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Identification and Classification of Risk Elements in the Construction Environment

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ABSTRACT
Amid the economic environment, of competitive costs in the civil construction, the tasks of identifying, evaluating and classifying the elements of risks present in construction projects in the civil construction sector become imperative. Risk management has a strong impact on the projects' development, affecting ventures schedules, costs and quality. This research aims at identifying, evaluating and classifying the elements that form risks present in the civil construction environment, based on references from the literature, validated by researches directed to engineers and professionals related to the subject of risk management. Its structure presents two distinct phases, with a qualitative approach, via a semi-structured, and a quantitative questionnaire, through a survey. This part of the research was carried out in a non-probabilistic sampling, represented by 105 professionals and specialists of the sector. In the approach, using the multivariate statistical analysis, it was verified the normality in the data distribution. This characteristic allowed the application of the factorial analysis to verify the variables behavior. The research results allowed us to distribute the risk elements in 205 events, 43 factors and 9 categories, duly commented, in order to help their perception and measurement in the projects of civil construction venture projects.

Keywords - Environment; Management; Risk & probability analysis.

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I. INTRODUCTION

Governments, in their several areas of action in the federation, class entities, the insurance market, financial institutions providing credit, users and society in general, have faced problems of all kinds related to civil construction works. The events that stand out from obtaining environmental licenses, to the quality of the materials used, through inefficient management of resources that directly impact the deadlines, the costs and the quality of the works carried out.

Preventive safety models, mandatory for financing lines, are associated with the insurance contracts that condition the correct identification and measurement of risk factors present in the projects. The treatment given to the risk may be basic and enough when dealing with protection of simple measurement assets, but it may be very complex when dealing with activities involving aspects related to civil construction.

It is possible to observe that the risk elements and their respective degrees of influence on the formation of the expected loss are not appropriately identified for the insurance contractor. For example, there is no objective definition of whether the risk of an error in the structural calculation of foundations is more common and important than the risk of a new economic plan, which would compromise the purchasing power of new borrowers interested in acquiring the property under construction. This would result in non-compliance, which, in volumes incompatible with the project, could stop the work due to a lack of cash flow.

The civil construction companies, motivated by the difficulty of evaluating all the risks

present in their projects in a standard way, determine parameters based on the experience and orientations of their professionals regarding the risks assumed for the formatting of the insurance policies for the financing and the management of the works. This standard follows rather subjective analysis criteria and does not present perceptible consistency in its foundation.

Based on the scenario presented, the conclusion of this research seeks to clarify the following questions:

Q1: How can risk elements be identified and organized so they can be studied and treated more accurately in management processes?

Q2: What is the degree of importance of the identified risk elements in civil construction projects?

Thus, this research, as a central problem, aims to identify, evaluate and classify risk elements associated with construction projects of enterprises, identifying their respective levels of criticality and grouping them according to their levels of structure.

This article is based on a doctoral thesis [1], followed a structured procedure for the literature review, using essential criteria for the selection of indexed newspapers, present in academic databases: Scielo, Scopus and Google Scholar. From the definition of the bibliographic research, a wide amount of materials related to the diverse forms of risk approaches in civil construction projects was verified. However, despite this high material quantity, it was identified that few works delimited their objectives to the concepts of classification and measurement of risk levels in civil construction projects. Thus, approaches with similarities to the subject and the methodology proposed by this research were evidenced.

As for the definition of the term risk, the literature presents several concepts with many similarities in the points of perception, mainly in the association of risks to loss.

Some complementary classifications can also be attributed to the risks, such as, identifying whether they are internal or external from the original environment [2, 3, 4]. Internal risks are those that reach only the enterprise analyzed, where managers are directly responsible for the identification and mitigating actions [1]. Examples of this definition are contractual risks and certain environmental, market risks and social risks, etc. In Brazil, there is no research on the analysis of market risk factors in the construction sector [5]. E risks can affect any economic activity and originate in the external environment of the company regardless of the management will or act, and they are associated with macroeconomic or political phenomena such as, for example, the category of political risks, certain environmental and social risks, etc.

Emphasizing the most evident risk aspects in Brazilian civil construction, research that addresses the subjects related to claims registry has been verified [6]. Risks of cancellation of works and losses, related to corruption cases, are widely discussed in the Brazilian society. They are described in the Guide to Ethics and Compliance CBIC in Construction developed by entities that assist in management references, such as the Brazilian Chamber of the Construction Industry (CBIC, from its Portuguese initials), which discuss the subject and provide guidance and warning for the institutions involved in civil construction projects. Confirming the concern with risks related to corruption, the regulatory aspects that involve risk management in Brazil are highlighted, especially reinforced by Law no. 12.846 / 2013, also known as the Anti-Corruption Law, which has been in force since January 2014 [1]. At the international level, other technical risks, such as construction of water tunnels, are part of the concerns [8]. These risks may have a significant impact on tunneling operations requiring additional work resulting in major cost and time overruns [9].

During the economic crisis that affected a large part of European nations from 2010 to 2012, with special impact on the construction sector, only 27% of UK companies used a rigorous risk management policy in their projects [10].

It is suggested the adoption of guidelines and standards, such as reference forms and guidelines for risk management processes, to generate greater support for their applied management in projects and organizations [11].

The list of risk factors was defined based on an extensive bibliographical research, developed in an exploratory way and included elements that are being discussed deeply in Brazilian society [1]. Little attention is paid to contractual, political, economic and financial risks, such as political instability, excessively bureaucratic contractual procedures and lack of adequate infrastructure (transportnetworks,electricityandtelecommunications) [12].

Several authors have contributed to the notes of other elements which are reported as the most significant risk factors, which often lead to increased costs and delays in the civil construction projects. Issues related to lack of resources of project funders, problems related to lack of leadership, relations with the contractor, problems with communication between the designer and project contractors, environmental and other causes [3, 13, 14, 15, 16, 17, 18, 19].

Some research highlights the influence of risk factors on economic, financial, political, contractual, legal and technical risk categories [20, 21, 22, 23, 24, 25, 26, 27].

Some authors address issues relating to contractual risks, regulatory entities or strong influence on the definition of compliance procedures and standards, which are adopted by Brazilian civil construction companies. Technical limitations of the equipment are also cited as factors that may increase new costs in a study of the load capacity of a crane in use [28, 29].

As a partial result of the cited references, this research identified and structured nine risk categories with their respective factors that present a considerable degree of impact on the constructive enterprise projects, as shown in Table 1.

Table 1. Risk categorization in the construction sector.

Risk Categories	**Risk Factors**
Political	Political instability
	Lack of government incentives
	Fragmented political structure
	Holding of elections
Legal	Rule changes
	Excessive bureaucracy
	Complexity of the legal system
Economic	Inflation and interest rate fluctuation
	Economic instabilities
	Currency exchange value fluctuation
Financial	Taxes
	Difficult accessibility to insurance
	Difficult accessibility to credit
	Corruption
	Financial capacity reduction of the work owner
	Financial capacity reduction of the contractor
	Financial capacity reduction of the subcontractors
Social	Interpersonal conflicts (wars, disturbance, rebellions, etc.)
	Interpersonal conflicts (mentality, education, civility, communication, culture, etc.)
Market	Strong competition
	Capacity reduction of technological innovation
	Quality reduction of construction materials
	Quality reduction and high labor costs
	Quality reduction of construction equipment
	Subcontractor unavailability
Natural (environmental)	Adverse weather conditions
	Unforeseen ground conditions
	Floods and overflow
	Fires
	Earthquakes and seismic waves
Contractual	Contract type and reduced “base price”
	Deadline reduction
Technical	Little experience of the design team
	Deficiencies and/or communication failures between the parties (designer and contractor; designer and work owner; contractor and work owner)
	Delays in approval of projects and regulations
	Project errors
	Successive changes in projects
	Incomplete information
	Deficiencies in the information for the proposal elaboration
	High project complexity
	Lack of experience in similar projects
	Claims at critical points in the execution phase
	Works of recovery or successive reforms

In the perspective of risk management, classifying and mapping factors with potential impacts to projects is a critical task for the initiation of mitigating actions [30]. The categories in Table 1 are broad civil construction situations, common and recurrent in several countries and generating incalculable losses to the sector.

II. RESEARCH METHOD

The first stage of research deals with a brief introduction, characterizing and contextualizing the subject and justifying and defining the proposed objectives.

The second stage presents a succinct bibliographic review, focusing on the definitions of risks and risk factors cited by the research of the references adopted and associated with the environment of civil construction projects.

The third stage of the research highlights its methodological structure, contemplating three main approaches that guided the exploratory applications of the study:

- Sample definition and identification;
- Structuring of questionnaires and data collection;
- Application of exploratory factorial analysis (EFA) and synthesis of results.

Finally, the research arrives at its final stage, where it presents the conclusions and suggestions for the continuation of new studies related to the subject.

2.1 Sample definition and identification

A sample may be probabilistic or non-probabilistic. In a first way, all the elements are considered a population that may have the same probability of being chosen, provided that the probability is different from zero. If this condition is not met, the sampling form will not be probabilistic. Where its application is considered based on the need to obtain information from a specific group or sector [31].

This work adopted a non-probabilistic sampling, characterized by 105 (one hundred and five) professionals working in the civil construction sector. For the definition and validation of the adopted sample size, the understanding of Leech et al. [32] was followed, as shown in Equation 1:

Sample size = (n-p)>50 → (105-43)>50 (1)

Where:

n is the sample size.

p is the quantity of variables present.

From the definition of the minimum sample size, the restrictive levels that conditioned a significant approach to load factors were considered, based on the literature [33, 37]. Using a sample with 105 responses, that research adopted the value of 0.50 for analysis of the load factors of the variables, as shown in Table 2.

Table 2. Importance of the load factor in relation to the sample size.

Sample size	Load factors
250	0.35
200	0.40
150	0.45
120	0.50
100	**0.55**
85	0.60
70	0.65

III. TEST RESULTS

3.1 Structuring of questionnaires and data collection

The research was based on two phases, characterized by the following aspects:

Preliminary phase - initial stage of research, characterized by the development and application of an open questionnaire, with 10 questions and structured by guidelines. This initial questionnaire was presented to a group of 21 respondents qualified as professionals related to the segment. Its results served as a guideline for the identification of risk factors present in enterprise projects in Brazil. In this preliminary phase, bibliographic research on risk elements was also conducted, detailed in Table 3.

Table 3. Relationship of Risk Factors as Academy.

Political	Political instability	[12, 56, 57, 58]
	Lack of government incentives	[12, 55, 56]
	Fragmented political structure	[12, 56]
	Holding of elections	[12, 59]
Legal	Rule changes	[12, 53, 54, 57, 58, 59, 60]
	Excessive bureaucracy	[12, 56, 58]
	Complexity of the legal system	[12, 56, 58]
Economic	Inflation and interest rate fluctuation	[53, 54, 55, 56, 57]
	Economic instabilities	[12, 54, 56, 58, 60]
	Currency exchange value fluctuation	[54, 57, 59]
Financial	Taxes	[12, 56, 60]
	Difficult accessibility to insurance	[53]
	Difficult accessibility to credit	[43, 56, 59]
	Corruption	[12, 53, 56, 57, 58]
	Financial capacity reduction of the work owner	[21, 43, 47, 50, 52, 53, 54, 55, 58, 62]
	Financial capacity reduction of the contractor	[12, 21, 43, 47, 50, 52, 53, 54, 55, 58, 62]
	Financial capacity reduction of the subcontractors	[59]
Social	Interpersonal conflicts (wars, disturbance, rebellions, etc.)	[53, 54, 55, 56, 58, 59, 60]
	Interpersonal conflicts (mentality, education, civility, culture, etc.)	[54, 56, 60]
Market	Strong competition	[56]

	Capacity reduction of technological innovation	[56]
	Quality reduction of construction materials	[53, 54, 55, 56, 57, 58, 61]
	Quality reduction and high labor costs	[53, 54, 55, 56, 57, 58, 59]
	Quality reduction of construction equipment	[12, 53, 54, 55, 56, 58]
	Subcontractor unavailability	[50, 53, 59]
Natural (environmental)	Adverse weather conditions	[53, 55, 56, 58, 59, 60]
	Unforeseen ground conditions	[50, 55, 58, 60]
	Floods and overflow	[50, 55, 56, 58, 59, 60]
	Fires	[55, 56, 58, 59, 60]
	Earthquakes and seismic waves	[55, 56, 58, 60]
Contractual	Contract type and reduced "base price"	[56, 58, 59]
	Deadline reduction	[15, 22, 59]
Technical	Little experience of the design team	[50, 60]
	Deficiencies and/or communication failures between the parties (designer and contractor; designer and work owner; contractor and work owner)	[21, 43, 47,50, 52, 53, 54, 55, 58, 60, 62]
	Delays in approval of projects and regulations	[43, 54, 55, 56, 59]
	Project errors	[21, 43, 50, 53, 55, 56]
	Successive changes in projects	[21, 43, 53, 55, 56, 57, 59]
	Incomplete information	[50, 60]
	Deficiencies in the information for the proposal elaboration	[50, 52]
	High project complexity	[21, 43, 47, 50, 52, 53, 54, 55, 58, 62]
	Lack of experience in similar projects	[6, 50, 52]
	Claims at critical points in the execution phase	[6, 50]
	Works of recovery or successive reforms	

Interviews by guidelines show some degree of structuring, based on the interviewer's points of interest. This procedure is associated with qualitative approaches, where respondents are encouraged to freely discuss their understandings related to the subject under discussion [34, 31]. The application of this tool helped identify the most relevant risk elements.

Final phase - Development of a structured questionnaire, applied in a non-probabilistic sample, made up of 105 respondents and characterized by civil engineering professionals with a higher degree and experience (professional and/or academic) related to the subject.

The questionnaires were organized into 3 risk levels: Level 1 to 9: risk categories (1 to 9); Level 2 to 43 risk factors (1.1 to 9.11); and level 3 to 205: risk events (1.1.1 to 9.11.5).

The statements were applied at parity from 1 to 5, and structured under the Likert scale, according to Table 4.

Table 4. Likert scale comparison for the responses.

(SD): I strongly disagree	**(D):** I disagree	**(N):** I do not agree or disagree	**(A):** I agree	**(FA):** I fully agree
1	2	3	4	5

Likert scale was used to obtain the degree of agreement that the respondent has with a given statement (with a given statement). This measure of scale involving extremes where the leftmost value would represent a negative response and the right one a positive response [35, 36].

IV. DISCUSSION OF RESULTS

Preliminary phase - This phase indicated that the existence of uniform procedures for the measurement and identification of risks in civil construction projects was not known to most of the

interviewees. The research also identified the most significant risk elements in the perception of the interviewees and their causes. These risk elements, including the pointed-out causes, were then considered by the final research in proposing the risk categories, factors and events.

Final phase – based on the results of this phase, exploratory factorial analysis (EFA) was applied with the objective of identifying and checking the relations and consistencies present among the variables addressed by the research. A factorial analysis allows variables that result in new factors. Aligned with the thought, one factor represents a linear combination of change of originals [35, 37]. Thus, many works present in the literature are verified and they highlight the use of factorial analysis for the verification of correlations between variables by means of the identification of common factors. The exploratory factor analysis was applied to the collected data, resulting in the classification of the variables into categorical levels, according to the groupings identified and presented in Tables 5 and 6.

Table 5. Synthesis of the results of the risk categories - level 1.

Risk Categories (1rs level)	**Environment**	**Cronbach's Alpha**	**KMO**
1: Political Risks	External	0.841	0.729
2: Legal Risks	External	0.885	0.854
3: Economic Risks	External	0.865	0.794
4: Financial Risks	Mixed	0.936	0.841
5: Social Risks	Mixed	0.942	0.864
6: Market Risks	Mixed	0.926	0.831
7: Environmental Risks	Internal	0.935	0.796
8: Contractual Risks	Internal	0.874	0.781
9: Technical Nature Risks	Internal	0.981	0.779

The organization of the elements was divided into groups defined as categories, factors and risk events. Based on the information obtained, the categories and risk factors were defined according to the most relevant criteria associating them. Thus, the first level of risk contemplates all nine categories of risk:

1. Political risks: they seek to identify the factors made up from risk events related to the interference with governmental or electoral decisions [10];
2. Legal risks: factors arising from risk events related to aspects of the legislation or regulation in force;
3. Economic risks: factors with risk events associated with aspects of the employed economic policy;
4. Financial risks: factors with risk events connected to several aspects of the financial management of the business or projects and include taxation, insurance, credit, cash flow and corruption;
5. Social risks: factors with risk events related to social structures in which the company or project is embedded;
6. Market risks: factors arising from risk events related to aspects of the market segment to which the company or project is inserted. It considers the possible effects of competitors participation, technological innovation, quality of labor or materials used;
7. Environmental risks: factors with risk events associated with climatic, soil, rainfall or flooding, earthquakes and even fire risks aspects. The category of Environmental risks is cited by several authors, with indicators of previous years' indexes and cost increases [38, 39];
8. Contractual risks: factors with risk events associated with aspects of hiring of civil construction services such as the risks related to the price-base formation to the deadline which affects schedule of the work. Such thinking is also by other researchers in studies of problems caused by contractual issues [28].
9. Technical nature risks: this category, contemplates the project-related risk factors. In this research, the focus on the risk factors and events are associated with the main aspects of construction and include the part of the project, execution and control of the work [40].

Table 6. Synthesis of the results of the risk factors - level 2.

Risk Factors (2nd level)	**Environment** (I) Internal / (E) External	**Cronbach's Alpha**	**KMO**	**Weighted average of risk factor**
1.1: Political instability	E	0.803	0.759	**3.078**
1.2: Lack of Government Incentives	E	0.722	0.624	**2.919**
1.3: Fragmented political structure	E	0.765	0.687	**2.736**
1.4: Holding of Elections	E	0.732	0.643	**3.186**
2.1: Rule changes	E	0.859	0.724	**3.306**
2.2: Excessive	I	0.77	0.67	**3.30**

bureaucracy		5	7	**4**
2.3: Complexity of the legal system	E	0.849	0.727	**3.523**
3.1: Inflation and interest rate fluctuation	E	0.793	0.699	**3.303**
3.2: Economic instabilities	E	0.787	0.694	**2.786**
3.3: Currency exchange value fluctuation	E	0.814	0.716	**3.265**
4.1: Risks with taxes	E	0.747	0.629	**3.237**
4.2: Difficulty in contracting of insurance	E	0.799	0.647	**2.822**
4.3: Difficult accessibility to credit	E	0.717	0.698	**2.987**
4.4: Corruption	I	0.912	0.889	**3.134**
4.5: Financial capacity reduction of the work owner	I	0.894	0.741	**3.246**
4.6: Financial capacity reduction of the contractor	I	0.878	0.857	**3.399**
4.7: Financial capacity reduction of the subcontractors	I	0.819	0.714	**3.188**
5.1: Interpersonal conflicts (wars, disturbance, etc.)	E	0.884	0.853	**3.087**
5.2: Interpersonal conflicts (mentality, education, civility, communication, culture, religion)	I	0.946	0.845	**2.899**
6.1: Strong competition	E	0.755	0.667	**2.881**
6.2: Capacity reduction of technological innovation	I	0.897	0.708	**2.979**
6.3: Quality reduction of construction materials	I	0.789	0.684	**3.043**
6.4: Quality reduction of labor	I	0.921	0.829	**3.652**
6.5: Quality reduction of construction equipment	I	0.854	0.882	**3.332**
6.6: Subcontractors unavailability	I	0.809	0.694	**3.191**
7.1: Adverse weather conditions	I	0.834	0.801	**2.965**
7.2: Unforeseen ground conditions	I	0.828	0.773	**2.918**
7.3: Floods and overflow risks	I	0.814	0.804	**2.915**
7.4: Fire risks	I	0.88	0.80	**3.10**
		8	8	**2**
7.5: Earthquakes or seismic waves risks	I	0.943	0.821	**3.075**
8.1: "base price" formation or reduced budget	I	0.777	0.689	**2.398**
8.2: Reduced execution time of labor	I	0.789	0.658	**3.364**
9.1: Little experience of the design team	I	0.887	0.818	**3.422**
9.2: Deficiencies and communication failures between the involved parties (designers, contractors, work owner, subcontractors, heads of stonemasons, workers, etc.)	I	0.933	0.874	**3.692**
9.3: Delays in the project regulation or approval	I	0.837	0.665	**3.387**
9.4: Project errors	I	0.934	0.883	**3.572**
9.5: Successive changes in projects	I	0.906	0.853	**3.604**
9.6: Incomplete information	I	0.867	0.771	**3.487**
9.7: High project complexity	I	0.906	0.831	**3.067**
9.8: Deficiencies in the information needed to prepare the proposal for the work	I	0.874	0.804	**3.508**
9.9: Lack of experience in similar projects	I	0.942	0.915	**3.303**
9.10: Claims at critical points in the execution phase	I	0.965	0.926	**3.241**
9.11: Risks in works of recovery or successive reforms	I	0.881	0.834	**3.153**

The results in Table 6 show that the risk factor 1.4 Holding of elections presented higher weighted average value (3.186) in category 1 (political risks), which gives it a higher degree of importance compared to the other factors. The risk factor that represented the lowest score was 1.3 Fragmented political structure with 2.736, and it is still considered important and valid. The results found out in the research on category 2 (Legal risks) showed that all the factors pointed out in the research are important. The factors in rule changes, excessive bureaucracy, and the complexity of the legal system presented results superior to 3.30 in their average of responses. The topics dealt with are the categories of political and judicial risk and the

relationship with the government associated with the political and governmental structure and relationship with the government, as influencing factors in the implementation of projects [41].

The category 3 (Economic risks) presented the risk of Inflation and interest rate fluctuation as the most significant risk factor, showing a result of 3.303 average between the responses. Although it is also relevant, the Economic instabilities was the risk factor with the lowest representation, with a result of 2.786, which was observed by the average of the respondents. An analysis of the results shows that this risk category is of great interest to Brazilian respondents and to researchers of other nationalities [18].

The risk factors indicate results greater than 2.822 in factor 4.3 Difficulty in contracting of insurance up to factor 4.6 Financial capacity reduction of the contractor which resulted in an average of 3.399. Respondents' concern with the tax burden is observed, pointed out in the factor 4.1 Risks with taxes which presented a final average of 3.237 It is worth mentioning that the results obtained with the risk factor 4.4 Corruption, indicating the concern of the respondents with the subject, materialized by the result of 3.134 among them. The risk of Corruption motivated the creation of the Anti-Corruption Law [42].

The results indicated by category 5 (Social risks) sought to identify the influence caused by the lack of security related to the factors of 5.1 Interpersonal conflicts related to cases of public disturbance, wars, rebellions, among other, with an average of 3.087, and 5.2 Interpersonal conflicts related to issues such as mentality, culture, religion and other social order issues, with an average of 2.899, opinion shared with category 6 (Market risks), that sought to know the perception of respondents related to 6.1 Strong competition factors, which presented at the lowest average, although relevant, of 2.881. The factor 6.4 Quality reduction of labor presented the most significant result indicating a great concern with this item, with an average of 3.652, followed by the factor 6.5 Quality reduction of construction equipment, with an average of 3.332. Many aspects related to this factor are cited as factors that contribute to project delays [43].

The category 7 (Environmental risks) sought to know the degree of acceptance and importance of the risks related to the environment in which the work will be executed, and includes issues related to the environment, to the weather and to the safety with a possibility of fires. This category is of great importance in the treatment to mitigate risks in other activities [44, 45].

The factor 7.4 Fire risks was the most significant, with an average of 3.102, followed by factor 7.5 Earthquakes and seismic waves risks, with an average of 3.075 Although this factor represents a topic of great relevance among researchers, to the point of developing the use of applications to help in their forecasting, the result is surprising, since the Brazilian soil is not susceptible to this type of problem, as a general rule [46].

The category 8 (Contractual risks) sought to find the results of the respondents' perception of risk related to the factor 8.1 problems and difficulties related to the price-base formation or reduced budget, which presented an average of 2.980, while the factor 8.2 Reduced execution time of labor presented an average of 3.364. These factors are considered equally important in the thought of other researchers [13, 15, 22, 47, 48].

The category 9 (Technical risks) aims to identify the factors of the most significant risks of this nature. The results obtained reveal a great concern of the respondents with almost all the risk factors pointed out in the research. The results highlight the factor 9.2 Deficiencies and communication failures between the involved parties (designers, contractors, work owner, subcontractors, heads of stonemasons, workers, etc.) with a highest average of 3.692, followed by factor 9.5 Successive changes in projects, with an average of 3.604. Emphasizing the ones which involve the projects, the factor 9.4 Project errors, with an average of 3.572. The results found match with research that cites the technical risk factors as the most critical to the construction projects [21, 49, 50].

The adoption and use of risk management models emerge as a way of adapting organizations to scenarios permeated by uncertainties and volatilities [51].

Table 7. Synthesis of the results of the risk events - level 3.

RISK ELEMENTS (3^{nd} level)	**Environment** Internal (I) – External (E)	**Arithmetic Mean per risk event**	**Load factors of risk factors**	**Weighted average of load factor**
		(C)	(B)	(A)
1.1.1 Delays in projects caused by political instability frameworks.	E	3.890	0.801	3.116
1.1.2 The risk does not obtain new projects because of lack of market reliance caused by political instability frameworks.	E	4.050	0.852	3.451

1.1.3 The possibility that changes might arise which affect the profitability of their projects caused by political instability frameworks.	E	3.760	0.819	3.079
1.1.4 In their projects, the risk of the government can lead to their actions differently from the former governments.	E	3.820	0.698	2.666
1.2.1 Reductions of public financing in the project development.	E	4.170	0.686	2.861
1.2.2 Cancellation of public financing in the project development.	E	3.860	0.742	2.864
1.2.3 The company considers the risk of governmental incentives reduction in the civil construction sector.	E	4.080	0.795	3.244
1.2.4 Loss of governmental incentives in the construction civil sector.	E	3.710	0.730	2.708
1.3.1 New economic packets arise or governmental impacts which compromise the economic results of the projects in progress.	E	3.880	0.764	2.964
1.3.2 New economic packets arise or governmental impacts which compromise the economic results of the new projects.	E	4.010	0.773	3.100
1.3.3 Their ideas or management politics will be different from the ones practiced by the government to the extent of the profitability of their projects.	E	3.410	0.625	2.131
1.3.4 Delays in projects due to changes in the governmental structure, such as changes in the power of the ministries or regulatory agencies, for example.	E	3.700	0.702	2.597
1.3.5 Cancellation of the new project bids due to changes in the governmental structure, such as changes in the power of the ministries or regulatory agencies, for example.	E	3.990	0.724	2.889
1.4.1 Suspension of public investments.	E	3.943	0.720	2.839
1.4.2 Delays in projects in progress caused by possible situations of social instability.	E	3.886	0.862	3.349
1.4.3 Cancellations of hiring of new projects.	E	4.029	0.836	3.368
2.1.1 Delays in project execution.	E	3.800	0.906	3.443
2.1.2 Losses to projects.	E	3.800	0.860	3.268
2.1.3 Cancellation of projects.	E	3.629	0.884	3.208
2.2.1 Delays in their projects.	I	4.133	0.840	3.472
2.2.2 Cancellation of projects.	I	3.657	0.779	2.849
2.2.3 New costs on projects.	I	4.124	0.871	3.592
2.3.1 Legal or fiscal contingencies.	E	3.924	0.884	3.469
2.3.2 Labor contingencies.	E	3.952	0.887	3.506
2.3.3 Legal environmental contingencies.	E	4.190	0.858	3.595
3.1.1 Losses to the project.	E	4.057	0.852	3.457
3.1.2 Compromising the continuity of activities.	E	3.857	0.873	3.367
3.1.3 Creating excessive indebtedness.	E	3.867	0.798	3.086
3.2.1 Losses to the caused project.	E	4.048	0.696	2.817
3.2.2 Reduction of investments of the private sector in civil construction projects by the clients.	E	4.260	0.745	3.173
3.2.3 Delays to the project.	E	3.894	0.781	3.041
3.2.4 Reduction of public works.	E	4.305	0.757	3.259
3.2.5 Cancellation of new public works.	E	4.267	0.679	2.897
3.2.6 Cancellation of public works in progress.	E	3.695	0.413	1.526
3.3.1 The exchange rates are modified over and above of the expected level and, consequently, they cause an increase in the project costs.	E	4.019	0.845	3.396

3.3.2 Cancellation of new projects.	E	3.692	0.854	3.153
3.3.3 Compromising the continuity of activities because of excessive indebtedness.	E	3.760	0.863	3.245
4.1.1 Increase in the construction costs.	E	4.181	0.718	3.002
4.1.2 Increase in the difficulty to obtain clients.	E	3.933	0.839	3.300
4.1.3 Cancellation of new projects.	E	3.857	0.884	3.410
4.2.1 In the case of natural accidents in their projects, there will be delays in the contracting of insurance.	E	3.723	0.741	2.759
4.2.2 In the case of natural accidents in their projects, the cancellation of new insurance policies will be produced.	E	3.288	0.753	2.476
4.2.3 Additional costs with insurances because of changes in the regulation.	E	3.705	0.837	3.101
4.2.4 Additional costs with insurances arise because of possible changes in this market behavior.	E	3.581	0.825	2.954
4.3.1 Reducing the capture of projects as a consequence of the reduction in the supply of credits to civil construction by the market.	E	4.171	0.637	2.657
4.3.2 Not develop their projects due to difficulties in maintaining their credit lines.	E	3.981	0.808	3.217
4.3.3 Compromising financial capacity because of credit difficulties.	E	4.076	0.787	3.208
4.3.4 The idea is that if you personify a negative image of a bad payer, do not get new credits for their projects.	E	4.067	0.705	2.867
4.4.1 The risk of not obtaining new projects with private sector clients.	I	4.076	0.818	3.334
4.4.2 The risk of not obtaining new projects with public sector clients.	I	4.162	0.771	3.209
4.4.3 The risk of discontinuation in projects with private sector clients.	I	3.857	0.785	3.028
4.4.4 The risk of discontinuation in projects with public sector clients.	I	4.057	0.803	3.258
4.4.5 In their projects, the risk of discontinuation of activities.	I	3.857	0.774	2.985
4.4.6 In their projects, the risk of not obtaining credits.	I	4.010	0.830	3.328
4.4.7 Risk of losing important employees and executives.	I	3.867	0.724	2.799
4.4.8 Discontinuation of activities with imprisonment of strategic executives.	I	3.971	0.789	3.133
4.5.1 There are delays in the schedule.	I	4.305	0.720	3.099
4.5.2 The project is canceled.	I	4.057	0.789	3.201
4.5.3 There are incapacities of the company in maintaining the expenses of the staff, equipment, fixtures, by constant delays in the receipts.	I	4.135	0.830	3.432
4.5.4 There is a situation of lack of control of the accounts because of the company indebtedness.	I	4.096	0.758	3.105
4.5.5 The activities were discontinued because of the values were not received (unpaid value).	I	4.210	0.806	3.393
4.6.1 There are delays in the schedule.	I	4.324	0.797	3.446
4.6.2 The project is canceled.	I	3.886	0.713	2.771
4.6.3 There are incapacities of the company in maintaining the expenses of the staff, equipment, fixtures, by constant delays in the receipts.	I	4.173	0.912	3.806
4.6.4 There is a situation of lack of control of the accounts because of the company indebtedness.	I	4.129	0.872	3.600

4.6.5 The activities were discontinued because of the values were not received (unpaid value).	I	4.202	0.803	3.374
4.7.1 There are delays in the schedule.	I	4.010	0.777	3.115
4.7.2 There are increases in project costs.	I	3.914	0.863	3.378
4.7.3 There are problems with the relationship with the work owner.	I	3.952	0.873	3.450
4.7.4 Wear and tear on the company's image.	I	3.981	0.705	2.807
5.1.1 Delays in the project because of increased lack of security.	E	3.942	0.868	3.422
5.1.2 Increase in project material costs.	E	3.981	0.830	3.304
5.1.3 Increase in project labor costs.	E	3.923	0.848	3.327
5.1.4 Losses with cancellations because of increased lack of public safety.	E	3.923	0.857	3.362
5.1.5 Loss of workers, equipment or materials.	E	4.010	0.874	3.504
5.1.6 Loss of credibility in the image of the company.	E	3.320	0.483	1.604
5.2.1 Losing resulting from sabotage of services or activities.	I	3.457	0.754	2.607
5.2.2 Delays resulting from sabotage of services or activities.	I	3.495	0.785	2.744
5.2.3 Project delays because of interpersonal conflicts between workers.	I	3.410	0.831	2.833
5.2.4 Project losses because of interpersonal conflicts between workers.	I	3.419	0.798	2.728
5.2.5 Project losses caused by communication difficulties between workers.	I	3.705	0.813	3.012
5.2.6 Project delays caused by communication difficulties between workers.	I	3.714	0.801	2.975
5.2.7 Project losses caused by occupational accidents arising from the existing culture of not following occupational safety standards or instructions according to the use of machines and equipment.	I	3.885	0.729	2.832
5.2.8 Project delays caused by occupational accidents arising from the existing culture of not following occupational safety standards or instructions according to the use of machines and equipment.	I	3.952	0.722	2.853
5.2.9 Project delays caused by disability in educational or cultural training among workers.	I	3.625	0.838	3.038
5.2.10 Project losses caused by disability in educational or cultural training among workers.	I	3.490	0.754	2.632
5.2.11 Project losses derived from failures in the execution of services and activities caused by lack of professionalism.	I	3.856	0.844	3.254
5.2.12 Project delays derived from failures in the execution of services and activities caused by lack of professionalism.	I	3.875	0.846	3.278
6.1.1 Loss of jobs.	E	3.885	0.749	2.910
6.1.2 The reduction of the charged values resulting in a decrease in benefits.	E	4.048	0.673	2.724
6.1.3 Increase in the costs of hiring labor.	E	3.714	0.844	3.135
6.1.4 Increase in the material costs.	E	3.581	0.769	2.754
6.2.1 The reduction of the charged values resulting in a decrease in benefits.	I	3.610	0.850	3.068
6.2.2 Delays to the project.	I	3.467	0.878	3.044
6.2.3 Losses to the project.	I	3.390	0.890	3.018
6.2.4 Difficulties in obtaining new services because of the compromise of the company's image in relation to the competition.	I	3.667	0.772	2.831
6.3.1 Bear with higher costs for having to obtain better quality materials in more distant places.	I	3.980	0.643	2.559

6.3.2 Compromise construction quality with low quality materials.	I	3.865	0.791	3.058
6.3.3 Delays in works with rework tasks because of the use of low-quality materials.	I	3.981	0.893	3.555
6.3.4 Accidents on the construction site because of the use of low-quality materials.	I	3.743	0.802	3.002
6.4.1 Make losses.	I	3.846	0.876	3.369
6.4.2 Delay risks.	I	4.095	0.914	3.743
6.4.3 Work accidents.	I	4.105	0.899	3.690
6.4.4 Damages with material losses.	I	4.181	0.910	3.805
6.5.1 Have losses with loss of materials in the projects.	I	3.981	0.838	3.336
6.5.2 Higher costs of transporting equipment to the construction site.	I	3.933	0.824	3.241
6.5.3 Miscellaneous losses caused by accidents arise.	I	4.038	0.868	3.505
6.5.4 Delays in project schedule.	I	4.038	0.804	3.247
6.6.1 Increases in construction costs.	I	3.904	0.814	3.178
6.6.2 Losses with conflicts between workers.	I	3.505	0.887	3.109
6.6.3 Losses with a low quality in the construction.	I	3.857	0.852	3.286
7.1.1 There are delays in the work.	I	4.105	0.745	3.058
7.1.2 There are suspensions in the work.	I	3.663	0.801	2.934
7.1.3 There are increases in project costs.	I	3.990	0.874	3.488
7.1.4 Problems occur with the work contractor because of interruptions or delays in the schedule.	I	3.867	0.838	3.240
7.1.4 Compromise their images.	I	3.438	0.612	2.104
7.2.1 Delays in the work.	I	4.095	0.768	3.145
7.2.2 Suspensions in the work.	I	3.587	0.783	2.808
7.2.3 Increases in project costs.	I	4.096	0.813	3.330
7.2.4 Problems with the work contractor because of interruptions or delays in the schedule.	I	3.952	0.822	3.248
7.2.5 Commitment to their images.	I	3.590	0.659	2.366
7.3.1 Delays in the work.	I	4.210	0.808	3.401
7.3.2 Suspensions in the work.	I	3.848	0.830	3.194
7.3.3 Increases in project costs.	I	3.952	0.831	3.284
7.3.4 Problems with the work owner (due to unnecessary interruptions or delays in the schedule, execution of processes in an improper manner or in disagreement with the standards of the construction company).	I	3.695	0.736	2.720
7.3.5 Commitment to their images.	I	3.452	0.573	1.978
7.4.1 Delays in the work.	I	3.876	0.901	3.492
7.4.2 Suspensions in the work.	I	3.648	0.833	3.038
7.4.3 Increases in project costs.	I	3.865	0.889	3.436
7.4.4 Problems with the work owner (due to unnecessary interruptions or delays in the schedule, execution of processes in an improper manner or in disagreement with the standard of the construction)	I	3.650	0.819	2.990
7.4.5 Commitment to their images.	I	3.600	0.709	2.552
7.5.1 Delays in the work.	I	3.552	0.946	3.361
7.5.2 Suspensions in the work.	I	3.514	0.950	3.339
7.5.3 Increases in project costs.	I	3.629	0.950	3.447
7.5.4 Problems with the work owner (due to unnecessary interruptions or delays in the schedule, execution of processes in an improper manner or in disagreement with the standards of the construction company).	I	3.231	0.894	2.888
7.5.5 Commitment to their images.	I	3.029	0.773	2.341

8.1.1 Be unable to comply with the work execution schedule.	I	3.952	0.883	3.490
8.1.2 Have their benefits reduced.	I	4.125	0.749	3.090
8.1.3 Be forced to lower the quality standard of the work.	I	3.327	0.683	2.272
8.1.4 Have their images affected by producing the work below its quality standard.	I	3.933	0.780	3.068
8.2.1 Failure to comply with the contractually agreed deadline for completion of the work.	I	4.010	0.880	3.528
8.2.2 To reduce the benefit expected in the project by being forced to absorb additional costs of new resources in order to meet contractually agreed deadlines.	I	4.115	0.886	3.646
8.2.3 Images affected by producing the work below its quality standard.	I	3.904	0.747	2.916
9.1.1 Errors in the materially realized project.	I	4.200	0.814	3.419
9.1.2 Delays in project realization schedule.	I	4.181	0.892	3.729
9.1.3 Increases in project costs.	I	4.219	0.874	3.687
9.1.4 Human losses in the work because of errors produced by failures in the project.	I	3.779	0.779	2.944
9.1.5 Material losses in the work because of errors produced by failures in the project.	I	4.210	0.791	3.330
9.2.1 Losses to the project.	I	4.190	0.926	3.880
9.2.2 Project errors of any species.	I	4.143	0.913	3.782
9.2.3 Conflicts between the parties involved in the project.	I	4.200	0.927	3.893
9.2.4 Delays in project realization schedule.	I	4.190	0.923	3.868
9.2.5 Damages to the image.	I	4.038	0.752	3.037
9.3.1 Delays in project realization schedule.	I	4.114	0.884	3.637
9.3.2 Increases in project costs.	I	4.000	0.922	3.688
9.3.3 Project cancellation.	I	3.552	0.798	2.835
9.4.1 Delays in project realization schedule.	I	4.219	0.888	3.747
9.4.2 Increases in project costs.	I	4.190	0.918	3.847
9.4.3 Material losses.	I	4.143	0.928	3.845
9.4.4 Human losses in the work.	I	3.667	0.707	2.592
9.4.5 Losses.	I	4.219	0.906	3.822
9.4.6 Damages to their affected images by producing the work with design errors.	I	4.171	0.858	3.579
9.5.1 Delays in work realization schedule.	I	4.330	0.828	3.585
9.5.2 Increases in project costs.	I	4.333	0.895	3.878
9.5.3 Conflicts between the parties involved in the project.	I	4.219	0.858	3.620
9.5.4 Images affected by producing the work below its quality standard.	I	4.076	0.829	3.379
9.5.5 Losses.	I	4.181	0.851	3.558
9.6.1 Delays in work realization schedule.	I	4.190	0.831	3.482
9.6.2 Increases in project costs.	I	4.219	0.919	3.877
9.6.3 Conflicts between the parties involved in the project.	I	4.114	0.836	3.440
9.6.4 Images affected by producing the work below its quality standard.	I	3.952	0.797	3.150
9.7.1 Errors in the materially realized project.	I	3.924	0.653	2.562
9.7.2 Delays in project realization schedule.	I	3.819	0.897	3.426
9.7.3 Increases in project costs.	I	3.867	0.899	3.476
9.7.4 Human losses in the work.	I	3.587	0.841	3.016
9.7.5 Images affected by producing the work below its quality standard.	I	3.505	0.812	2.846
9.7.6 Material losses in the work.	I	3.644	0.844	3.076

9.8.1 Project losses because of lack of information on important details for the preparation of the proposal of the work being contracted.	I	3.971	0.656	2.605
9.8.2 Delays in project realization schedule.	I	4.173	0.934	3.898
9.8.3 Increases in project costs.	I	4.146	0.909	3.768
9.8.4 Errors in the materially realized project.	I	4.175	0.901	3.761
9.9.1 Errors in the materially realized project.	I	4.029	0.779	3.138
9.9.2 Delays in project realization schedule.	I	4.010	0.874	3.504
9.9.3 Increases in project costs.	I	4.010	0.871	3.492
9.9.4 Human losses in the work.	I	3.810	0.786	2.994
9.9.5 Images affected by producing the work below its quality standard.	I	3.648	0.821	2.995
9.9.6 Material losses in the work.	I	3.971	0.873	3.467
9.9.7 Insufficiency of material resources.	I	3.952	0.896	3.541
9.9.8 Insufficiency of labor resources.	I	3.924	0.839	3.292
9.10.1 Claims at prop walls.	I	3.810	0.645	2.457
9.10.2 Claims because of foundation underpinning.	I	3.824	0.829	3.170
9.10.3 Claims because of inadequate blocking of pillars.	I	3.816	0.906	3.457
9.10.4 Claims because of lack of expansion and movement joint.	I	3.735	0.918	3.429
9.10.5 Claims because of faults in forms and notes.	I	3.814	0.940	3.585
9.10.6 Claims because of laying the concrete.	I	3.755	0.857	3.218
9.10.7 Claims because of errors in concrete curing.	I	3.842	0.881	3.384
9.10.8 Claims because of steel corrosion.	I	3.673	0.847	3.111
9.10.9 Claims because of cracking in the reinforced concrete.	I	3.716	0.818	3.039
9.10.10 Claims at metallic structures.	I	3.782	0.915	3.461
9.10.11 Claims at wooden structures for cover.	I	3.733	0.896	3.344
9.11.1 Fires.	I	3.728	0.689	2.569
9.11.2 Claims because of excavations, landfills and inadequate treatment of slopes.	I	3.856	0.833	3.212
9.11.3 Claims because of the presence of water (mines, leaks, infiltrations)	I	3.865	0.900	3.479
9.11.4 Claims at lowering of the water table.	I	3.854	0.915	3.527
9.11.5 Damage to other buildings in the execution of stakes.	I	3.843	0.775	2.978

Table 7, representing only Category 3 risk events, by way of illustration, shows the results based on the identification of the weighted average (A), formed by the relationship between the load factor of each risk event (B), and the simple arithmetic mean of the questionnaire responses (C).

It is important to highlight that only one variable 3.2.6, (Cancellation of public works in progress.) resented a load factor (0.413) lower than the premise (0.55) defined for the research. However, according to other researchers, this variable was considered consistent because it presented a load value higher than 0.30, the minimum acceptable in exploratory research [37].

V. CONCLUSION AND RECOMMENDATIONS

Based on the obtained data through the application of exploratory factorial analysis (EFA), this research sought to clarify problems, answering the questions of the introduction. Thus, according to the results presented by Tables 5, 6 and 7 of this research, the risk structures were grouped into three levels, as defined below:

1st level: Risk categories: a set of risk factors associated with a gender of approach. In this research, 9 risk groups are considered: Political risks, Legal risks, Economic risks, Financial risks, Social risks, Market risks, Risks as a result of environmental problems or Natural causes or environmental risks only, Contractual risks and Technical order risks;

2nd level: Risk factors: a set of risk events that characterize the presence of risk factors in each process or project. An example of Risk Factor in the questionnaire is Political instability because its

existence is configured from the presence of events: the way in which governments are run or to scenarios of political instability;

3rd level: Risk events: situations that, despite being contemplated by the projects, can arise and generate problems of delays, cancellations, cost increases or losses to the projects and their operational, tactical or strategic processes.

In the classification based on this research, the risk events represent the elements that influence the origin of the risk factors which, in turn, are grouped by gender and constitute the scope of the risk categories.

From the identification and definition of the classification of the risks, it was possible to associate their scopes according to the environments that originate them, as illustrated in Table 8.

Table 8. Synthesis of the results presented to the risk levels.

Classification	**Level**	**Internal**	**Mixed**	**External**	**TOTAL**
Risk categories (1st level)	1	3	3	3	**9**
Risk factors (2nd level)	2	29	-	14	**43**
Risk events (3rd level)	3	150	-	55	**205**

The results present a total of 9 risk categories, divided into 43 risk factors encompassing 205 risk events. Thus, the degree of importance of each risk element was evidenced by tables 5, 6 and 7 presenting the research results.

In view of the data presented by the responses to the central questions of the research, some relevant points can be highlighted, such as:

1. Half of the risk categories originate in both environments (internal and external), a fact that evidences the need to implement risk management processes focused on mitigating potential internal factors and evaluating scenarios external to the organization, aiming to foresee situations that may generate undesirable scenarios for the execution of its activities;

2. Following the premise adopted by the previous question, it is verified that more than two thirds of the risk factors and three quarters of the risk events are related to the internal environment. This fact ratifies the observation of the previous analysis.

VI. PRACTICAL RELEVANCE AND POTENTIAL APPLICATIONS

Finally, research contributes to elucidating various aspects inherent in good risk management practices, without the pretension of exhausting the theme.

As a suggestion for new research work in risk management, it is recommended to deepen the risk elements involved in this model, which may be influenced on a greater or lesser scale, according to other factors.

For example, if the project under study is developed by an engineering department of the company itself. In this situation, risk factors related to internal controls may exercise more influence and weight than factors related to contractual risks, for example. It would be interesting to further investigate the risk factors by activity segment or type of contractor.

It is worth mentioning that contractors in the public segment have different characteristics from the ones of the private sector.

The research did not aim to exhaust the subject of risk management, letting to future researchers to address various aspects of this important management activity

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