RECOMMENDATIONS FOR RISK IDENTIFICATION METHOD SELECTION ACCORDING TO PRODUCT DESIGN AND PROJECT MANAGEMENT MATURITY, PRODUCT INNOVATION DEGREE AND PROJECT TEAM

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ABSTRACT
No other type of project is in greater need of risk management than new product development projects. This is due, largely, to the innovative profile of such projects and, consequently, of the risks involved. In this context, the importance of risk management has been increasing considerably. Risk management methods rely on risk identification. Several methods for risk identification are available in the literature and each one has its own characteristics in terms of complexity, application time, and requirements for specialist and information. Therefore, it is difficult to know how to choose a risk identification method, and which criteria to employ in making the choice. Thus, in this paper, a model for the selection of a risk identification approach, considering the product design process and project management maturity, product innovation and project team, is proposed. To conclude, a discussion on what this study means to practitioners and academicians is presented.

Keywords: risk identification, maturity, innovation, project team.

1 INTRODUCTION
The development of a new product is a wide process that includes planning and product design aspects, covering all of the activities involved in such a process. In this paper, the product development process (PDP) is understood as the whole process of transforming the information necessary for the identification of the demand, the production and the use of the product.
The PDP is extremely complex and involves the implementation not only of product development practices, but also project management activities. Project management (PM) includes the activities related to planning and coordinating resources and activities to successfully reach the objectives [1].
However, even if all the PM processes are defined, experience shows that it is rare that a project proceeds without any unexpected disturbances to the projected course [2]. This is partly due to the existence of risks, mainly in the initial phases of the product design, which commonly involve vague, qualitative and often insufficient information [3].
In this context, risk management (RM) in product design is fundamental to reaching project objectives. RM includes basically identifying, analyzing, treating, monitoring and controlling the risks in a project in a pro-active way [4]. The risk identification process consists of identifying and describing the potential negative events of the project and their consequences for the project. Several methods are presented in the literature for risk identification. Each one presents different characteristics with regard to the complexity, implementation process, need for expertise, implementation duration, characteristics of the PDP and project plan information, among others. The decision to use a risk identification method that does not consider the project needs and project team, or is not compatible with the preparation and profile of the manager, will not lead to the required effect in terms of the RM. Therefore, how should the most appropriate method with regard to the project context and the company situation be selected? Also, in a new product development project environment, which criteria should be adopted for the selection of a risk identification method that satisfies the needs and expectations of the project and its team?
During our literature review, no study dedicated to selecting the risk identification method was found. We consider that there is a lack of information to determine which risk identification method is most

suitable for a new product development project. Thus, the present article seeks to guide companies through the definition of a model and to provide some recommendations regarding the choice of a risk identification method taking into consideration selection criteria that will be discussed herein. This information will allow companies to choose the most appropriate risk identification method, according to their current situation and facilitate its application.

2 PRODUCT DESIGN AND RISK MANAGEMENT

2.1 Product design

Given the great importance of product development at the right time and with results that stir interest on the market, development procedures which give good solutions, with planning and flexibility are required.

In order to facilitate the product development process, several methodologies are available in the literature (for example [5], [6], [7]).

A model called the Product Integrated Development Process (PRODIP), which was developed with the aim of clarifying the knowledge on the PDP, providing support for the process understanding and application of the process is presented [8]. Figure 1 shows the graphic representation of the PRODIP model, with the macro-phases decomposed into eight phases and the range of involved knowledge domains involved, illustrating their involvement through the PDP phases. Each phase is described through seven elements: inputs; activities; tasks; knowledge domains, mechanisms; controls and outputs. According to Figure 1, the macro-phase of planning corresponds to the project planning phase. It encompasses the elaboration of the product project plan, which is the main phase output. The design involves the elaboration of the product design and the manufacturing plan, being decomposed into four phases, namely, informational design, conceptual design, preliminary design and detailed design. The main results of each phase are, in respective order, the design specifications, the product concept, the economic feasibility and the investment required. The macro—phase of implementation includes the implementation of the manufacturing plan for the company production plant and the project closure, and is decomposed into three phases, namely, pilot production, launch and project validation. The main outputs of each phase encompass, in respective order, the product release, the initial production and the project closure.

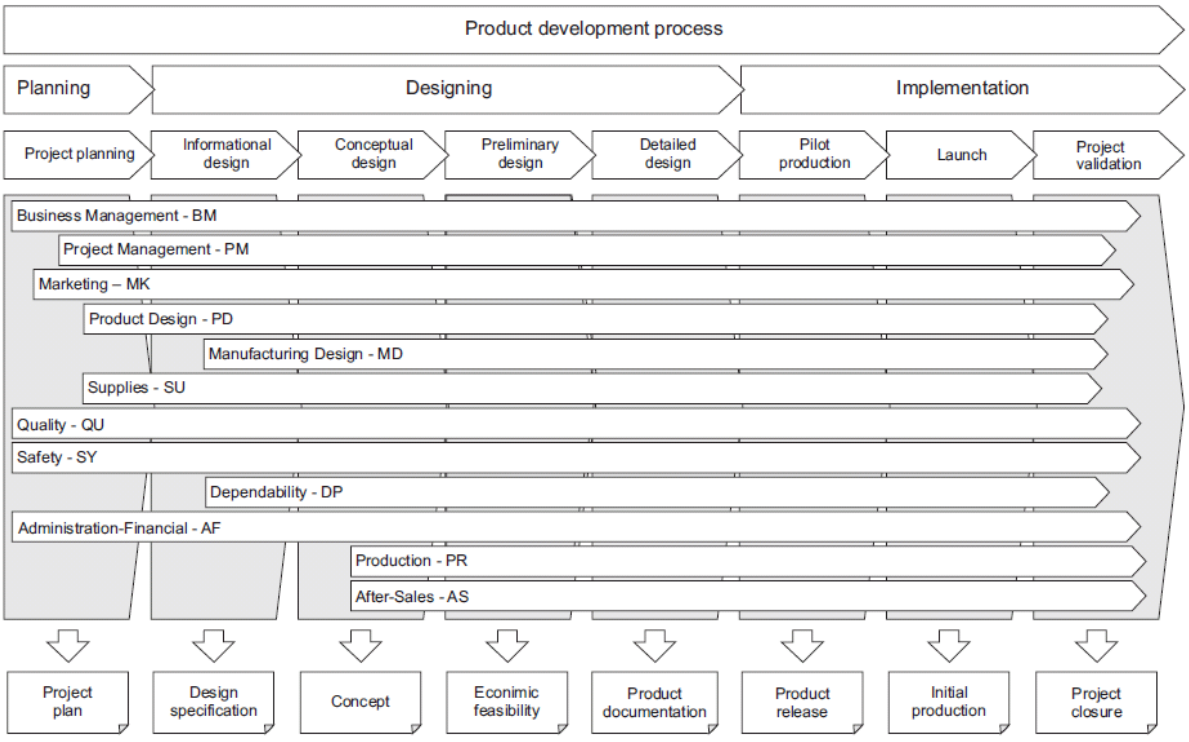

Figure 1 - Graphic representation of product integrated development process model (PRODIP) [8].

2.2 Risk management

Product development projects are considered successful when they result in high quality products, low cost and make efficient use of the time and available resources [6]. The project management (PM) consists of planning, organizing, monitoring, controlling and reporting of all the project aspects and the motivation of all those involved in it to achieve the project objectives [1]. The Project Management Institute [4] presents the PM in nine knowledge areas: integration, scope, time, cost, quality, human resources, communications, purchasing (acquisition) and risks.

In general terms, risk is an undesirable event with a probability of occurrence and impact. Risk management, the focus of this study, consists in identifying, analyzing, treating, monitoring and controlling of the project risks.

For this, several RM models are available in the literature. Table 1 gives details of two of them with their constituent processes. Basically, these models are inserted in the processes of risk identification, risk analysis, risk treatment and risk monitoring and control. Some models begins with the RM planning process [4].

However, the main difference between RM models is that, frequently, the literature reports several risk management methods specific to certain process, mainly to the risk identification and risk evaluation processes [10]. These two processes are decisive because they lead to the selection and implementation of preventive and/or corrective actions. We are particularly interested in the risk identification process, since risk management relies on risk identification, so it will influence strongly the others processes. The main methods found in the literature and adopted in practice in the RM are presented in the next section.

Table 1. Risk Management Models

Risk Management Processes					
Risk management planning	Risk identification	Qualitative risk analysis	Quantitative risk analysis	Risk treatment	Risk control
PMI, 2004	ISO 10006 PMI, 2004	ISO 10006 PMI, 2004	ISO 10006 PMI, 2004	ISO 10006 PMI, 2004	ISO 10006 PMI, 2004

2.3 Risk identification methods

Several methods can be used for risk identification. The brainstorming method consists of a general method of information collection and creativity which, in the case of risk identification, has the objective of obtaining a wide list of the project risks [9].

Delphi is perhaps the best-known method of using group evaluations in forecasting. This is a method for the systematic collection and collation of evaluations from isolated anonymous respondents on a particular topic, through a set of carefully designed sequential questionnaires interspersed with summarized information and feedback of opinions, derived from earlier responses. The participants are asked individually, usually by mailed questionnaires, about the risks associated with a particular project. These are then collated and summarized in such a way as to conceal the origin of the individual opinion. The results are then circulated and the participants are asked if they wish to revise their earlier forecasts. These rounds can continue until the estimates stabilize [4, 11, 12].

In turn, the analogous comparison consists of investigating what happened in previous similar projects in order to identify possible risks in the current project. Checklists can be drawn up based on previous projects with items to be verified in several project areas that can indicate risks associated with them [13].

Also, the semi-structured interview technique and the risk analytical structure (RAS) are suitable for risk categorization [4, 11]. The semi-structured one-to-one interview is an interactive dialogue aid for eliciting risks directly from the interviewee [12]. The RAS lists the categories and subcategories in which the risks can appear in a typical project. One of the benefits of these methods is to remind the project team members of the potential risks.

The use of the method FMECA (Failure Mode, Effects, and Criticality Analysis) is proposed [14] to identify the product design activity failure modes in terms of information input, treatment and transmission, along with the causes of internal or external failures and imperfections, and their effect on the output elements (which frequently constitute the input elements of the next process).

A Risk Model for the product design activities is proposed [3], based on the PRODIP model (Figure 1). The following risk subcategories for the risk category product design is defined: inputs (risks

originating from the input information or physical objects to be processed or transformed by the task); tasks (risks associated with the transformation of input processes into outputs during the execution of each activity); domains (risks arising from the specialists involved in the designing activities), mechanisms (risks derived from the methodologies, techniques, tools and other resources adopted in the tasks) and outputs (risks relating to the information or processed physical objects transformed by each task (production deliveries)).
The authors also define the category of project management risk, which is subdivided into: scope, time, costs, quality, human resources, communications and purchasing. Based on these two categories and their respective subcategories, the authors present more than three hundred typical risks associated with the product design activities. The Risk Model presented by the authors aims to guide the managers with less experience in such processes. However, the Risk Model is not intended to identity all the possible risks, since such a task would be impossible due to the particularity of each project.
In this regard, the employment of a structured questionnaire for each risk subcategory mentioned above is also proposed [3]. The results of the questionnaire application, combined with the selection of the pertinent risks for the project according to the Risk Model proposed, form the list of risks to which the project will be exposed.

2.4 Project team role and importance to the risk identification

Risk management as the least practiced discipline among project management knowledge areas [15]. In many organizations, there is often the tendency to discourage people from bringing imminent problems to the attention of management. This attitude is the result of a misunderstanding of risk management. Thus, although most of the RM models begin directly with the risk identification process, the literature that deals with RM advises companies to organize the project environment before implementing the RM. Thus, regardless of the method to be adopted in the RM processes, there is consensus in the RM literature that some common procedures must be adopted before and during the implementation of the risk management in product development projects.
Real changes must occur in both management of the organization and behavior of individuals before risk management will improve. First, it is essential to manage risk as an asset, seek diversity in perspectives and information sources and minimize uncertainty in time, control, and information [16].
Also, it is recommended that the role of the leadership and the project team in the RM processes be define [4]. The people involved in the risk management must have a clear and objective understanding of the design problem and project context. This question is important mainly for the identification of risks coherent with the reality of the project. In addition, depending on the complexity of the methods be used, risk management relies on the competence of a specialist related to the methods to be used, in order to apply then correctly [2]. In this regard, it is fundamental that the project team, mainly the project manager, receives training on the method to be used. A properly qualified and configured team can make more precise and opportune decisions in relation to risk identification
Concerning the human aspect, an effective risk management process will succeed by changing the organizational culture to motivate the individual. Cultural changes require time and repetition before they are firmly embedded in the organization. The project team sensitization in relation to the importance of risk management, especially the risk identification, is essential for the project team to learn and gain knowledge within the company. Attitudes such as recognizing and minimizing biases in perceiving risk, being proactive and rewarding those who identify and manage risks early, even if the risks become problems, are recommended [16].

2.5 Risk identification review conclusion

Through the brief, but wide, literature review given above, it can be verified that the methods available in the literature for risk identification vary according to the complexity, implementation process and duration, PDP need and project planning information, and the required involvement of specialists to identify the risks and apply the method. It is thus important to know which method is most appropriate, considering these characteristics, the context of the project and the reality of the company.
The level of risk management implementation can vary from project to project, depending on such factors such as size, project type, who is the customer, relationship with the corporate strategic plan and corporate culture [11].

Finally, many authors have developed methods to identify risks, but none of them has researched the selection of the most appropriate risk identification method for new product development projects according to certain criteria.
Therefore, this study aims to define the criteria to be adopted for the selection of the risk identification method. A typology is then given for the most commonly used risk identification methods and recommendations for the selection of the risk identification method. Finally, a discussion on the managerial implications of this study and final conclusions are presented.

3 SELECTION CRITERIA FOR THE CHOICE OF THE RISK IDENTIFICATION METHOD

The description of the risk identification methods given above shows that some methods require different level of information on the PDP and PM of the company. This is the case in brainstorming, a method easy to implement, that only requires that the project team members have a clear and common understanding of the project to begin the risk identification process.
On the other hand, other methods require that the PDP and the PM are more structured, as occurs with [3] and FMECA. Such methods are applied directly to the PDP activities. In other words, they seek to identify the risks of the PDP in a more detailed way. Thus, these methods require more specific and accurate information on the processes for coherent risk identification. Also, due to the complexity of these methods and the amount of information generated during their application, systems capable of manipulating and storing such information are needed. It can thus be inferred that different risk identification methods require different levels of PDP and PM structuration.
In that way, analyzing the various risk identification methods shows that these methods require different product design processes and PM maturity levels. Thus, the first criterion for the selection of the most appropriate risk identification method in product design is the maturity level in the PDP and in the PM.
The maturity concept is related to the notion of development from some initial state to some more advanced state [17]. Implicit in this is the notion of evolution, suggesting that the subject, in this case the product design and PM, may go through a number of intermediate states on the way to maturity.
Maturity approaches have their roots in the field of quality management. One of the first to be proposed was Crosby's Quality Management Maturity Grid [17]. Perhaps the best tool derived from this approach is the Capability Maturity Model (CMM) developed by the Software Engineering Institute - Carnegie Mellon University, Pittsburgh, which has conducted extensive research on improving the quality of the software development process [17, 18]. The CMM concept inspired the development of other models, designed for the study of NPD maturity, as well as the PM Process Maturity $(PM)^2$ Model level [19]. To evaluate the maturity of both product design and PM we decided to use a combination of these two models level [15, 19], since they summarize the characteristics found in most of the maturity models adapted to product design and PM.
The model proposed by [19] is represented in Table 3, in the second column called Product Design. This model is subdivided into five maturity levels in which the following dimensions are considered: whether the activity has been accomplished, whether the company uses appropriated methods or tools and at which stage the company lies in terms of the incremental evolution level. The $(PM)^2$ Model is also represented in Table 3, but in the three last columns called *Project Management* (Key PM Processes, Key Focus areas and Organizational) also distributed across five levels of maturity.
Besides a continuous improvement in their processes, companies seek to innovate. The essence of product innovation is to create or establish something new. In this text, innovation is understood as the degree of product originality. Since this process necessarily involves risk, innovative companies require a strategy not of risk avoidance, but of early risk identification and management [20]. Thus, the product innovation criteria assume a fundamental role in the choice of the risk identification method to be used in product design, because projects with a high innovation degree require an in-depth study of the risks compared to previous similar projects.
In these cases, as will be seen further on, methods that allow the most detailed risk identification are more suitable. As the criterion degree of product innovation influences the choice of the risk identification method strongly, in this paper, the product innovation classification model used is seen in Table 4 [21].
As shown in the product development model, PRODIP, the PDP requires knowledge of several areas of the company. This highlights the importance of the effective involvement of the project team in the

RM. The involvement of multiple knowledge areas in a project introduces uncertainties, which can generate risks, arising from ambiguity with respect to the specification of responsibilities; perceptions of roles and responsibilities; communication across interfaces; and the capability of a project team.

Table 3. Maturity models adopted.

Maturity level	Product design [19]	Project Management - $(PM)^2$ [15]		
		Key PM Processes	Key Focus areas	Organizational
Level 5	Transformation of product cycle design process integrated into the cycle of incremental improvement, the change management and the project planning.	PM processes are continuously improved. PM processes are fully understood. PM data are optimized and sustained.	Innovative ideas to improve PM processes and practices.	Project-driven organization. Dynamic and fluid organization. Continuous improvement of PM processes and practices.
Level 4	Control of all activities based on indicators and actions, integrated into the processes of the changes management and incremental improvement. The management of critical parameters is applied.	Multiple PM program management PM processes data are quantitatively analyzed, measured and stored.	Planning and controlling multiple projects in a professional matter.	Strong teamwork. Formal PM training for project team.
Level 3	There are performance indicators of all activities.	Formal project planning and control systems are managed.	Systematic project planning and control for individual projects.	Team oriented. Informal training of PM skills and practices.
Level 2	Use of functional modeling, definition of solutions principle, alternative conceptions, application of QFD, FMEA and CAE. Integration supply chain and specification of the production process and assembly.	Informal PM processes are defined. Informal PM problems are identified Informal PM data are collected.	Individual project planning	Team oriented (weak). Organizations possess strengths in doing similar work
Level 1	Definition of requirements in a non systematic way, definition of a product sketch, structures and drawings. Use of CAD, product requirements, analysis of life cycle, macro planning, talks with suppliers. Adoption of simple approval of phases (gates).	No PM processes or practices are consistently available. No PM data are consistently collected or analyzed.	Understand and establish basic PM processes.	Functionally isolated. Lack of senior management support. Project success depends on individual efforts.

Moreover, the project team also plays a very important role in the NPD risk management. The team members should be involved in the risk management processes, because these are the people most qualified to identify, analyze, respond to and control the risks. Thus, they are also one of the most important resources for reducing risks due to their competence and experience [22].

However, certain methods of risk identification require more time, experience and knowledge for their application, as in the case of the FMECA. Other methods provide some indications of possible risks without the constant and intense presence of specialists' and their abilities, for example the use of check-lists. Therefore, the elements time, experience and knowledge of the project team consist of the third criterion to be adopted for the selection of the risk identification method, here represented as the project team.
In this regard, the recommendations for the selection of the risk identification method, in product design, will be based on the three criteria presented above: product design and project management maturity levels, product innovation degree and project team. However, a typology for risk identification methods will first be presented, which will be used later.

Table 4. Degree of product originality [21].

Project Type	Characteristics
Innovative	New tasks or problems are assisted by a new principle solution or a new combination of a family of principle solutions.
Adaptable	The principle solution is preserved and only the configuration is adapted to the new peripheral conditions.
Alternative	The size and/or the arrangement of components or subgroups is varied, which is typical of series constructive and/or modular systems.

4 TYPOLOGY OF RISK IDENTIFICATION METHODS

The objective of this section is to classify the main identification methods according to their predominant characteristics to facilitate the definition of recommendations for a more appropriate selection of the risk identification method. The typology for risk identification methods adopted in this article is defined according to three approaches: analogical, heuristic and analytical [9].
The analogical approach is based mainly on the experience acquired in the management of previous and similar projects. Since this experience has been formalized, it is possible to proceed through comparison using, for instance, checklists. An advantage of this approach is that its application is usually fast and simple. A disadvantage is that the project team may focus on the checklist and forget to explore other risks that are not present on the list.
The heuristic approach consists of the use the project team creativity and/or expertise, for example, through a brainstorming meeting with specialists. This approach is efficient in terms of risk identification, since it is applied following strict rules and principles. For instance, the right expert must be selected and involved to insure their active participation. This approach allows an enhancement of the project team’s ability to visualize the risks which they may encounter and to incorporate this culture into the company. This is extremely important, since the risk management motivates the company to visualize the future and try to predict what may go wrong [23].
Finally, the analytical approach is the most well-known and currently used in the industry for the study of technical risks [9]. This approach is based on the FMECA method that gives procedures applicable to PM. In general, analytical approaches have the advantage of proposing an exhaustive investigation; however, this advantage requires a relatively heavy application that frequently needs the use of a computer science application for the data processing.
Considering the literature review on the risk identification method presented above, some of these methods are grouped according to the classification of risk identification above, as shown in Table 5.
It is worth pointing out that, although each method is classified into a specific approach, it can, and frequently does, present characteristics of another approach. For example, the checklist approach must be associated with creativity techniques, since each project is unique. Here, we classify the methods according to the predominant approach.

Table 5. Classification of the risk identification methods *Table 5.*

Analogical approach	Heuristic approach	Analytical approach
Checklist	Brainstorming	FMEA
Analogical comparison	Delphi Method	Monte Carlo
EAR		[3]

5 PROPOSED RESEARCH MODEL

The underlying assumption in the model proposed is that when the risk identification approach is selected taking into consideration the design process and project management maturity, the product innovation degree and team profile will have a positive effect on the risk identification success. The framework for the proposed research is provided by the model in Figure 2.

The model also suggests that the company must seek for the continuous improvement of the processes. With regard to the risk identification success, the company must constantly evaluate it and verify whether it is consistent with the needs of the product design and project management processes, as well as the project team expectations. If this is not the case, another approach, which the company is in a situation to apply, must be adopted.

As discussed in the previous section, there is no evidence to support any of the links in this model. So, the following series of recommendations are proposed in an attempt to focus research efforts on risk identification and benefit the project manager, stimulating the culture of risk management in the company and supporting risk reduction in new product development projects.

As an example, consider that a project manager would like to implement a risk management process in a product development project. At this moment, the following doubt may arise: which risk identification method should be adopted?

As shown in Figure 2, for the selection of some of the risk management approaches, analogical, heuristic and analytical, it is recommended, firstly, that the project manager defines the level of maturity of the PDP and PM, the originality of the product and the team profile. In the example, according to Table 3, it was defined that the level of maturity of the PDP and PM corresponds to level 2. The product originality degree is innovative (Table 4) and the project team has little knowledge and experience related to the project to be developed. According to Table 5 and the recommendations presented below, the approach recommended for this situation it is the heuristic approach.

Such an approach is advisable, because in the level 2, the PM is still informal and also, such an approach is relatively simple to apply. Furthermore, this approach is more suitable for innovative and adaptable projects. Although, in the considered example considered, the project team has little knowledge and experience, the heuristic approach allows the risk identification, since the project is understood by all and the project team creativity is stimulated in the risk identification. As the organization processes develop, the project manager should revalue the suitability of the risk identification approach, beginning, again, with the proposed model.

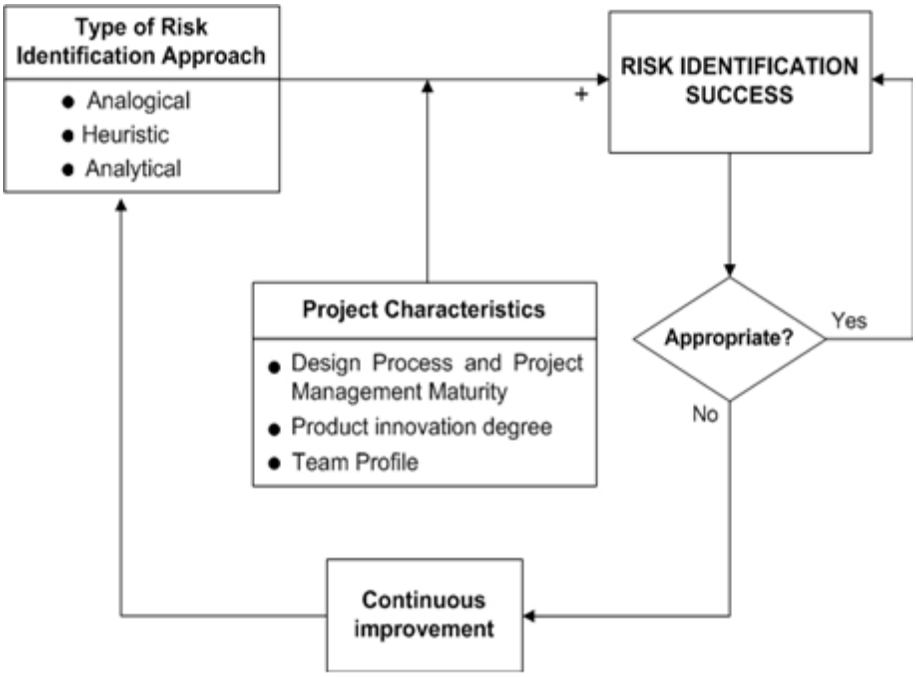

Figure 2 - Model for the selection of the risk identification approach.

6 RECOMMENDATIONS FOR SELECTION OF RISK IDENTIFICATION METHOD

Based on the model for selection of the risk identification approach given above, we present some recommendations on which one implement according to three criteria: product design and PM maturity level, product innovation degree and project team (Table 6).

According to Table 6, for the correct implementation of the analogical methods, the level of product design and PM maturity recommended corresponds to at least level 3. Although the application of the analogical methods is fast and easy, they consist of a systematic and wide form of risk identification that requires formalized information on the product design and project management for their elaboration or expansion [24].

Table 6. Classification of the risk identification approach for the selection of the method

Criteria / Typology	Product Design and PM Maturity	Product Innovation	Project Team
Analogical	3+	Adaptable/Alternative	+
Heuristic	1+	Innovative/ Adaptable	++
Analytical	3+ Product design and $(PM)^2$ - Key PM Processes and Focus Areas	Innovative	+++
	4+ $(PM)^2$ - Organizational		
+++: very important ++: important +: less important			

6.1 Analogical approach

In relation to the product originality level, the analogical approach is more appropriate for alternative and adaptable projects, since the methods that use these approaches are based on experience and comparison with previous projects [13, 24]. For instance, checklists present a list of standardized risks and thus their application is more appropriate for projects that have similar characteristics, that is, alternative and adaptable projects.

Having examined fifteen case histories of risk management in NPD, [24] suggested that the project teams should be cautious in the use of the methods that follow this approach, no matter how well they have been developed. They can aid in avoiding simple oversights, but must be used in a discussion mode to assure that analogous or related items are identified. Therefore, these approaches can be used as a starting point and must be customized according to the project.

In the analogical approach, it seems that the project manager's responsibility is simplified. Also, it is essential to reflect on potential events that are not present in the methods, but could appear.

The application time that the analogical approach requires for its adequate application is shorter when compared to the other approaches, because of the simplicity of the methods. However, because it is not easy to captured expert knowledge, the process is time-consuming and due to commercial pressures normally present during risk analysis assignments, the risk study must be carefully managed to optimize the time invested in each stage [12].

The analogical approach complemented by the cumulative experience of the project team is a great aid to inexperienced project team leaders. The use of the team's experience in combination with the checklist items to remind its members of the types of issues that may arise is recommended [24].

6.2 Heuristic approach

As the heuristic approach is based on the exploitation of the participants' creativity for the identification of the maximum possible risks, the level of maturity advisable for the successful implementation of these methods is level 1, since it is thus assured that all the project team members have understood the product design problem and are familiarized with the project context. This approach is best used when a problem is well defined, the major issues involved in the problem have already been identified and there is no need to explore the problem further.

The heuristic approach is more suitable for innovative and adaptable projects. These project types require the stimulation of the project team to identify new risks, mainly in the case of the innovative

projects due to their high degree of originality in terms of product, project management, etc. For instance, brainstorming sessions are an effective way to channel natural creativity into identifying what can go wrong on the project.
Particular attention must be paid to the constitution of the project team that will be involved in the risk identification, mainly, when the brainstorming methods are adopted. The presence of members who possess certain prestige or authority can prevent the generation of certain ideas through diverting them. In such cases, it is recommended that these specialists are consulted separately. For the brainstorming method, the size of the group will have a direct impact on the quality of the data obtained [10]. The maximum number of specialist recommended in a brainstorming session is 6 and a session should last a maximum 3 or 4 hours [24].
The Delphi method also involves specialists but they are consulted individually so that hierarchies and individual reputations do not affect the application of the method. Here, the number of specialists does not matter since the company can manage the information which is generated. Depending on the importance of the project to the company, it may not be possible to pass on many details of the project to external specialists. This can result in superficial and limited risk identification. On the other hand, it is less common for companies of today to perform all of their critical development activities in-house. The project partners must participate in the Delphi session. They are the most suitable people to identify the risks and to reduce them, since all of them have an interest in the project success.

6.3 Analytical approach

For the analytical approach it is recommended that the maturity level of the product design and PM (Key PM processes and Key focus areas) is equivalent to at least level 3. The higher the maturity level of the company in relation to the product design and PM, the better will be the results of the elaboration and application of the analytical approach. The volume of information generated by the methods which use this approach requires that the company is in a situation to manage it. Also, often the project team needs to analyze in detail the project planning and the product design process to define more adequately the types of failures that can occur, the effects and possible causes of failures, in the case of FMEA. For the application of the method proposed by [3], the formalization of the product design and PM allows a wider use of the method, because the risks of all the elements that form such processes can be identified in a structured way. Thus, a structured product design process and formal project planning are essential.
The analytic approach is very appropriate for innovative projects, because this type of project presents a lot of new situations, with associated risks, which must be identified and analyzed in details.
With regard to the project team, the analytical approach needs a minimum of experience to develop, as well as specialists from different domains of the project to identify the all possible failure modes, their causes and effects [14]. Maturity level 4 for the criterion project team is the most adequate, which suggests strong teamwork as well as formal PM training of the project team. To achieve success in the application of the methods it is essential that the project manager or facilitator has an excellent knowledge of the methods that use this approach, and it is very important that the project team understands the procedures that form the methods. Experience is not always a prerequisite for this approach. Experienced project teams may feel blocked in the identification of new risks. Moreover, it may be that in their perception they dominate the project and see no risks related to the project. The application time for this approach is much longer than that of the others, because of its complexity.

7 MANAGERIAL IMPLICATIONS

From a managerial perspective, this article is important to facilitate the decision process of selecting a risk identification method. Thus, the implementation of a risk identification approach will be easier, since the company will choose the method that is the most suitable for its organization. This will facilitate the adoption of a risk identification method.
Through the appropriate selection of the risk identification approach and considering the procedures outlined above, it is hoped that companies will increase the quantity and quality of risks which are identified, as well as develop a pro-active culture within the company. A study of this nature has the objective of stimulating the use of risk management in companies, beginning with the risk identification, regardless of the organization level.
This is of greater importance when the company is structuring and systematizing the project management, in other words, the company is still in an incipient state in relation to the PM, however,

demonstrating interest and initiative in evolving in this application field. In this way, although the PM is still being structured, this article offers orientations regarding how to choose the risk identification method, taking into consideration the current state of the company.
Moreover, as the company becomes more professional in its project management, this article allows that the choice of the risk identification method to be adopted accompanies the evolution. The risk identification method will be coherent with the level of demand of the project management and project needs. This means, that the risk identification process will follow, in an appropriate way, the evolution of the company project management. From an academic point of view, this article identifies the differences that exist between the more common methods of the risk identification methods proposed in the literature. Furthermore, it attempts to model the RM implementation process in companies, beginning with the risk identification which could generate new researches.

8 DISCUSSION AND CONCLUSIONS

This paper will allow companies to place themselves in position to the selection of the most appropriate risk identification approach considering the product design and project management maturity levels, product innovation degree and project team.
Although, in most cases, the RM begins with risk identification, this process alone is not sufficient for a successful RM in projects. Thus, it can be stated that a limitation to this approach is that is deals only with the choice of the risk identification method. Research that addresses the choice of methods for the other RM processes, taking into consideration the criteria defined above, would be very useful for companies that develop products. Therefore, the companies need to choose the most appropriate methods for each process of the RM taking into consideration the product design, PM and product maturity level and project team. In this way, the use of a complete RM strategy would be encouraged in the companies.
In future studies of this research model needs to be tested in practice in order to validate the model in product development projects and assess its efficiency, as well to evaluate the recommendations for risk identification method selection here proposed.

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