE Jordan Conference on Applied Electrical Engineering and Computing Technologies (AEECT)*. 1–6. https://doi.org/10.1109/AEECT.2015.7360573

[2] Associação Brasileira das Empresas de Software. 2021. Mercado Brasileiro de Software – Panorama e Tendências 2021. https://abes.com.br/wp-content/uploads/2021/08/ABES-EstudoMercadoBrasileirodeSoftware2021v02.pdf

[3] Andrea E Berndt. 2020. Sampling methods. *Journal of Human Lactation* 36, 2 (2020), 224–226.

[4] Barry Boehm. 1989. Software risk management. In *ESEC '89*, C. Ghezzi and J. A. McDermid (Eds.). Springer Berlin Heidelberg, Berlin, Heidelberg, 1–19.

[5] Katarína Buganová and Jana Šimíčková. 2019. Risk management in traditional and agile project management. *Transportation Research Procedia* 40 (2019), 986–993. https://doi.org/10.1016/j.trpro.2019.07.138 TRANSCOM 2019 13th International Scientific Conference on Sustainable, Modern and Safe Transport.

[6] Juliette Michelle Parada Carvallo, Hanna Oktaba, and Elsa Ramírez Hernández. 2018. Risk Assessment Forum. In *2018 6th International Conference in Software Engineering Research and Innovation (CONISOFT)*. 160–164. https://doi.org/10.1109/CONISOFT.2018.8645949

[7] Mauricio Concha, Marcello Visconti, and Hernán Astudillo. 2007. Agile Commitments: Enhancing Business Risk Management in Agile Development Projects. In *Agile Processes in Software Engineering and Extreme Programming*, Giulio Concas, Ernesto Damiani, Marco Scotto, and Giancarlo Succi (Eds.). Springer Berlin Heidelberg, Berlin, Heidelberg, 149–152.

[8] Lee J Cronbach. 1951. Coefficient alpha and the internal structure of tests. *psychometrika* 16, 3 (1951), 297–334.

[9] Portia Crowe, Ali Mostashari, Mo Mansouri, and Robert Cloutier. 2009. 9.2.1 Reference Framework and Model for Integration of Risk Management in Agile Systems Engineering Lifecycle of the Defense Acquisition Management Framework. *INCOSE International Symposium* 19, 1 (2009), 1391–1405. https://doi.org/10.1002/j.2334-5837.2009.tb01022.x

[10] Saru Dhir, Deepak Kumar, and V. Singh. 2019. *Success and Failure Factors that Impact on Project Implementation Using Agile Software Development Methodology*. 647–654. https://doi.org/10.1007/978-981-10-8848-3_62

[11] Digital.ai. 2021. *15th annual state of agile report*. Digital.ai.

[12] Vasile Dorca, Radu Munteanu, Sorin Popescu, Adrian Chioreanu, and Claudius Peleskei. 2016. Agile approach with Kanban in information security risk management. In *2016 IEEE International Conference on Automation, Quality and Testing, Robotics (AQTR)*. 1–6. https://doi.org/10.1109/AQTR.2016.7501278

[13] Abdelrafe Elzamly, Burairah Hussin, and Norhaziah Md Salleh. 2016. Top Fifty Software Risk Factors and the Best Thirty Risk Management Techniques in Software Development Lifecycle for Successful Software Projects. *International Journal of Hybrid Information Technology* 9 (06 2016), 11–32. https://doi.org/10.14257/ijhit.2016.9.6.02

[14] Priscila Ferreira de Araújo Lima, Maria Crema, and Chiara Verbano. 2020. Risk management in SMEs: A systematic literature review and future directions. *European Management Journal* 38, 1 (2020), 78–94. https://doi.org/10.1016/j.emj.2019.06.005

[15] Fernando Vedoin Garcia, Jean Hauck, and Fernanda Narloch Rizzo Hahn. 2022. Managing Risks in Agile Methods: a Systematic Literature Mapping. In *Proceedings of the 34th International Conference on Software Engineering and Knowledge Engineering*. https://doi.org/10.18293/SEKE2022-123

[16] Muhammad Hammad and Irum Inayat. 2018. Integrating Risk Management in Scrum Framework. In *2018 International Conference on Frontiers of Information Technology (FIT)*. 158–163. https://doi.org/10.1109/FIT.2018.00035

[17] Muhammad Hammad, Irum Inayat, and Maryam Zahid. 2019. Risk Management in Agile Software Development: A Survey. In *2019 International Conference on Frontiers of Information Technology (FIT)*. 162–1624. https://doi.org/10.1109/FIT47737.2019.00039

[18] Faisal Hayat, Ammar Ur Rehman, Khawaja Sarmad Arif, Kanwal Wahab, and Muhammad Abbas. 2019. The Influence of Agile Methodology (Scrum) on Software Project Management. In *2019 20th IEEE/ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD)*. 145–149. https://doi.org/10.1109/SNPD.2019.8935813

[19] Juhani Iivari and Netta Iivari. 2011. The relationship between organizational culture and the deployment of agile methods. *Information and Software Technology* 53 (05 2011), 509–520. https://doi.org/10.1016/j.infsof.2010.10.008

[20] Shareeful Islam, Haris Mouratidis, and Edgar Weippl. 2014. An empirical study on the implementation and evaluation of a goal-driven software development risk management model. *Information and Software Technology* 56 (02 2014), 117–133. https://doi.org/10.1016/j.infsof.2013.06.003

[21] ISO 14971:2019 2019. *Medical devices – Application of risk management to medical devices*. Standard. International Organization for Standardization.

[22] ISO 31000:2009 2009. *Risk Management – Principles and guidelines*. Standard. International Organization for Standardization.

[23] ISO 62304:2006 2006. *Medical device software – Software life cycle processes*. Standard. International Organization for Standardization.

[24] ISO 80001:2010 2010. *Application of risk management for IT-networks incorporating medical devices*. Standard. International Organization for Standardization.

[25] Shahedul Huq Khandkar. 2009. Open coding. *University of Calgary* 23 (2009), 2009.

[26] Diana Kirk and Ewan Tempero. 2006. Identifying Risks in XP Projects through Process Modelling. In *Proceedings of the Australian Software Engineering Conference (ASWEC '06)*. IEEE Computer Society, USA, 411–420. https://doi.org/10.1109/ASWEC.2006.31

[27] A. Koutsoyiannis. 1977. Theory of Econometrics. *Open Journal of Statistics* (1977).

[28] Jefferson Seide Molléri, Kai Petersen, and Emilia Mendes. 2020. An empirically evaluated checklist for surveys in software engineering. *Information and Software Technology* 119 (2020), 106240. https://doi.org/10.1016/j.infsof.2019.106240

[29] Jaana Nyfjord and Mira Kajko-Mattsson. 2007. Commonalities in Risk Management and Agile Process Models. *International Conference on Software Engineering Advances (ICSEA 2007)* (2007), 18–18. https://api.semanticscholar.org/CorpusID:11055815

[30] Edzreena Edza Odzaly, Des Greer, and Darryl Stewart. 2018. Agile risk management using software agents. *Journal of Ambient Intelligence and Humanized Computing* 9 (2018), 823–841.

[31] Alain Pinsonneault and Kenneth Kraemer. 1993. Survey Research Methodology in Management Information Systems: An Assessment. *Journal of Management Information Systems* 10, 2 (1993), 75–105. https://doi.org/10.1080/07421222.1993.11518001 arXiv:https://doi.org/10.1080/07421222.1993.11518001

[32] Project Management Institute PMI. 2017. *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)* (6 ed.). Project Management Institute.

[33] T. Punter, M. Ciolkowski, B. Freimut, and I. John. 2003. Conducting on-line surveys in software engineering. In *2003 International Symposium on Empirical Software Engineering, 2003. ISESE 2003. Proceedings.* 80–88. https://doi.org/10.1109/ISESE.2003.1237967

[34] Sandra L. Ramírez-Mora and Hanna Oktaba. 2017. Productivity in Agile Software Development: A Systematic Mapping Study. In *2017 5th International Conference in Software Engineering Research and Innovation (CONISOFT)*. 44–53. https://doi.org/10.1109/CONISOFT.2017.00013

[35] Lucio Ribeiro, Cristine Gusmao, Wilmar Feijo, and Vicente Bezerra. 2009. A case study for the implementation of an agile risk management process in multiple projects environments. In *PICMET '09 - 2009 Portland International Conference on Management of Engineering Technology*. 1396–1404. https://doi.org/10.1109/PICMET.2009.5262002

[36] Rogério Salgado. 2021. *Brasil já é o 4º maior mercado do LinkedIn no planeta*. https://www.linkedin.com/pulse/brasil-j%C3%A1-%C3%A9-o-4%C2%BA-maior-mercado-do-linkedin-planeta-salgado-/?originalSubdomain=pt Acessado em 14/09/2023.

[37] Eva-Maria Schön, Dirk Radtke, and Christian Jordan. 2020. Improving Risk Management in a Scaled Agile Environment. In *Agile Processes in Software Engineering and Extreme Programming*. Springer International Publishing, Cham, 132–141.

[38] André Sousa, Joao Pascoal Faria, and Joao Mendes-Moreira. 2021. An Analysis of the State of the Art of Machine Learning for Risk Assessment in Software Projects. In *Proceedings of the 33rd International Conference on Software Engineering and Knowledge Engineering, SEKE*. 1–10.

[39] Anselm L Strauss and Juliet Corbin. 2004. Open coding. *Social research methods: A reader* (2004), 303–306.

[40] Kevin Suryaatmaja, Dermawan Wibisono, Achmad Ghazali, and Rachma Fitriati. 2020. Uncovering the failure of Agile framework implementation using SSM-based action research. *Palgrave Communications* 6 (01 2020), 8. https://doi.org/10.1057/s41599-019-0384-9

[41] Keith S. Taber. 2017. The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education* 48, 6 (June 2017), 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

[42] Maureen Tanner and Ulrich von Willingh. 2014. Factors Leading to the Success and Failure of Agile Projects Implemented in Traditionally Waterfall Environments. In *Human Capital without Borders: Knowledge and Learning for the Quality of Life*. Portoroz, Slovenia, 693–701. https://api.semanticscholar.org/CorpusID:32999003

[43] Breno Gontijo Tavares, Carlos Eduardo Sanches da Silva, and Adler Diniz de Souza. 2019. Practices to Improve Risk Management in Agile Projects. *International Journal of Software Engineering and Knowledge Engineering* 29, 03 (2019), 381–399. https://doi.org/10.1142/S0218194019500165 arXiv:https://doi.org/10.1142/S0218194019500165

[44] Breno Gontijo Tavares, Mark Keil, Carlos Eduardo Sanches da Silva, and Adler Diniz de Souza. 2020. A risk management tool for agile software development. *Journal of Computer Information Systems* 61, 6 (2020), 561–570.

[45] Fernando Vedoin Garcia, Jean Hauck, and Adriano Borgatto. 2024. An Analysis of the State of Practice of Risk Management in Agile Organizations in Brazil - Supplementary Material. Mendeley Data, V2. https://doi.org/10.17632/rdy3s9vzsb.2

[46] Marcel Vieira, Jean C. R. Hauck, and Santiago Matalonga. 2020. How Explicit Risk Management is Being Integrated Into Agile Methods: Results From a Systematic Literature Mapping. In *19th Brazilian Symposium on Software Quality* (São Luís, Brazil) *(SBQS'20)*. Article 15, 10 pages. https://doi.org/10.1145/3439961.3439976

[47] Zuzana Virglerova, Muhammad Asif Khan, Raimonda Martinkute-Kauliene, and Sandor Kovacs. 2020. The internationalization of smes in Central Europe and its impact on their methods of Risk Management. *www.amfiteatrueconomic.ro* 22, 55 (2020), 792. https://doi.org/10.24818/ea/2020/55/792

[48] Andreas Westfeld and Andreas Pfitzmann. 2000. Attacks on Steganographic Systems. In *Information Hiding*, Andreas Pfitzmann (Ed.). Springer Berlin Heidelberg, Berlin, Heidelberg, 61–76.

[49] Li Xiaosong, Liu Shushi, Cai Wenjun, and Feng Songjiang. 2009. The Application of Risk Matrix to Software Project Risk Management. In *2009 International Forum on Information Technology and Applications*, Vol. 2. 480–483. https://doi.org/10.1109/IFITA.2009.542