A theoretical conceptual model for risk and uncertainty management in projects

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Abstract
This paper aims to systematize a conceptual framework of risks and uncertainties in project management. A systematic review of the literature was performed combining bibliometric and content analysis. The Hive Structure of Risk and Uncertainty Management is proposed, mixing soft and hard approaches.

Keywords: project management, risk, uncertainty

Introduction
In general, organizations develop projects to achieve set goals. Organizations use human, physical or material resources to plan and execute their projects. To ensure the success of the projects, risk management is essential for the mitigation or elimination of surprises, such as rework and excessive costs.

Many innovation projects finish far from their initial estimates and are surrounded by uncertainties. Goffin and Mitchell (2005) indicated that the development of new products, services and processes is inherently uncertain, and dealing with risk and uncertainty is fundamental to the management of innovation.

In their work on managing uncertainty in projects, Meyer et al. (2002) noted that risk management is directed to the identification and control of variations and predictable uncertainties. However, for innovation projects or projects embedded in dynamic environments, wherein large uncertainties are concentrated, one should go beyond the traditional methods of risk management and adopt fewer techniques focused on planning and more directed to flexibility and learning.

The risks and uncertainties concepts are differentiated in the literature. For that is necessary to distinguish these two terms to explain their influence on the performance of projects. (Perminova et al. 2008).

This work aimed to explore the concepts of risks and uncertainties in the context of project management and innovation and to provide a model for integrated management. For this, an analysis of the academic research on the topic of “risks” and “uncertainties” was performed in the literature of “project management” and “innovation”. Two searches were performed using the Institute for Scientific Information (ISI) Web of Knowledge, the first with the topics “risk”,

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“project management” and “innovation” and the second with the topics “uncertainty”, “project management” and “innovation”.

This paper is structured into 4 sections. Section 2 provides a summary of the research methods adopted, followed by the research results and the theoretical model in section 3. Section 4 finishes the article with the conclusions and recommendations for future studies.

**Research Methods**

The methodological approach used was a systematic review of the literature guided by bibliometric and content analysis methods.

**Sample and Procedure**

The ISI Web of Knowledge (Web of Science) database was selected for their focus on search articles from other databases, such as Scopus, Proquest and Wiley, that are published in indexed journals and with an impact factor calculated in the Journal Citation Reports (JCR).

Two searches were performed in September 2013. The terms used in the first search were “risk*” and “Project* management” and in the second search were “uncertainty*”, “Project* management” and “innovation”. Both searches were investigated in all the databases of the ISI Web of Knowledge, resulting in 65 studies for the first search and 72 for the second. The asterisk (*) inserted into the 2 searches was used as a wildcard character that represented any other character. At this stage, it was not used as a filter of area, temporal or document type. The term innovation was added to the search because uncertainties are inherent to the innovation process.

Subsequently, the result was filtered by selecting only articles, decreasing the number of studies in the first search to 34 and in the second search to 54. These numbers constitute the final search sample. The final samples were published during the period from 1994 (first occurrence for the search of risks) and 1995 (first occurrence for the search of uncertainty) to 2013. The metadata of the sample of these articles were extracted from the ISI databases, and the analyses were performed using two software programs: Sitkis 2.0 (Schildt 2002) and Ucinet for Windows, 6.289 (Borgatti et al. 2002). The Sitkis program imported and debugged the metadata, and the Ucinet program designed the networks.

**Results**

The search result was divided into four topics: the main topics related to each term, the most cited papers, the concept of each term in the literature and a concept model to integrate both terms.

**Risks**

Figure 1 shows the network of keywords. To create this network, a filter of a minimum of three citations of each keyword was used. In the organization of words, it was possible to identify four groups of words. At the top is the group of words related to organizational strategy and tactics. At the bottom left is the group of words that attempt to define the word risk, at the center are the words related to competitive advantages and on the right are the words related to product development and radical innovation.
Uncertainties

Figure 2 shows the network of keywords. To generate this network, a filter of a minimum of five citations of each keyword was used. In the organization of words, it was possible to identify five groups. At the top is the group of words related to strategy and management. At the top left is the group of words related to product development, at the center are words related to competitive and motivating advantages for the study of uncertainties in the searches, in the lower right corner are the words that approximate to a concept of uncertainty in a sense of cause (ambiguity and complexity) and consequence (failure) and on the right are the set of words directed to uncertainties using a more macro approach (i.e., not only directed to the individuality of the project). On the bottom of the figure is a group of words related to techniques and procedures for dealing with the uncertainties.
Most cited articles
Of the 34 articles, the sum of all citations was 430. To identify the most cited papers, the cutoff was at least 15 citations per article; using this criterion, 8 articles were highlighted. The sum of citations of these articles was 351, corresponding to 81.62% of the total citations with the average of 18 citations per year and 2 citations per article per year. These articles are shown in Table 5. Figure 3 shows a graph with the evolution of the citations of these articles over time.

![Figure 3. Evolution of the 8 most cited articles over time.](image)

The article by Huchzermeier and Loch (2001) was the search article with the highest number of citations and of greater current relevance. The goal of this article was to present the values of flexible management in Research and Development (R&D) projects. The authors used the term uncertainty to indicate stochastic variability. Five types of uncertainties in the R&D environment and how they influence management flexibility were presented in the article: variability in market payments, budgets, performance, market requirements and deadlines.

Regarding the flow of information in the process of new product development, Eppinger (2001) provided a tool that can simplify the process of iteration. According to this author, the management of the process of new product development should focus more on the flow of information than on the delegation of activities. The author correlated the term risk with technological complexity and learning.

With respect to knowledge management in the context of the management of innovative projects, Hall and Andriani (2003) presented the knowledge needs required for the process of innovation. Furthermore, the authors correlated risk with the term vulnerability.

According to De maio et al. (1994), the need to manage the interdependence between projects at the portfolio level was presented as a way to support the success of new product development. In the article, the authors presented a framework that models the organizational dynamics in the organizations that develop products. The authors used the term risk as synonymous with uncertainty.

In their article made by Tiwana et al. (2006) on escalation situations in software projects noted that managers recognize the value of real options in the decision-making process. The real options would be the process of delaying the projects decisions to the latest possible moment to make the decisions with a greater assertiveness and a smaller number of uncertainties. The
authors noted the need to have flexibility to address the uncertainties in the software projects and designated uncertainty as a cause for risk.

Kwak and Anbari (2009) presented the result of a study on subjects associated with project management. In this study, 8 subjects that provide greater support to project management were identified: (1) Portfolio Management and Strategy, (2) Operations Research and the Science of Decisions, (3) Organizational Behavior and Human Resources Management, (4) Information Technology and Information Systems, (5) Applied Technologies and Innovations, (6) Performance Management and Earned Value Management, (7) Engineering & Construction and (8) Quality Management and Six Sigma. In the same article, the growth and importance of the management of risk and uncertainties by professionals and academics was observed; however, the concept of risks or uncertainties was not presented.

The article by Wang and Lin (2009) addressed the evaluation of the risks of overlapping activities in the process of new product development. The authors presented a model to analyze the impact of overlapping activities and used the term risk as being a doubtful event with an associated probability.

Zwikael and Globerson (2006) described the Success Critical Factors that distinguish the projects that achieved success from those that did not. From this concept, the authors performed a study of the impact of 16 processes and identified what they termed the Success Critical Processes. The method was based on a field study with 282 project managers. The terms risk and uncertainty were distinct from each other. The author relied on the definition of Meyer et al. (2002), where the uncertainties were classified into 4 types: variation, foreseen uncertainty, unforeseen uncertainty and chaos.

**Uncertainties**

Regarding the search of uncertainties, from the total of 54 articles, the sum of all citations was 1454. To identify the most cited articles, the cutoff was at least 50 citations per article, and 11 articles were highlighted based on this criterion. The sum of the citations of these articles was 1040, which correspond to 71.52% of the total citation with the average of 18 citations per year and 2 citations per paper per year. These articles are shown in Table 6.

Figure 4 shows a graph of the evolution of the citations of these articles over time.
Tatikonda and Montoya-Weiss (2001) presented a study on the multidisciplinary in the process of new product development through the integration of operations with marketing. The term uncertainty was noted as an absence of knowledge on the exact means to complete a task or project.

In the context of project types, Shenhar (2001) indicated that although the literature on project management notes similarities of tools and procedures among the successful projects, the same form of management by processes and tools does not fit all of the contexts of projects. In the same article, projects were classified into four levels of uncertainty and 3 of complexity. The levels of uncertainty were projects of low technological uncertainty, medium technological uncertainty, high technological uncertainty and super-high technological uncertainty, and the dimensions of complexity were a simple assembly project, a systemic project that includes more than one component and a joint project that comprises several systems.

The article written by Pich et al. (2002) is one of the articles with the highest growth in the number of citations; these authors addressed uncertainties, ambiguity and complexity in terms of the suitability of the information. In their article, the authors defined three strategies for project management: instructionism, learning and selectionism. For these authors, risk was defined as the relationship between the probability of an event happening and its impact, and uncertainty was defined as a lack of knowledge.

Tatikonda and Rosenthal (2000) applied the concept of uncertain activity in the context of product development, characterization and outcome. Their results suggest that the high levels of complexity were not associated with the total failure of the project but with some specific elements of the outcome. The uncertain activity was defined by the authors as the difference between the total knowledge required to perform a task and the existing knowledge in the organization. The concept of technological risks was observed in the article as being synonymous with uncertain activity.

Green et al. (1995) presented a study on radical technological innovation in which various dimensions of the concept of radical innovation were addressed. In the article, the term risk was synonymous with a lack of experience. The term uncertainty was presented as technological doubts.

The exploration of different types of project management was tackled by Lewis et al. (2002). In their study of 80 projects, the authors found that a mix of management styles increased the performance of the teams. In the context of the article, uncertainty was described as a lack of knowledge.

Clegg et al. (2002) presented the concept of governmentality applied to Project Management. According to the authors, governmentality would be a liberal form of governance. One of the points addressed by the authors was that governmentality can support quality management in projects, the concept of alliance, knowledge exchange and low cost transactions. In the article, there was no distinction between the terms risk and uncertainty.

Sommer and Loch (2004) presented selectionism and learning strategies in the context of uncertain projects and unforeseeable uncertainties. The authors defined unforeseeable uncertainty as that for which it is not possible to plan contingencies or estimate probabilities.

The article written by Shenhar (1998) was based on a study of 26 cases. The author showed that there was a need to adopt a more specific contingency approach than in project management in organizations. In the article, the projects were classified by four levels of uncertainty, as in the article by the same author from 2001 (Shenhar, 2001).

Thieme et al. (2003) presented a conceptual model to support the development of new products that have market survival. The authors did not distinguish between the terms risk and
uncertainty; however, they used the term uncertainty in the context of environment.

**Concept**

Table 1 presents a summary of the concepts used by the authors of the most cited articles from both searches.

<table>
<thead>
<tr>
<th>Author</th>
<th>Article</th>
<th>R/U</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huchzermeier and Loch (2001)</td>
<td>Project management under risk: Using the real options approach to evaluate flexibility in R&amp;D</td>
<td>U</td>
<td>Used the term as stochastic variability</td>
</tr>
<tr>
<td>Eppinger (2000)</td>
<td>Innovation at the speed of information</td>
<td>R</td>
<td>Used the term risk as technological and learning complexity</td>
</tr>
<tr>
<td>Hall and Andriani (2003)</td>
<td>Managing knowledge associated with innovation</td>
<td>R</td>
<td>Used the term risk as vulnerability</td>
</tr>
<tr>
<td>De maio et al. (1994)</td>
<td>A Multi-Project Management Framework For New Product Development</td>
<td>R/U</td>
<td>Used the term risk as synonymous with uncertainty</td>
</tr>
<tr>
<td>Tiwana et. al. (2006)</td>
<td>Information systems project continuation in escalation situations: A real options model</td>
<td>R/U</td>
<td>Cited uncertainty as a cause for the risk</td>
</tr>
<tr>
<td>Kwak and Anbari (2009)</td>
<td>Analyzing project management research: Perspectives from top management journals</td>
<td>-</td>
<td>There was no reference to risks or uncertainties</td>
</tr>
<tr>
<td>Wang and Lin (2009)</td>
<td>An overlapping process model to assess schedule risk for new product development</td>
<td>R</td>
<td>Used the event risk as a doubtful event with a linked probability</td>
</tr>
<tr>
<td>Zwikael and Globerson (2006)</td>
<td>From Critical Success Factors to Critical Success Processes</td>
<td>R/U</td>
<td>Designated the term risk as distinct from uncertainty. Uncertainty was classified into four types: variation, foreseen uncertainty, unforeseen uncertainty and chaos</td>
</tr>
<tr>
<td>Tatikonda and Montoya-Weiss (2001)</td>
<td>Integrating operations and marketing perspectives of product innovation: The influence of organizational process factors and capabilities on development performance</td>
<td>U</td>
<td>The term uncertainty was noted in the article as a lack of knowledge about the exact means to complete a task or project</td>
</tr>
<tr>
<td>Shenhar (2001)</td>
<td>One size does not fit all projects: Exploring classical contingency domains</td>
<td>U</td>
<td>Categorized uncertainties as projects of low, medium, high, and super-high technological uncertainty</td>
</tr>
<tr>
<td>Pich et. al. (2002)</td>
<td>On uncertainty, ambiguity, and complexity in project management</td>
<td>R/U</td>
<td>Risk was defined as the relationship between the probability of an event happening and its impact, and uncertainty was defined as a lack of knowledge</td>
</tr>
<tr>
<td>Tatikonda and Rosenthal (2000)</td>
<td>Technology novelty, project complexity, and product development project execution success: A deeper look at task uncertainty in product innovation</td>
<td>R/U</td>
<td>Uncertainty was the difference between the total knowledge required to perform a task and the existing knowledge in the organization; the term risk was used as uncertain activity</td>
</tr>
<tr>
<td>Green et al. (1995)</td>
<td>Assessing A Multidimensional Measure Of Radical Technological Innovation</td>
<td>U</td>
<td>The term was used as technological doubts</td>
</tr>
<tr>
<td>Lewis et al. (2002)</td>
<td>Product development tensions: Exploring contrasting styles of project management</td>
<td>U</td>
<td>The term was used as a lack of knowledge</td>
</tr>
<tr>
<td>Clegg et al. (2002)</td>
<td>Governmentality matters: Designing an alliance culture of inter-organizational collaboration for managing projects</td>
<td>-</td>
<td>Risks or uncertainties were not mentioned</td>
</tr>
<tr>
<td>Sommer, and Loch (2004)</td>
<td>Selectionism and learning in projects with complexity and unforeseeable uncertainty</td>
<td>U</td>
<td>The authors defined unforeseeable uncertainty as that for which it is not possible to plan contingencies or estimate probabilities</td>
</tr>
<tr>
<td>Thieme et al. (2003)</td>
<td>Project management characteristics and new product survival</td>
<td>U</td>
<td>Used the term uncertainty in the context of an uncertain environment</td>
</tr>
</tbody>
</table>

Legend: R, risk; U, uncertainty

As is shown in Table 1, the terms were sometimes treated as synonyms; however, there were some authors who presented elements that justified the separation of the concepts. For Ward and Chapman (2003), the use of the term risk in organizations did not include the lack of knowledge of the other events (uncertainties). Therefore, the authors noted that it would be important that the organizations transform risk management into uncertainty management.

**Conceptual Model**

Normally, the process of risk management is carried out as follows: when a cause is
identified, its impact is analyzed by the project team, depending on the risk aversion of the project, a response plan is prepared and then the risk is then monitored and controlled by a resource. One problem with this process is that risk management, in general, analyzes the cause as having only one outcome in a ratio of 1 to 1, when in fact the cause can lead to many other uncertain impacts (ratio of 1 to n).

In this situation, one outcome has been identified and will be monitored; however, the others possible effects are ignored because they were not identified or because of the lack of resources in the organization. Resource in this context are related to human resources.

In this approach, the resources are using all of their efforts in the contingency actions and containment of the identified risk (Figure 5). Typically in organizations, one of these resources is considered to be responsible for the risk.

The Hive Structure of Risk and Uncertainty Management is presented in contrast to the method just described (Figure 6). In this approach, the resources are not completely allocated with a focus on a particular risk but are allocated in a way in which two or more resources are considered responsible for each risk and uncertainty.

In a way, the Hive Structure of Risk and Uncertainty Management can be compared to a fire brigade at a company, the brigade is formed by some employees who are selected to be trained. When an uncertain claim happen, these are able to act. In the structure, employees are trained to know how to proceed with the uncertainties and / or risks at the project;

In this management format, the organization has to possess the necessary skills to address the uncertainties, including the following:

- Flexibility (Huchzermeier & Loch, 2001)
- Knowledge Management (Hall & Andriani, 2003)
- Ability to generate alliances (Clegg et al., 2002)
- Ability to improvise (Leybourn, 2006)
- Resilience (Thomas & Mengel, 2008)
In an organization with the necessary skills, when an uncertainty is discovered and identified and transformed into a risk, the need to make a decision at that moment is assessed. If a decision is required, some of the techniques mentioned in the literature are used. Otherwise, the identified uncertainty moves to the process of risk management, where it will be identified, analyzed and, if necessary, monitored.

1. Conclusions

This study analyzed the concepts of risk and uncertainty in the literature of project management and innovation in a horizontal manner. Although the terms risks and uncertainties appear similar, the literature shows that for many authors, these terms have distinct meanings and are used in different contexts. The term risk is closer to a cause and consequence relationship with a linked probability, while the term uncertainty stands out in the context of a lack of knowledge.

This study contributed to the identification of gaps for future studies, the identification of key journals addressing the subjects, the main authors, the keywords that relate to each of the terms, the distinction of the terms found in the literature and the presentation of a theoretical conceptual model to perform the joint management of uncertainties and risks.

For future studies (in addition to those mentioned in section 3.4), it is important to perform a practical study of the theoretical conceptual model presented.

A limitation of this study was that only a single database was used, and the analysis was performed only on articles with the highest number of citations.

A possible future study (in addition to the studies indicated in section 3) is to identify when to address risk management and when to address uncertainty management.

Bibliography