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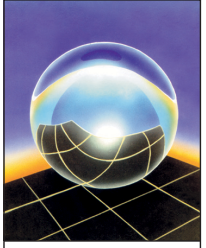
Characterization of risk factor management in infrastructure projects

Caracterização da gestão de fatores de risco em projetos de infraestrutura



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Leandro Ranolfi Girardi[1]
Roque Rabechini Junior[2]
José da Assunção Moutinho[3]

Abstract: This study aims to understand how risk factor management is characterized in the performance of infrastructure projects. The multiple-case study methodology was used, including the analysis of five projects in two different economic sectors. Empirical evidence suggests that the impact of risk factors in the performance of projects depends on risk management intensity and on the skills of risk managers, but it does not vary with project complexity. Furthermore, the intensity of the analyzed performance dimensions may vary according to the influence of the factors considered.

Keywords: Infrastructure project; Performance; Risk management; Risk factor; Complexity.

Resumo: *Este estudo tem por objetivo compreender como se caracteriza a gestão dos fatores de risco no desempenho de projetos de infraestrutura. Para tal, utilizou-se o referencial teórico associado tanto à literatura voltada para o gerenciamento de riscos quanto sobre complexidade e desempenho de projetos. A estratégia de pesquisa utilizada baseou-se no método de estudo de casos múltiplos, compreendendo a análise de cinco empreendimentos em dois segmentos econômicos distintos. As evidências empíricas sugerem que o impacto dos fatores de risco no desempenho dos projetos depende da intensidade da gestão dos riscos e das habilidades dos gerentes de risco, mas não varia com a complexidade dos projetos. O estudo também indica que a intensidade do desempenho nas dimensões analisadas varia de acordo com a influência dos fatores considerados.*

Palavras-chave: *Projeto de infraestrutura; Desempenho; Gerenciamento de risco; Fator de risco; Complexidade.*

1 Introduction

Investments in infrastructure projects are necessary conditions for the economic growth of a country. This is not a trivial effort. Few countries have been able to mobilize resources, in a horizon of more than 20-30 years, without reductions that compromise the integrity and quality of the projects in this sector (Frischtak, 2009). In general, and regarding the experience of developed countries and emerging economies (Fay & Morrison, 2005), it is observed that these projects result in assets that, if well managed, can contribute to sustainable gains in competitiveness (Ng & Loosemore, 2007).

The infrastructure sector involves great values (Flyvbjerg, 2014). In Brazil, from 2011 to 2014 R$ 759 billion were invested, and of this total, about 50% was intended for the segment of oil and natural gas, 18% in electric power, 9% in telecommunications, 8% in rail expansion, 7% in highways, 5% in sanitation and 2% in ports (Lanzana & Lopes, 2011). Despite this volume of resources, the Ministry of Finance (Brasil, 2013) adds that the projects achieved so far were not sufficient to meet the domestic demand and that new cycles of investments will be needed in the coming years.

[1] Programa de Pós-graduação em Administração - Gestão de Projetos, Universidade Nove de Julho – UNINOVE, Avenida Francisco Matarazzo, 612, Barra Funda, CEP 05054-010, São Paulo, SP, Brazil, e-mail: lrgira@hotmail.com

[2] Programa de Pós-graduação em Administração, Universidade Nove de Julho – UNINOVE, Avenida Francisco Matarazzo, 612, Barra Funda, CEP 05054-010, São Paulo, SP, Brazil, e-mail: roquejr@usp.br

[3] Universidade do Estado do Rio de Janeiro – UERJ, Rua São Francisco Xavier, 524, CEP 20550-900, Rio de Janeiro, RJ, Brazil, e-mail: moutinho_pmp@yahoo.com.br

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For the investors, there are opportunities for new projects, mainly through Public Private Partnerships (PPPs). However, when evaluated by management view, it is perceived that the shortcomings in the management limits the scope of its objectives (Young et al., 2012). The study conducted by Ibbs & Kwak (2000) ended that risk management is the most critical area in infrastructure projects. Thus, if the respective risk factors are not well managed will involve negative reflexes in their performance (Shenhar et al., 2005; Zwikael & Ahn, 2011).

With these considerations, the identification of risk factors that influence the performance of projects and the understanding of the implication on the dimensions of performance are an important potential to its management. This result is characterized as basic element for filling a gap in the Brazilian literature on the subject. Thus, this article aims to answer the following question: how is characterized the risk factors management on the performance of infrastructure projects?

This study aims to better understand how is characterized the risk factors on the performance of infrastructure projects. As specific objectives, seeks to determine the presence of risk factors and the performance of projects; assess the relationship between the presence of risk factors and the performance impact; and identify how the risk factors management can influence the management of projects.

2 Theoretical framework

This infrastructure in a country represents a set of assets, which if managed effectively, can become attractive to foreign investments, in addition to supporting the development and social, cultural, and economic stability of a nation (Ng & Loosemore, 2007). According to these authors, there are different types of infrastructure projects, divided into two categories: a) economic: bridges, drainage systems, industrial plants, telecommunications, rail transport, etc.; b) social: construction of schools, prisons and hospitals, tourist systems, etc.

According to Sanderson (2012), the economic category has as predominant characteristics, involves a substantial portion of resources; presents a life expectancy measured in decades and the clients are public organizations. The main suppliers are private companies which frequently reserve the property of a portion of the infrastructure, that stipulate the collection by services rendered, at the end of the project.

Another feature of the economic infrastructure projects is that they tend to have poor performance (Datta & Mukherjee, 2001; Chan & Chan, 2004; Shen et al., 2006; Flyvbjerg, 2007, 2008; Eriksson & Westerberg, 2011). In the study conducted by Flyvbjerg et al. (2002) when examining transport projects found that 90% had the cost overruns. Meng (2012) found, as a result of his research that 35.6% of projects are not completed on time and that 88.2% have some type of defect. In a later study, Flyvbjerg (2014) investigated infrastructure projects of various types and located in different countries, ending that the cost overruns reached 1,900%.

In the field of studies on the discipline of project management, surveys point to a variety of performance dimensions that go beyond the traditional iron triangle (PMI, 2013). Some aspects that stand out in this vision refer to the changes - project without major changes (El-Sayegh, 2008; Shenhar & Dvir, 2007); activities: activities being managed on the progress (Ghosh & Jintanapakanont, 2004; Shenhar & Dvir, 2007); integration - presence of a detailed framework and integration between budget and schedule of activities (Raz et al., 2002; Shenhar & Dvir, 2007); and risks - risk management throughout the project (Ghosh & Jintanapakanont, 2004; Shen et al., 2006).

Multidimensional analysis of performance, besides bringing a greater assertiveness in decisions with the use of indicators (Aragón, Pamplona, & Vidal Medina, 2013), can help to the sustainability of the business (Zdanytė & Neverauskas, 2011). For infrastructure projects, the bigger the amplitude and intensity on performance evaluation, the greater the chances of success (Flyvbjerg, 2007). However, one should consider that these ventures are also sources of risks, because they involve many stakeholders (Antoniou et al., 2013), contracts and contractors (Ghosh & Jintanapakanont, 2004). The goal of identify risks and categorize them into risk factors, is to prevent negative events with large impacts on the results of the projects (Redmill, 2002; Jordão et al., 2015).

Among the risk factors (Wang & Tiong, 2000; Ghosh & Jintanapakanont, 2004; Shen et al., 2006; Bing et al., 2007; Ng & Loosemore, 2007; Lam et al., 2007; Ke et al., 2010; Mu et al., 2014) in infrastructure projects include: a) contractual and legal: risks related to the management of contracts; b) financial and economic: risks associated with the financial capacity of the contractor and market conditions; c) not controllable forces: risks from circumstances beyond control; d) suppliers: risks inherent to suppliers; e) natural/physical: risks related to the infrastructure; f) operational: risks associated with productivity and operations; g) political: risks from policy interventions; i) planning: risks inherent to planning variances; j) procrastination: hazards from the way as the projects are managed; k) safety and social: risks related to the safety, environmental issues and social aspects.

According to Wang et al. (2004), in addition to the identification and analysis of risks, their management also involves the response and control processes. However, its practice in projects (risk assessment) is still considered insufficient and ineffective

(Chapman & Ward, 2004) to ensure best performances (Elkington & Smallman, 2002; Ke et al., 2010; El-Sayegh, 2008; Shengli et al., 2008; Mu et al., 2014). From this finding emerges the first proposition: **PR01 - risk assessment by management of risk factors improves the performance of infrastructure projects.**

The higher the intensity of management, lower the presence of risk factors (Zwikael & Ahn, 2011). Additionally, Raz et al. (2002) adds that there is a positive correlation between the management of the risk factors and the performance of projects. In this respect, this management already would reduce the impact on the different goals of the projects (El-Sayegh, 2008; Shengli et al, 2008; Love et al., 2011).

The methods for managing risks have been widely discussed in the literature on projects (Jaafari, 2003; Kwak & Stoddard, 2004; Lyons & Skitmore, 2004; Kerzner, 2009; Zwikael & Ahn, 2011; PMI, 2013). Within this framework, Raz & Michael (2001) established a Ranking with the most contributory practices to the management, relating them to the processes of identification, assessment, response, monitoring, control, and background. As a result of the research, as well as show the main techniques, the authors also suggested that the management of risks is also linked to an alternative process, since of the ten best practices evaluated five are part of the background, as shown in the Table 1.

By analyzing the Table 1, note that the practices related to the process control were those that had the worst perception of contribution to the risk management (Raz & Michael, 2001). Yet, according to the authors, there are two possible explanations for this finding: 1) the risk control techniques are ineffective and therefore were perceived as inadequate; 2) much time and effort are invested in the previous processes of risk management, which are carried out with other activities of project planning.

The users understand the difficulty to show the benefits obtained with the use of risk management, lack of resources for the function, lack of experience with the techniques and time for application (Kwak & Stoddard, 2004; Lyons & Skitmore, 2004; Wallace et al., 2004), in addition to the low authority and lack of ability of the project managers as limiting factors to their management (Globerson & Zwikael, 2002). This statement lead to the following proposition:

Table 1. Practices that contribute most to the risk management.

Practices/techniques	Process	*Ranking*
Brainstorming	Identification	8
Regular report on risks	Identification	24
Determination of the likelihood of the risks	Assessment	14
Determination of the impact of the risks	Assessment	3
Order of the risks	Assessment	17
Determination of responsibilities	Reply	2
Planning for risk mitigation	Reply	12
Lists with time limit and action items	Reply	9
Redesign of the project to mitigate the risks	Reply	21
Review of risks identified	Monitoring	16
Periodic review of documents	Monitoring	20
Periodical reporting of the status of the risks	Monitoring	19
Periodical reporting of the risk mitigation plan	Monitoring	25
Report critical risks to the senior manager	Monitoring	6
Analysis of course, deviations and exceptions	Control	26
Redesign of the project	Control	23
Prototyping	Background	7
Simulation	Background	1
Benchmarking	Background	13
Requirements management	Background	10
Supplier management	Background	5
Configuration control	Background	4
Quality control	Background	11
Quality management	Background	15
Training programs	Background	22
Survey of customer satisfaction	Background	18

Source: Adapted from Raz & Michael (2001).

PR02 - the intense use of skills of the risk managers in the risk factors management improves the performance of infrastructure projects.

Most problems in projects is managerial and not technical (Shenhar & Dvir, 2007). Similarly, Thamhain (2013) adds that if the team is effective, the influence of risk factors can be mitigated. As infrastructure projects are associated with various risks (Shen et al., 2006), it is necessary the use of specific management methods, based on the different levels of complexity of the projects (Shenhar et al., 2005) or due to the impact caused both by the presence (Kim, 2011) and the types of risks involved in these projects (Thamhain, 2013).

According to Shenhar & Dvir (2007) the standardization of projects by the complexity considers three levels: 1) assembly: deals with a single component; has a small team and intense communication; with little formality and documentation; 2) system: deals with entire platforms and systems, performing the creation not only of the product but also collateral supplies; 3) matrix: deals with a dispersed collection of systems that work together to achieve a common purpose, sometimes called a system of systems. This evidences lead to the proposition: **PR03 – the effort in the prior standardization of the degree of complexity of the risk factors management improves the performance of infrastructure projects.**

Discover the degree of complexity of the projects is part of a management model, whose purpose is to obtain the best results (Pich et al., 2002; Cooke-Davies et al., 2008; Giezen, 2012; Ahern et al., 2013; Antoniou et al., 2013).

3 Methodological research procedure

This research is classified as descriptive (Triviños, 1992; Gil, 2011), qualitative (Yin, 2015), inductive (Martins & Theóphilo, 2009) and was approached by the method of multiple case studies (Yin, 2015). The methodological path followed in this research passed through the following phases: a) elaboration of research topic and the objectives, from the process of identification of gap in the literature; b) definition of the theoretical framework to frame the study; c) preparation of study propositions (PRO-1, PRO-2 and PRO-3) creating the theoretical model; d) identification and selection of analysis units; e) development and validation of the instrument of collection at brainstorm meeting and pre-test with experts in infrastructure projects; f) data collection of the five cases studied; g) analysis and discussion of the results based on the specialized literature; h) completion of the work, also composed by practical contributions, limitations and suggestions for future studies.

As show in the introductory section, this article aims to answer the following question: how is characterized the risk factors management on the performance of infrastructure projects? Consequently, the main objective is to better understand how is characterized the risk factors in the performance of infrastructure projects. To this end, three specific objectives were pursued: a) determine the presence of risk factors and the performance of projects; b) assess the relationship between the presence of risk factors and the performance impact; c) identify how the risk factors management can influence the management of projects.

From a wide review of the theoretical framework involving the characterization of infrastructure projects, the multiple dimensions of performance of projects and the management of risk factors, three propositions could be drawn up: PRO-1, PRO-2 and PRO-3, according to Figure 1, result in a theoretical model on the problem of the research.

The definition of PRO-1 is related to the fact that the risk assessment reduces the impact of their presence on the performance of projects (Zwikael & Ahn, 2011) and that the effectiveness of such management is

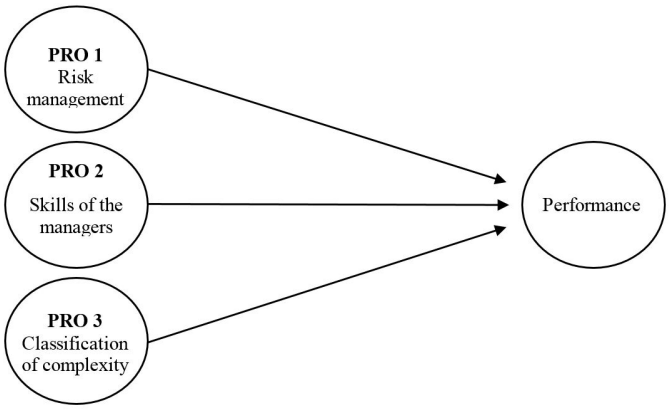

Figure 1. Theoretical/conceptual model of research.

only achieved when the level of complexity is low (Barki et al., 2001). This proposition is based on the fact that the increased intensity in risk management reduces the presence of risk factors (Chapman & Ward, 2004; Mu et al., 2014) and that the projects with greater intensity in risk management is also the with best performance (Raz et al., 2002; Zwikael & Ahn, 2011).

PRO-2 is based on the need of preparing managers for which decisions are reflected in a better performance of projects. The risk assessment process is one of the most applied by managers (Lyons & Skitmore, 2004), but the lack of ability for the execution of this task limits their efficiency (Globerson & Zwikael, 2002; Raz et al., 2002). Thus, it should be noted that the performance impact of the projects varies with the level of presence of risk factors (Datta & Mukherjee, 2001; Ng & Loosemore, 2007) and with the risk factor type involved in the project (Ghosh & Jintanapakanont, 2004; Thamhain, 2013).

PRO-3 states that depending of the complexity, greater effort is involved to the identification of risks (Kwak & Stoddard, 2004) and that this complexity is translated in a series of negative reflexes in the achievement of the objectives of the projects (Antoniou et al., 2013). It is also state that risk management is more intense in projects with higher levels of complexity (Barki et al., 2001; Shenhar & Dvir, 2007), the presence of risk factors grows with increasing complexity (Shenhar et al., 2005; Giezen, 2012;) and that performance tends to be better in projects with less complexity (Pich et al., 2002; Cooke-Davies et al., 2008; Antoniou et al., 2013).

In this research, the analysis units chosen were economic infrastructure projects whose risk management processes, and subsequent performances, are far from the desired (McKim et al., 2000; Flyvbjerg et al., 2002; Shenhar & Dvir, 2007). In this way, five cases have been selected and evaluated by the technique of synthesis of cross cases (Yin, 2015). The choice of cases occurred for convenience (Martins & Theóphilo, 2009) choosing, by selection of contrasting and complementary cases (Yin, 2015) and from the dimensions: complexity (assembly, system, and matrix) and economic segments (trade and services) of the respective client companies.

For survey the profile of the cases surveyed were considered, the total budget of the project, the number of people involved, the duration, the economic segment of client companies, location (State) of the project and the complexity, as shown in Table 2.

The case 1 aimed to expand and modernize the lubricant factory of a large-scale national company, active in the energy segment. The case 2 aims the deployment of a unit of coke for a large-scale national company. The case 3 had as purpose the construction of a gas plant in the State of Paraná. The case 4 had as objective the reform of a test lab for an international company of the automotive segment. The case 5 sought the expansion of a railway line and the improvement of urban mobility in one major cities of Brazil. As shown in Table 3, the profile of respondents was also surveyed.

The respondents have a good level of education (two graduates, two specialists and a master), are experienced (average 26 years) and mature (average of 50 years). Civil Engineering Graduation was present in four of the respondents. Two of them (cases 2 and 5) have an international certification in project management.

Table 2. Characterization of the studied cases.

Parameters	Case 1	Case 2	Case 3	Case 4	Case 5
Segment	Lubrication	Coke	Fuel	Automotive	Transport
State (UF)	RJ	-	PR	SP	-
Budget (R$)	15 million	2,2 billion	1,2 billion	2,8 million	1,5 billion
Labor	100	1500	35	40	300
Duration (months)	13	60	36	12	48
Complexity	System	Matrix	System	Assembly	Matrix

Source: elaborated by the authors.

Table 3. Characterization of the respondents.

Parameters	Case 1	Case 2	Case 3	Case 4	Case 5
Age (years)	37	60	52	59	44
Experience (years)	17	20	26	30	30
Education	Civil engineer	Civil engineer	Civil engineer	Civil engineer	Computer
Education	Graduation	Master	Graduation	Specialist	Specialist
Certification	Not	PMP	Not	Not	PMP

PMP = Project Management Professional. Source: elaborated by the authors.

The instrument used for data collection was developed and validated in a brainstorm meeting with an executive certificate in project management and extensive experience in a national transport company, in October 2014. Then, the pre-test was attended by three experts in infrastructure projects. In the selection of experts, sought the balance between qualification and professional experience. For this, one possessed academic profile; the other academic, but based on the market; and the last market oriented.

Data were collected between November and December 2014, with four interviews conducted at distance using a questionnaire validated in the previous phase, and one conducted face-to-face, what made possible the direct observation of the researchers.

Regarding the analysis of the results, the presence of the ten risk factors in infrastructure projects was calculated by the formula $\text{index of presence} = \sum(\alpha X)*100/5$ adapted from the study of Ghosh & Jintanapakanont (2004). α is the constant which expresses the weight gave to each response, ranging from 1 (very low) to 5 (very high); and, $X = n/N$, where n is the frequency of responses and N is the total number of responses. The highest possible presence is 100.00.

Another index used in this study refers to the performance index, which reflects the performance of the projects from the opinion of the respective project managers. This calculation was carried out using the following formula $\text{Performance Index} = \sum(\beta)*100/35$, where β expresses the sum of the weights for each data response to assess the seven dimensions of performance studied in this research (time; cost; changes; activities; integration; risks; quality). The weights, by Likert scale of 5 points, ranging from 1 (totally disagree) to 5 (completely agree), with the highest possible performance being 100.00.

To assess the relationship and the degree of impact of risk factors on the dimensions of performance of infrastructure projects were considered three levels of classification: low, medium, and high. Specifically regarding to the presence of risk factors in projects the following criteria were adopted: a) low: index of presence less than or equal to 33.00; b) medium: index of presence between 33.00 and 66.00; c): high: index of presence greater than or equal to 66.00.

4 Presentation and analysis of results

4.1 Presence of risk factors

The analysis of the presence of risk factors in projects is an important step to prevent damage in the performance. It is assumed that all projects have risks associated. Thus, the risk factor with the highest index of presence in cases surveyed was the procrastination (70.00), followed by the planning (36.00), natural/physical (32.00), operational (28.00), suppliers (21.00), safety and social (16.00), contractual and legal (14.00), not controllable forces (12.00), political (11.00) and financial and economic (10.00).

The superiority of the procrastination factor is explained by the risks: a) delays in construction: schedule control errors (cases 1, 2 and 5), inadequate resource estimates (cases 1, 2, 4 and 5), little comprehensive activities definition (cases 1, 2, 3, 4 and 5), unrealistic duration estimates (cases 1 and 5), among others; b) third parties delay: improper sizing of teams (cases 1, 2 and 3), sequencing of activities (cases 2 and 5) and interference on the suppliers (cases 4 and 5), etc. At the other extreme is the financial and economic factor, which is explained mainly by the risk of financial mismanagement of the contractor, which had the smallest presence, since most projects use public resources for its implementation.

Two risks not expected in the literature consulted, were raised in the interviews, and allocated by the researchers to the political and operational risks factors, respectively. They are: a) Corruption: bribery in exchange for cooperation or support (cases 2 and 5); b): integration between members of the different teams involved in projects (case 4).

4.2 Performance of projects

When evaluating the performance, dimensions was found that four respondents disagree that projects (cases 1, 2, 4 and 5) are on time and on budget. This fact also shown in other studies, to end that more than 85% of the projects are closed with a surplus of time and cost.

Most respondents (cases 1, 4 and 5) also disagreed that the projects have minor changes, few reviews of engineering tasks and planning contains detailed frameworks and integration between budget and schedule. In cases 1, 2, 3 and 4 the replanning were monthly, reflecting significant changes in scope. Integration management (cases 2, 4 and 5) was also considered a bottleneck, because during the execution of the projects, several were the difficulties with acquisition and delivery times by suppliers.

Among the respondents, three nor agreed, nor disagreed about the risks being managed on the projects (cases 1, 4 and 5). The neutrality of the opinions about this dimension was evaluated with the professionals and is justified by the poor knowledge on the processes that involve the project risk management (identification, assessment, response, and control). The respondent of the case 5, for example mentioned that their focus of attention "are the activities that need to deliver". Finally, three respondents agreed that their infrastructure projects (cases 1, 3 and 4) have all the activities being managed in terms of progress and with the total quality, properly managed.

In these terms, although 32.5% of respondents believe that their projects were efficient in seven

studied dimensions of performance, other 45% disagree with that statement. The classification of projects by performance index was thus defined: case 3 (82.50), case 2 (52.50), case 4 (47.50), case 1 (45.00) and case 5 (42.50).

4.3 Relationship between risk factors and performance

The presence of procrastination, suppliers, political, planning, contractual and legal, and operational factors proved to be more associated with projects that have high impact on time (cases 1 and 5). Already the risk factors natural/physical and financial and economic, approached each other because they are related to the medium-term impact cases (cases 2 and 4). The projects with safety and social factors, and not controllable forces are more linked to the lesser-term impact (case 3).

The presence of suppliers and procrastination proved to be linked to projects with high impact on costs (cases 4 and 5), while the natural/physical, safety and social, planning, political, and not controllable forces showed greater link with the medium degree of impact on costs (cases 1 and 2). The cases with the presence of contractual and legal factors, operational and financial and economic approached most of the projects with the lowest degree of impact on costs (case 3).

The projects with presence of procrastination, planning and supplier factors are more associated with the high-impact on changes (cases 1 and 4). Already the cases with the presence of risk factors natural/physical, political, contractual and legal, financial and economic are associated more with the medium impact on changes (cases 3 and 5). To the respondent of the case 3 "although the concern on risks of nature is large it doesn't imply major changes". The presence of factors safety and social, operational, and not controllable forces are more linked to projects with less impact on the changes (case 2).

On can verifies that the projects with the presence of operational and suppliers factors relate to high impact on the dimension activities (cases 2 and 5). According to the respondent of the case 5, "operational factors and alignment with supplier are worrying for the high degree of dependence between them". As for the procrastination factors, not controllable forces, safety and social, planning and financial and economic, it was found that their presence is more associated with the cases with medium impact on activities (cases 3 and 4). The presence of factors political, natural/physical, contractual and legal is more linked to projects with low impact on activities (case 1).

It was also found that the presence of factors planning, procrastination, contractual and legal, and operational is linked with projects with high impact on integration (cases 1 and 2). The respondent of the case 2 was concerned, on planning activities as "integration often is exempted on the project, but the great villain when the risks occur". Factors natural/physical, political, not controllable forces, suppliers, financial and economic are more related to the degree of impact medium (4 and 5 cases). According to the respondent of the case 4, "natural weather can sometimes shake the structures of the project". Already the cases with the presence of safety and social factors differ from others by showing greater connection with low impact on integration (case 3).

The presence of risk factors procrastination, suppliers, planning, contractual and legal demonstrated greater relationship with the projects with high impact on risk management (case 2), followed by natural/physical factors, political, financial and economic, operational with medium impact (cases 1, 4 and 5). In addition, the projects with the presence of safety and social factors and not controllable forces are distinguished from others by the lower impact on risk management (case 3).

It is possible to note that the projects with the presence of the financial and economic, and operational factors were more related to high impact on the quality (case 2). Already the presence of planning, suppliers, procrastination, contractual and legal factors are more associated with the cases with medium impact (cases 1, 4 and 5). Finally, the projects with safety and social, not controllable forces, natural/physical and political factors demonstrated greater proximity with the low impact on quality, according to the respondent of the case 3.

The summary of existing associations between the ten risk factors and the seven dimensions of performance assessed in this study are showed in Table 4.

4.4 Management of risk factors

Once the infrastructure projects are exposed to different risks, we sought to assess which techniques were used in their management. For this survey was used a list defined by Raz & Michael (2001) which includes the practices or techniques that contribute most to the risk management in projects. The results of this survey are showed in Table 5.

From Table 5, note that the techniques applied in the cases studied are among those that more contribute to the risk management. When evaluating the cases separately, exist different management intensities between the projects (number of processes; practices applied in each case). Thus, among the projects analyzed, the case 3 presented the highest intensity in the management of risks, as it was the only one that applied all the management processes set in the

Table 4. Relationship between risk factors and performance.

Risk factors	Dimensions of Performance						
	P	C	M	A	I	R	Q
Contractual and legal	High	Medium	Medium	Low	High	High	Medium
Financial and economic	Medium	Low	Medium	Medium	Medium	Medium	High
Not controllable forces	Low	Medium	Low	Medium	Medium	Low	Low
Suppliers	High	High	High	High	Medium	High	High
Natural/physical	Medium	Medium	Medium	Low	Medium	Medium	Low
Operational	High	Low	Low	High	High	Medium	High
Planning	High	Medium	High	Medium	High	High	Medium
Political	High	Medium	Medium	Low	Medium	Medium	Low
Procrastination	High	High	High	Medium	High	High	Medium
Safety and social	Low	Low	Low	Medium	Low	Low	Low

P = period; C = cost; M = changes; A = activities; I = integration; R = risk; Q = quality. Source: elaborated by the authors.

Table 5. The most commonly used practices in risk management on cases studied.

Practices	Process	Cases
Brainstorming	Identification	1, 3 and 5
Determination of the impact of the risks	Assessment	3
Determination of responsibilities	Reply	2, 3 and 5
Planning for risk mitigation	Reply	3
Report critical risks to the senior manager	Monitoring	2, 3 and 5
Redesign of the project	Control	1, 2, 3, 4 and 5
Benchmarking	Background	1, 3 and 5
Supplier management	Background	2, 4 and 5
Quality management	Background	3 and 4
Survey of customer satisfaction	Background	1, 3 and 4

Source: elaborated by the authors.

literature consulted and showed the highest frequency in the use of risk management practices. Then appears the case 5 (5 processes; 6 practices), followed by cases 2 (5; 5), 4 (2; 4) and 1 (2; 3), respectively.

When analyzing the PRO-1, was found that with the increase in the intensity of the risk management there has been a reduction in the presence of risk factors in projects. It was also found that the projects with greater intensity on risk management were also those with the best performances. However, risk management, by itself, is not sufficient to ensure the success of the projects. Other aspects should also be assessed, as the previous classification of the complexity of projects, aiming their appropriate management. The graphical representation of the theoretical trends of PRO-1 is showed in Figure 2.

It is observed in Figure 2, that with increasing the intensity of risk management the presence of risk factors reduces and project performance improves, tending to accept the PRO-1. It was also found that the efficiency of the projects is achieved (A and B) when the management intensity of risk factors is compatible with the style of management of complexity applied (cases 3 and 4). However, there are evidences denying that risk management is more intense in projects with higher levels of complexity, just by the cases 1 and 3 of intermediate complexity (system) that present the lowest (1 case) and greater intensity in risk management (case 3).

Among the risk factors assessed, only three showed evidence favorable to accept the PRO-2 (procrastination, natural/physical, safety and social). Regarding to the presence of other factors, or decreased with increasing complexity (not controllable forces), or were lower in the projects matrix (contractual and legal, financial and economic), or were higher in the projects with less complexity, as the assembly and system (operational, non-controllable forces, planning, contractual and legal) as Table 6.

Another observation about the PRO-2 refers to the fact that the best performances were obtained by system projects (cases 1 and 3) and not in the assembly (case 4). This evidence strengthens the thesis that the risk factors to be administered, maximize the effectiveness of the methods of management (risk and complexity) which, in turn, minimize the impact of risk factors on the performance of projects (example is the case 3). In these terms, the classification of the degree of complexity has not demonstrated positive influence on the performance of the infrastructure projects, tend to reject the PRO-2.

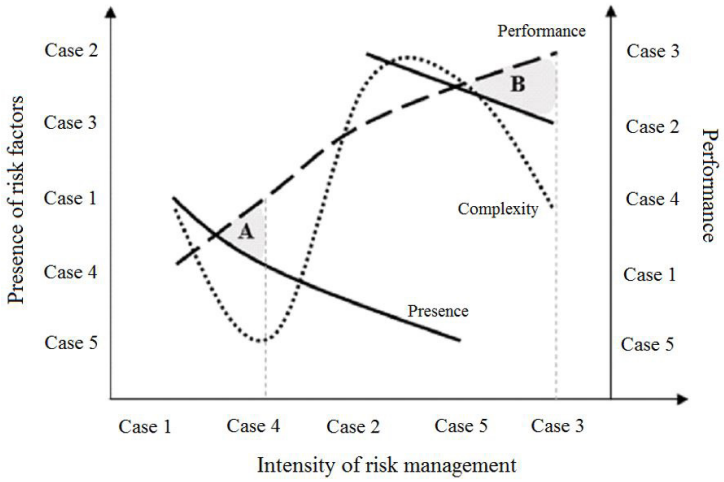

Figure 2. Influence of risk factors in the risk management process.

Table 6. Presence of risk factors in projects with different levels of complexity.

Risk factor	Index of Presence		
	Assembly	System	Matrix
Procrastination	50.00	50.00	100.00
Planning	45.00	62.50	45.71
Natural/physical	26.67	40.00	40.00
Operational	60.00	17.14	25.00
Suppliers	40.00	15.00	50.00
Safety and social	10.00	30.00	30.00
Contractual and legal	15.00	20.00	12.50
Not controllable forces	30.00	25.00	15.00
Political	20.00	7.50	20.00
Financial and economic	16.67	16.67	10.00

Level of complexity = Assembly < System < Matrix. Source: elaborated by the authors.

In the context of the PRO-3, risk factors procrastination, safety and social, and not controllable forces were the only ones who showed consistency between the presence of risk factors and the impact on the performance of projects. Thus, note that in most cases the degree of presence of risk factors was not related to the performance impact. Among the risk factors that validate such claim are: operational, contractual and legal, and suppliers (cases 1 and 5); natural/physical, political, financial and economic (case 4); and planning (cases 2 and 3), as showed in the Table 7.

From the information showed in Table 7 it was found that the impact and the performance dimension influenced by risk factors vary between them. To group the risk factors related to projects with high impact on the performance (procrastination, planning, operational, suppliers, contractual and legal) it was perceived that the time dimension is influenced negatively by all, as well as the integration and risks dimensions.

The suppliers risk factor, in addition to be linked to projects with high impact on the performance, was that showed the largest number of dimensions influenced by him (time, cost, changes, risks, activities and quality). Among the reasons that explain the extent of the impact of this factor was the inability of the suppliers to meet, with products or services, the demands agreed. Thus, the effective management of risks related to suppliers is a vital condition for the better performance of the projects.

Other risk factors that affect a significant number of dimensions of performance are procrastination, natural/physical, financial and economic, safety and social. The procrastination factor is more linked to projects with high impact on the dimensions time, cost, changes, integration and risks. The natural/physical factor has greater proximity to the medium impact on performance in time, cost, changes, integration and risks. In the same way, the financial and economic factor also is associated with the medium impact, however in time, changes, integration, risks and activities.

Table 7. Performance dimensions more influenced by risk factors.

Risk factor	P	I	Dimensions more influenced
Procrastination	High	High	Time, cost, changes, integration and risks
Planning	Medium	High	Time, changes, integration and risks
Natural/physical	Low	Medium	Time, cost, changes, integration and risks
Operational	Low	High	Time, integration, activities and quality
Suppliers	Low	High	Time, cost, changes, risks, activities and quality
Safety and social	Low	Low	Time, changes, integration, risks and quality
Contractual and legal	Low	High	Time, integration, risk and quality
Not controllable forces	Low	Low	Time, changes, integration, risks and quality
Political	Low	Medium	Cost, changes, integration and risks
Financial and economic	Low	Medium	Time, changes, integration, risk and activities

P = presence; I = impact. Source: elaborated by the authors.

Finally, the safety and social factor is more linked to the projects with low impact on the dimensions time, changes, integration, quality and risks.

When evaluating the risk factors, planning, operational, contractual and legal, is noted that is more related to projects with high impact on performance. The planning risk factor has greater influence on the dimensions time, changes, integration and risks, while the operational factor has greater impact on time dimension (including the cultural risk), integration, activities and quality. The contractual and legal risk factor, in turn, showed greater influence on the time, integration, quality and risks.

With respect to the influence of the factor of political risk is more associated with the degree of impact medium on the dimensions cost, changes, integration and risks. Despite the corruption risk not having been part of the initial scope of this research, he also participates in the political risk factor and, therefore, had its impact evaluated, even if informally. Contrary to dimensions most influenced by political factor, the corruption risk showed a greater influence on the cost dimension. Finally, the last factor analyzed was not controllable forces, which show low-impact on the dimensions time, changes, risks and quality.

The performance risk dimension was one of the most influenced by all risk factors except operational. This reflects the greater preparation of respondents on technical aspects of the projects, which simplified the mitigation of operational risks (cases 1, 2, 3 and 5) and the consequent reduction of the impact on the risks dimension. The efficiency in the management of projects was reached with the balance between the minor presence of risks and the level of performance expected. In this way, the intense use of skills of the risk managers in the risk factors the performance of infrastructure projects, tending to accept PRO-3.

From the three propositions of this study shows that the best risk assessment and increasing the use of the skills of managers in the management of risk factors contribute positively to the performance of the projects, as shown in Figure 3.

The influence of risk factors on the performance of infrastructure projects was considered of accentuated relevance to the area of project management, as it provides strong improvement in risk management and is essential for the improvement of knowledge and skills of project managers. To reach such findings, this research used a variety of theoretical frameworks, techniques and epistemological approaches, culminating in three specific objectives and correlated.

The specific objectives were basis that guides this study and for its strong relationship with the question of research is worth being rescued in this section. The first is to determine the presence of risk factors and the performance of projects. The second evaluates the relationship between the presence of risk factors and the impact on performance. Finally, the third specific objective aims to identify how risk factors influence the management of projects and which dimensions of performance are most affected by them.

In total, ten risk factors were identified in the literature and, in this study, had their attendance rates calculated for the infrastructure projects surveyed. The risk factor with the biggest presence was the procrastination factor, followed by planning, natural/physical, operational, suppliers, safety and social, contractual and legal, not controllable forces, political, financial and economic. The risks with corruption (offering bribe in exchange for cooperation or support) and cultural (integration between members of the different teams involved in projects), not find in consulted literature, were identified in the field research and allocated to the political and operational risks factors, respectively.

With respect to the performance of infrastructure projects, it is ended that 45% of them showed performance below the desired. This is justified mainly by changes over the projects, reviews of systems engineering tasks, planning without detailed framework and low integration between budget and schedule. The performance dimensions more affected by risk factors studied are time, cost, risks, changes and

Description of the proposal	When		Improvement	Result
Risk assessment obtained by management of risk factors.	Improve ment	➡	Positive	Performance of infrastructure projects.
Classification of the degree of complexity of the project to the management of risk factors.	Perform	➡	-	
Use of the skills of risk managers in the management of risk factors.	Increases	➡	Positive	

Figure 3. Characterization of the risk factors management on the performance of infrastructure projects.

integration. On the other hand, 32.5% of the projects were considered efficient in performance dimension activities, being managed in terms of progress and overall quality (quality plan, goals and control).

5 Final considerations

In the context of this study, it should be noted that the characterization of the management of risk factors: a) depends on the intensity of the risk management; b) does not vary with the complexity of the projects; c) According to the text, the characterization of procrastination, planning, operational, suppliers and contractual and legal is high on the performance dimensions time, integration and risks; d) the characterization of physical and natural, political and financial and economic is medium on the performance of the dimensions integration, changes, risks and costs; and e) the characterization of safety and social, and forces not controllable is low on the performance of the dimensions time, changes, risks and quality. Highlighting the need for the preparation of managers, in terms of knowledge and skills, for a risk management more efficient.

In this way, we can say that the improvement of the risk assessment and the heavy use of the skills of managers in the management of risk factors result in improvements in the performance of infrastructure projects. However, this same influence cannot be said about the previous classification of the complexity in these types of projects.

In practical terms, the main contributions drawn from the research for better performance for these types of projects are:

a) A list of the main practices (techniques) that can be applied in risk management, considering the management processes more deficient in infrastructure projects (identification, assessment, and monitoring of risks). The use of these techniques appropriately certainly could lead the project to good results.

b) Identification of seven dimensions of project performance (time, cost, changes, activities, integration, and quality risk management) that tend to be affected in different ways by risk factors (which in this study was limited to ten), and who deserve to be managed in the project.

c) A list of risk factors (procrastination, planning, natural/physical, operational, safety and social, contractual and legal, not controllable forces, political, financial and economic), more present in infrastructure projects (does not exclude the existence of others) which may simplify the implementation of the first process for managing risks, i.e., identification of risk.

d) Presentation of useful information as suggestions for the qualitative and quantitative analysis of risks. It was possible enumerating the trend of impact of risk factors in different dimensions of performance. This information serves as input to the prioritization of risk factors from the effects on the projects

Regarding the limitations, the unit of analysis was composed of economic infrastructure projects, it is not possible to ensure the representation of the set of infrastructure projects conducted in Brazil. In addition, the research strategy adopted, the case studies, it is not proposed to create generalizations on the subject and problematic of the research. However, it is expected that this research could open the way for new studies on the subject discussed.

As additional research in the area of risk management in infrastructure projects, is suggested to deepen the discussions on each of the risk factors linked to infrastructure projects; analyzing skills and competencies related to managing risks, considering different professional profiles; analyzing the influence of risk factors on performance, considering each phase of the life cycle of infrastructure projects; search about specific methodology for the definition of instruments, techniques or practices to be used in the management of risks, from the economic sector in which the infrastructure project is inserted; investigate the impact of risk factors on other spheres of performance as, for example, the stakeholders; and

replicate this study considering a specific segment of the infrastructure sector.

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