Multicriteria approach to financial risk analysis in an innovative software development project at Porto Digital in Pernambuco

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Abstract: the article aims to evaluate the critical risk factors that have a financial impact on an innovative software development project carried out by a small Porto Digital company in Pernambuco. To develop this research, it used an integrated methodology composed of three steps, namely: (i) use of the Non-traditional Capital Investment Criteria (NCIC) multicriteria method for quantification and hierarchy of risk factors; (ii) use of the risk matrix to classify risk factors; and (iii) the Monte Carlo simulation to simulate the project's aggregate net present value based on the risk factors studied. The results revealed three risk classes in the project, class A (++) composed of risk factors associated with external actions, schedule compliance, requirements failures, unavailability of labor and management, and execution failures, which, in isolation, have a low potential for financial loss. Class A (+) is composed of the risk of unavailability of financial resources in the project, and, finally, class B, the most severe, is composed of the risk factor related to planning failures, especially the selling force of the proposed innovation. This had a loss power of 49.2% of the project's NPV and an aggregate NPV disturbing power of about 95%. In addition, it was found that, together, the risk factors studied have the power to make the project financially unviable, as a negative average NPV_A was identified, with a probability of 67.044% remaining in this condition.

Keywords: Innovative Project; Financial Risks; Software Development; Integrated Methodology.

Artigo recebido em 26/10/2019 e aceito em 27/11/2019.

1 - Introduction

All organizational actions have some level of risk involved, either at higher or lower levels. This risk results from the fact that the proceeds of these actions are not previously determined. Thus, for Damoradan (2009), a risk is the probability of a situation occurring and, as a consequence, financial losses, especially cost increases, over the economic life of the investment, are generated, if it actually occurs.

In projects, the risk is related to the project's failure to deliver expected results, which may include delays in marketing products, rising costs, damage to a company's reputation by offering a product that will harm society (KÖHLER; SOM, 2014).

When talking about innovative projects, the risks are multidirectional and complex in nature (SAMANTRA et al., 2016) because of the constant changes in the innovation process (creation, execution, and sale) and the difficulty of knowing their results. In the future, risk assessment is constrained by the lack of experience or insight into possible side effects by project analysts and managers. In addition, risks in innovative projects are more exposed to complex interactions, often correlated with the dynamics of the economic, cultural, technological, and regulatory environment in which projects are developed (ASSMUTH et al., 2010).

On the other hand, companies located at Porto Digital in Pernambuco, and most of them are micro and small companies, have a high degree of innovation. Having between 2010 and 2012, an innovation percentage of, on average, 97% in products, of which 69% were new products for the domestic market, and 93% in processes, where 585 were for the sector in which they operate (ABDI, 2013).

In the information technology (IT) sector, the Brazilian Software Companies Association (ABES) predicts that by 2020, 90% of growth in the country's sector will be directed to innovation technologies linked to smart industries (ABDI, 2013). Among the Brazilian regions, the northeast region stands out in terms of growth in the software sector, with the states of Pernambuco and Bahia as one of the main responsible for this growth (ABDI, 2013).

In parallel with this finding, it is known that the mortality rate of micro and small enterprises is significant, an average of 24.4% at the national level for companies incorporated in 2007, according to SEBRAE/NA (2013). In the information technology sector, about 23% of the companies incorporated in 2007 did not survive after their 2 (two) years of existence (SEBRAE/NA, 2013), which is very close to the national average that encompasses several segments.

Therefore, assessing the risks involved in Porto Digital companies' innovative projects is also of great importance for the design of public policies to increasingly stimulate the local productive arrangement (APL) of information technology in Pernambuco, aiming to embark new sources of financing and, above all, to guide structured management practices aimed at effective risk management, adding value to developed enterprises and containing underestimated or overestimated costs.

Thus, this case study aims to apply an integrated methodology to assess the critical risk factors that have a financial impact on an innovative project developed by a small company at Porto Digital in Pernambuco in the information technology sector.

2 - Theoretical framework

2.1 Financial risks in innovative projects

When talking about innovative projects, the related risks are present in all phases of the project, mainly due to the oscillation of their costs, because unknown events that may impact on the future development of the project are not dominated by the managers in the planning phase, because most of the time, they do not have a historical parameter that is used as a foundation to guide project investment or divestment decisions (SAMANTRA et al., 2016; MIORANDO et al., 2014).

Risks in information technology (IT) projects consist of a number of factors or conditions that can pose a severe threat to the successful completion of the project. The development of these projects should be analyzed in the same way as many other types of investment, as the utilization and allocation of available resources are made to maximize returns and minimize unnecessary costs (COSTA et al., 2007). Thus, Table 1 describes the main financial risk factors in innovative information technology projects, that is, those that have the possibility of financial disbursement there.

Table 1 - Main risk factors present in innovative information technology projects

Code	Risk Factors	Brief Description	References
F_1	Risk associated with benefit calculation / planning	Underestimated / overestimated benefits due to limitations of the estimation process (complexity); Impacts on benefits from underestimated/ overestimated mid-term project disruption. Inadequate planning.	Costa et al. (2007), Han and Huang (2007), Warkentin et al. (2009), Wang et al. (2010), Kadareja (2013), Miorando et al. (2014), Zhang (2016).
F_2	Risk associated with External Actions	Impact on cost benefits due to underestimation or overestimation of competitor responses; Impact on the benefits of entering a new substitute technology in the (foreign) market; Impacts arising from changes in the business environment or customer demand; Impacts of unforeseen regulatory agency actions; Not meeting the needs of end users.	Kadareja (2013), Fanet al. (2013), Abbassi et al. (2014), Miorando et al. (2014), Samantra et al. (2016), Zhang (2016).
F_3	Risk associated with financial capital in the project	Underestimated / overestimated costs due to limitations in the estimation process; Underestimated / overestimated financing costs. No input of financial resources during the Project.	Wang et al. (2010), Kadareja (2012), Fang et al. (2013), Abbassi et al. (2014), Miorando et al. (2014), Samantra et al. (2016), Scarpellini et al. (2016).

Code	Risk Factors	Brief Description	References
F_4	Infrastructure Risk / Technical Requirements	Underestimated / overestimated costs arising from the proposed technology; Costs of potential performance, instability, integrity, functional, interface, data, safety and quality design issues, changing underestimated / overestimated requirements; License and equipment costs.	Tong Lu and Heng Yu (2012), Fang et al. (2013), Miorando et al. (2014), Abbassi et al. (2014).
F_5	Risk associated with labor	Qualifications of the development team; Recruitment and selection costs; Underestimated / overrated development team experience.	Chen et al. (2009), Wang et al. (2010), Tong Lu e Heng Yu (2012), Kadareja (2013), Abbassi et al. (2014), Miorando et al. (2014), Samantra et al. (2016), Zhang (2016).
F_6	Risk associated with project execution and support	Costs of underestimated / overestimated technical or intellectual project difficulties; Underestimated / overestimated development environment maturity; Needs for increments throughout the project; Impact due to possible changes to support staff; Underestimated / overestimated costs of agents that provide inputs for project development.	Tong Lu and Heng Yu (2012), Kadareja (2013), Miorando et al. (2014), Samantra et al. (2016), Zhang (2016).

Code	Risk Factors	Brief Description	References
		Costs due to lack of project management monitoring, communication, internal bureaucratic process.	
F_7	Runtime risks	Costs arising from non-development of the project within the established schedule.	Wang et al. (2010), Fang et al. (2013), Miorando et al. (2014), Samantra et al. (2016), Zhang (2016).

Fonte: elaborado pelos autores

As shown in Table 1, it can be seen that the risks present in innovative IT projects manifest themselves in several dimensions, such as costs, benefits, skill and experience, size and complexity, architecture and performance, schedule, clarity and scope, support organizational, impact of change, business environment, technological maturity, and the way risk is planned and managed (MIORANDO et al., 2014), and as a consequence, there are several possibilities for interference in the project's cash flow. The failure of these projects and their added value to companies.

2.2 - Multicriteria approach to financial risk assessment in innovative projects

The method used for the intended analysis is Non-Traditional Capital Investments Criteria (NCIC). It was developed by Boucher and MacStravic (1991) as a complement to Saaty's (1980) AHP (Analytic Hierarchy Process) method. In it there is the alignment of the multicriteria evaluation of alternatives with the value analysis to identify attributes to be prioritized, from the monetization of the chosen criteria (which are quantitative and qualitative in nature), that is, it develops alternative scores that are determined in monetary terms, making an implicit assessment of explicit attributes and allowing results to be incorporated into traditional analyzes of economic value (NORRIS; MARSHALL, 1995).

Its use is inserted in several fields, such as the selection of R&D projects in the electricity sector based on the benefits they could provide, project team competence and economic and financial viability (FERREIRA et al., 2010) and in the case of the feasibility of Canadian vertical farms in urban centers from an economic, environmental and social point of view (LUCENA et al., 2014).

In this section, it was developed the modeling of the NCIC method already incorporating the AHP steps. Thus, initially, regarding the financial dimension, a reference case was established that represents the value generated by the project under critical loss conditions (KIMURA; SUEN, 2003). Therefore, based on the project's NPV, the $NPV_{ADVERSE}$ is estimated based on the company's projection for the pessimistic scenario of the value generated by the project, representing the gains obtained in a scenario of significant losses. Thus, the NPV variation (ΔNPV) is obtained through Equation 1 (KIMURA; SUEN, 2003; BOUCHER et al., 1997).

$$\Delta NPV = NPV - NPV_{ADVERSE} \quad (1)$$

The structuring of the method begins by determining the degree of dominance between the analyzed criteria, which is measured in terms of relative importance from pairwise comparisons. To make this comparison, square matrices (n x n) are used, in which the rows (i) and columns (j) correspond to the n criteria analyzed. The great innovation in this model is that comparisons are also made with the financial criterion studied. The scale used in this research is described in Table 2.

Table 2 - Numerical scale adopted in this research.

Numerical scale	**Reciprocal Scale**	**Verbal Scale**	**Description**
1	1	Both elements are of equal importance.	Elements have the same level of financial loss.
3	1/3	Moderate importance of one element over another.	Element *i* has a moderate loss level relative to element *j* (around 10%).
5	1/5	Strong importance of one element over another.	Element *i* has a strong loss level relative to element *j* (around 20%).
7	1/7	Very strong importance of one element over another.	Element *i* has a very strong loss level relative to element *j* (around 40%).
9	1/9	Extreme importance of one element over another.	Element *i* has an extremely strong loss level relative to element *j* (around 80%).
2, 4, 6 e 8	1/2, 1/4, 1/6, 1/8	Intermediate Values.	When you have a compromise condition between two definitions.

Source: Adapted from Saaty (1980) and PMI (2013).

With this adapted Saaty scale, the project manager estimates the financial importance of each risk factor (Table 1) through paired comparisons between them in terms of port losses. Regarding the comparison between the ΔNPV and the other risk factors, their degree of importance is verified by following the same scale, for example, when it is defined that an ΔNPV of R$ 7,000 is less important than a maturity period. Highly representative short delivery to the project. Continuing, with the comparison matrix constructed, each element of the matrix was divided by the sum of the values of the respective column *j*. With the values obtained, the average for each line (*i*) was calculated to obtain the weights of each risk factor in the project.

Still, the NCIC method uses logical consistency analysis to validate the consistency in comparisons made by managers using the Eigen vector. Consistency is calculated using the rate or consistency ratio (CR) of judgments using Equation 2.

$$CR = \frac{CI}{RI} \qquad (2)$$

Where RI = random consistency index, obtained for a reciprocal matrix of order *n*, with nonnegative elements. This factor is randomly generated and is presented in Table 3.

Table 3 - Random Consistency Indices (RI)

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Ri	0	0	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49	1,51

Source: Saaty (1980).

And, the consistency index (CI) is given by Equation 3.

$$CI = \frac{\lambda_{máx} - n}{n-1} \qquad (3)$$

Where: λ_{max}= highest eigenvector value of the judgment matrix obtained through the Eigen vector. *n* = array order number. According to Saaty (1980), if the consistency ratio is less than 0.1 (10%), it can be stated that there is consistency. Otherwise, if CR ≥ 0.10, the judgments should be redone until the inconsistency is attenuated. Continuing the development of the NCIC method, having the weights (importance) that each risk factor has in the project, a device called total present value (VPT) of the project was created through Equation 4 (BOUCHER; MACSTRAVIC, 1991; SOUZA et al., 2012).

$$VPT = \frac{\Delta VPL_{projeto}}{\omega_{\Delta VPL}} \quad (4)$$

Where: NPV = net present value of the project, TPV = total present value, ω_{NPV}= weight of NPV criterion obtained by the normalized matrix-vector, $\Delta NPV_{\text{project}}$ = calculated based on Equation 1. Then, given the scale used in Table 2, for each risk factor (F_n) was calculated its value of loss (VL), Equation 5, based on the TPV, i.e., at this time, the qualitative risk factors derived of the comparison matrix were quantified in the same unit of the NPV, this quantification is given by BOUCHER and MACSTRAVIC, 1991, and SOUZA et al., 2012.

$$VL_{Fn} = TPV\ .\ \omega_{Fn} \quad (5)$$

Where: TPV = total present value, ω_{Fn} = the risk factor weight (F*n*) obtained by the normalized matrix-vector and VL_{Fn} = aggregate risk factor loss (F*n*) in the project. Depending on the steps described so far, the higher the aggregate loss of the risk factor, the higher the level of criticality for the project, indicating that this is an element that needs to be monitored by managers. Also, adapted from Boucher and Macstravic (1991), one can calculate the aggregate NPV (NPL_A) of the project, which is expressed by Equation 6.

$$NPV_A = NPV - \sum_{i=1}^{n} VL_{Fi} \quad (6)$$

Thus, the project's aggregate net present value (NPV_A) is the result of the project's NPV subtracted from the sum of the aggregate losses that each risk factor provides to the project.

3 - Method

The research method adopted in this paper is the case study, with a predominantly quantitative approach, besides being descriptive and exploratory. The choice for this method was due to its in-depth analysis ability in certain objects or situations, allowing a better knowledge of the existing processes and relationships established (YIN, 2009) in the analyzed project.

The research opted for intentional and non-probabilistic sampling (YIN, 2009). For, it is interested in the manager's opinion to establish the preference and dominance relations between risk factors of a project carried out, which, being innovative, have singularities that cannot be generalized. This approach was chosen because the researchers' accessibility has to the project manager, and also, the company is registered at Porto Digital in Pernambuco.

Porto Digital, which was born in July 2000, is a cooperation between the state government, the private sector, and educational institutions. It aims to create and promote a viable environment for the development of technology-based enterprises. Besides, it has three aspects of prioritization in its actions, namely: knowledge production, from the information technology and creative economy segments aiming at the economic development of the region and adding value to the investments received; urban revitalization and social inclusion (MARQUES; LEITE, 2008).

Regarding the companies located in Porto Digital Pernambuco, they have innovation activities in the software and services segments of information technology and creative economy. The companies installed there has an intense R&D capacity, aiming at the creation of technologically innovative products to meet the needs of the market, as having as raw material the high technology, it is necessary to use the knowledge directed to the creation of innovative products, and existing demands. Thus, this research analyzed an innovative project in information technology carried out at Porto Digital. The interview lasted about 80 minutes, held on May 2016. For the present work to achieve its objectives, the methodology was subdivided into three steps.

Step 1: Initially the net present value of the project (Equation 7) was calculated based on the cash flow (revenues and costs) made available by the company for the analyzed project (FCt), discounted at the SELIC (basic interest rate of the economy) rate of the same project (i) realization period.

$$NPV = \sum_{t=1}^{n} \frac{FC_t}{(1+i)^t} - II \quad (7)$$

Where: II = initial investment; t = months of project completion. In possession of the project's NPV, as stated earlier, the interview with the manager was asked to provide peer comparisons between risk factors in Table 1 and the ΔNPV (the latter was established based on the value generated by the project in a pessimistic scenario of losses generated by risk factors in the project). Then, Non-Traditional Capital Investments Criteria was applied to both projects based on the steps described in section 2.2 of this paper, aiming to identify the critical risk factors in the project analyzed in terms of monetary values.

Step 2: To complement the previous analysis, the frequency with which the factors studied in Table 1 appeared in the project was obtained in the interviews. For this, a Likert scale from 1 to 5 below was used (Table 4).

Table 4 - Frequency classification of project risk factors

Ranking	Description	Weighting
Very rare	Probability of occurrence of 10% in the project.	1
Rare	Probability of occurrence of 30% in the project.	2

Eventual	Probability of occurrence of 50% in the project.	3
Frequent	Probability of occurrence of 70% in the project.	4
Very frequent	Probability of occurrence of 90% in the project.	5

Source: Adapted from Paulo et al. (2007) and PMI (2013).

Having the frequencies and impact (provided by the NCIC method) of the risk factors, it was possible to classify these, by areas delimited by a risk matrix, as established by Chittoor (2013) and PMI (2013), that establish an ordinary classification of risks through values representing states, for example, C - high risk, B - medium risk, and A - low risk. This step is valid because risks can be prioritized for further quantitative analysis, yet, a contingency plan can be established from the severity demonstrated by the risk factors (PMI, 2013), taking into account the frequency and severity that impact the project.

Step 3: By multiplying the frequencies with the levels of importance (weights that represent project losses) obtained by the NCIC method, both normalized, a severity index (SI) was created (SOUZA et al., 2012; HOSSEN et al., 2015). With this severity index, two index numbers were created for each risk factor studied, that is, (1+SI) and (1-SI). Thus, the assumption was that the more severe the risk factor, the more variations it will generate in the project's financial results (SAMANTRA et al., 2016).

Thus, triangular distributions were created by multiplying the index numbers created (maximum and minimum values) and the financial losses identified by the NCIC method, with the expected distribution value being the one obtained by the NCIC. Under these assumptions, a Monte Carlo simulation with 500,000 interactions was performed to ascertain the degree of variation of the NPV (simulation input function; Equation 6), followed by a sensitivity analysis to identify the risk factor that most contributed to the variation of the value of the project undertaken. The software used for this purpose was Crystal Ball 11.0.

4 - Analysis of Results

4.1 Description of the innovative project analyzed

The project developed belongs to a small company that is ten years old and was registered at Porto Digital de Pernambuco for two and a half years (between 2011 and 2013). The useful life of the project was two years (realized in 2011 and 2012) with a total cost of R$213,800.00, and it is a project-oriented to the creation of a platform to support the innovation management in companies, medium and large.

The developed platform is a corporate social network that assists in innovation management processes and continuous improvement. Its social network format enables the participation of all involved with the company (employees, customers, partners, among other agents) in the development of new products and services, organizational improvement actions, and business processes, contributing, above all, to institutionalize the innovation process.

The platform server is continuously adapted to the structure of the client companies, and the changes that may occur that may impact the innovation management process. The platform also stands out for its agility and flexibility in managing its collaborative community and in monitoring the evolution of ideas and their innovation results for managers through the implementation of new technologies developed by the company in Porto Digital.

The technology proposed by the project is a development from derivatives, by refining an existing platform, for example, corporate networks, to direct them to the innovation process of companies (ENTEKHABI; ARABSHAHI, 2012).

According to the cash flow data provided by the company, the project's NPV was calculated, and the amount of R$ 6,857.06 was obtained, revealing that from a financial point of view, the project was viable. The company then explained that in the pessimistic scenario estimated by the company through a scenario study and market research, the project's NPV could suffer critical average losses of 40% from the previous value, due to the underestimation of underestimated overall planning costs from the project. Thus, the project's $NPV_{ADVERSE}$ was calculated, and the amount of R$4,114.23 was obtained, with an ΔNPV= R$2,742.83.

4.2 Step 1: Applying the Non-Traditional Capital Investments Criteria Method

Table 5 shows the project preferences matrix built with the company director, who was also responsible for project development. As presented in the methodology of this paper, the judgments were made between the risk factors presented in Table 1 and measured in the scale of Table 2. It is already clear that risk factor 1 (F_1), related to the estimation of benefits in the phase of planning already shows the same impact to global losses in NPV and of greater importance concerning the other risk factors analyzed in this research, according to the preferences established by the respondent.

Table 5 - Matrix of preferences of the innovative project analyzed

CODE	**ΔNPV**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**	**F_7**
ΔNPV	1.00	1.00	5.00	5.00	5.00	5.00	5.00	5.00
F_1	1.00	1.00	7.00	6.00	7.00	7.00	5.00	9.00
F_2	0.20	0.14	1.00	0.33	0.33	0.25	0.50	0.25
F_3	0.20	0.17	3.00	1.00	3.00	4.00	2.00	3.00
F_4	0.20	0.14	3.00	0.33	1.00	1.00	1.00	1.00
F_5	0.20	0.14	4.00	0.25	1.00	1.00	1.00	2.00
F_6	0.20	0.20	2.00	0.50	1.00	1.00	1.00	3.00
F_7	0.20	0.11	4.00	0.33	1.00	0.50	0.33	1.00

In addition, the preferences matrix for the project had a CI (consistency index) = 0.132532, which resulted in a CR (consistency ratio) = 9.39949%, i.e., the established preferences are consistent. Then the weights of each risk factor in the project were obtained, as well as the loss value of each one (Table 6).

Table 6 - Weights and loss values of risk factors analyzed

Criteria	**Weights**	**Loss Values**	**Relative importance ranking**
ΔNPV	27.830%	R$ 2,742.83	2º
F_1	34.222%	R$ 3,372.80	1º
F_2	3.027%	R$ 298.4	8º
F_3	11.297%	R$ 1,113.39	3º
F_4	5.576%	R$ 549.57	6º
F_5	6.447%	R$ 635.39	5º
F_6	6.573%	R$ 647.85	4º
F_7	5.028%	R$ 495.54	7º
Total	100%	R$ 9,855.71	-

As observed in Table 6, it was possible to verify that the risk factor related to the estimation of its benefits (F_1) presented a higher power of loss than the base case used of NPV (variation of 40%), revealing a potential financial loss beyond that estimated, by the manager, i.e., a loss specifically 23% greater than the project could lose in an adverse situation.

As shown in Table 6, by the NCIC method used in this research, the risk factor F_1 could cause a value loss of R$ 3,372.80, a loss of about 49% of the overall value generated by the project. According to the respondent, the project presented a problem regarding the commercialization of the proposed innovation, because despite hiring consultancy in the planning phase, where it was not able to predict a scenario where the demand for the developed product was incipient.

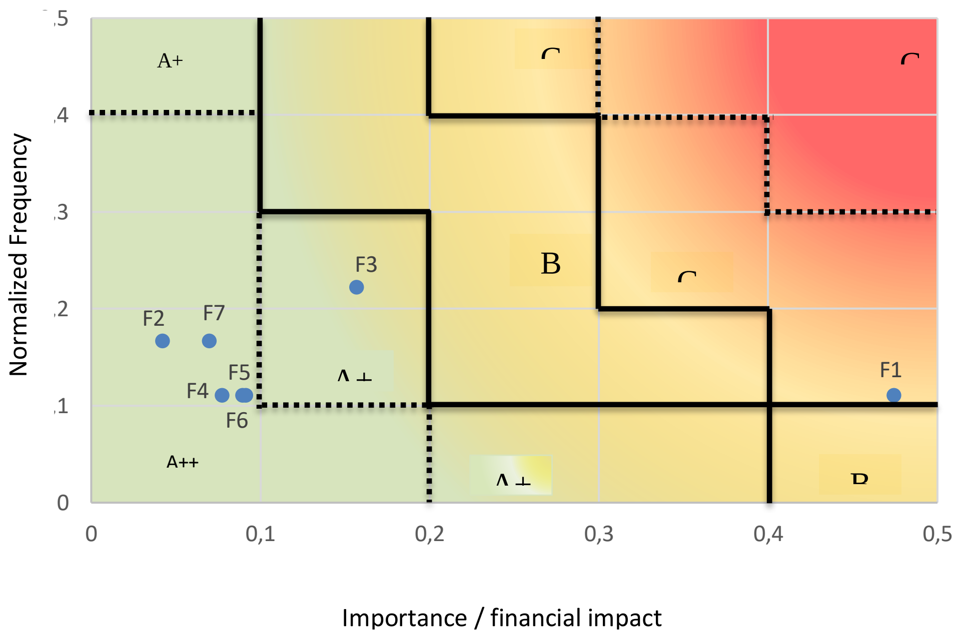
This fact confirms Schumpeter's (1988) classic idea that innovation generates wealth for its entrepreneur once there is an alignment between innovation itself and its underlying management and marketing effort. Thus, gains can be obtained, and a new pattern can be created in the market. Kadareja (2013), Samantra et al. (2016), and Zhang (2016) argue that the greater the advance knowledge of the sales force of developed innovation, the higher the project's success rate.

Thus, in the project under study, the underestimation of the benefits arising from the sales plan could severely affect the project, in addition to the losses pointed out by the manager in the situation of announced global losses. Moreover, from the manager's important attributions, it was possible to verify that an underestimation of financial capital could compromise R$ 1,113.39 (about 16.3% of its value). In the third level of risk, the factors related to execution (loss of R$ 647.52), labor (loss of R$ 637.39), technical requirements (loss of R$ 549.57), and schedule (loss R$ 495.54) showed a low financial impact on the project. It is noteworthy that with the level of intermediate innovation which provides a certain degree of differentiation, losses resulting from environmental actions were very low impact on the project, compromising only about 4.35% of the value generated.

4.3 Step 2: Building the Risk Matrix

In order to classify the risks identified in step 1 of this research, a risk matrix (frequency x importance) of the project was initially built, based on the methodology proposed by PMI (2013) and Chittoor (2013) and described in topic 3 of this paper. The results are shown in Figure 1.

Figure 1 - Risk matrix (control x importance)



Through Figure 1, it was possible to classify the risk factors of the project analyzed into three classes, as represented in Table 7.

Table 7 - Risk classification according to risk matrix (importance x frequency)

NPV	Class A (++)	Class A (+)	Class (C-)
	Σ = 2,626.39	Σ = 1,113.39	Σ = 3,372.80
R$6,857.06	F_2: 298.34 (4.4%*) F_7: 495.54 (7.2%) F_4: 549.57 (8.0%) F_5: 635.39 (9.3%) F_6: 647.85 (9.4%)	F_3: 1,113.39 (16.2%)	F_1: 3,372.80 (49.2%)

* These percentages indicate the risk factor loss power relative to the project NPV.

It can be seen from Table 7 that most of the project risk factors analyzed are class A (++), that is, those that alone have a low potential for value loss for projects, with the maximum individual financial loss of 9.4% of the project's NPV. Also, in class A (+), those risks that are in the transition zone were found, that is, they may, over time, move to class B (CHITTOOR, 2013), so they need follow-up mechanisms periodic. In isolation, the risk factors that make up this class have a loss higher than that presented by the previous class, that is, they need to be monitored because they are in a region where small increases in severity or frequency cause them to already change categories, in the analyzed project. F_3 is in this situation.

Finally, the most critical class for the project analyzed is C (-), where managers must carry out action plans to circumvent their short-term losses. In this class is the risk factor F_1, having the power to compromise about 49% of the project's NPV. This percentage is considered for a small business, which often has many organizational weaknesses. It is emphasized that the class A(++) should not be ignored by the company, because if the risk factors of this class manifest together, they have the power to compromise about 38% of the value generated by the project.

4.4 Step 3: Perform Project Net Present Value Simulation

To analyze the project results in a probabilistic manner, that is, considering the uncertainties arising from the risk factors studied, the NPV_A simulation was performed in order to achieve this objective, as described in step 3 of the methodology. Simulation input values are shown in Table 8, and the simulated NPV_A probability distribution and project simulation statistics are shown in Figure 2.

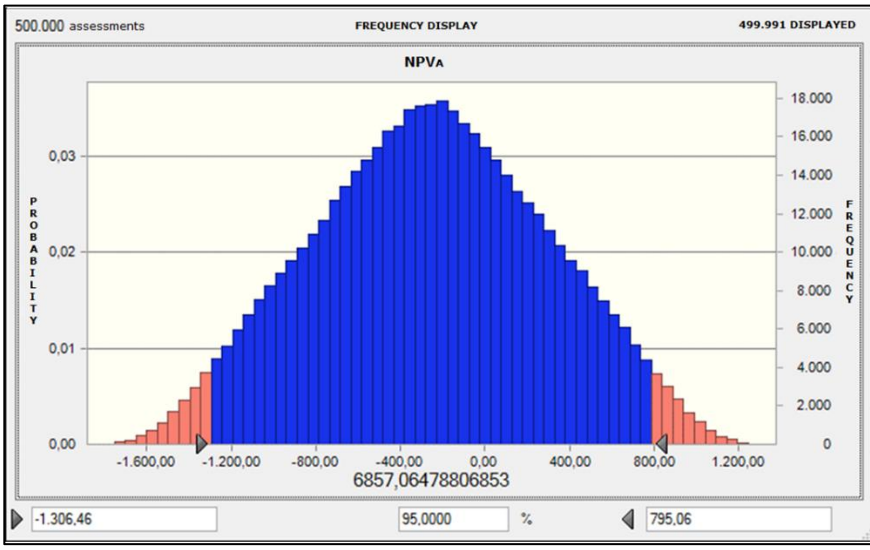
Table 8 - Construction of triangular distributions for simulation

Risk factors	GI	$FM_{MÍN}$	$FM_{MÁX}$	Simulation Input Values		
				$V_{MÍN}$	VM	$V_{MÁX}$
F_1	0.39113	0.608870	1.391130	R$ 2,053.60	R$ 3,372.80	R$ 4,692.00
F_2	0.051896	0.948104	1.051896	R$ 282.86	R$ 298.34	R$ 313,82

Risk factors	GI	$FM_{MÍN}$	$FM_{MÁX}$	Simulation Input Values		
				$V_{MÍN}$	VM	$V_{MÁX}$
F_3	0.258231	0.741769	1.258231	R$ 825.88	R$ 1,113.39	R$ 1,400.90
F_4	0.063732	0.936268	1.063732	R$ 514.55	R$ 549.57	R$ 584.60
F_5	0.073684	0.926316	1.073684	R$ 588.57	R$ 635.39	R$ 682.21
F_6	0.075129	0.924871	1.075129	R$ 599.18	R$ 647.85	R$ 696.53
F_7	0.086198	0.913802	1.086198	R$ 452.82	R$ 495.54	R$ 538.25

Caption: GI: normalized severity index of risk factors. FM_{MIN}: minimum value multiplier factor. FM_{MAX}: multiplier factor of the maximum value. V_{MIN}: minimum value. VM: average value. VMmax: maximum value.

Figure 2 - Project NPV_A Probability Distribution and Simulation Statistics



NPV_A statistics	Values
Interactions	500.000
Average	-255.51
Median	-255.49
Mode	-
Standard deviation	552.98
Asymmetry	-0.001
Kurtosis	2.45
Coefficient of variation	-2.16
Minimum	-1,842.69
Maximum	1,338.99
Mean error	0.78

Analyzing the distribution of NPV_A, given the values used, it can be seen that although its most likely value is negative, there is a 32.965% probability of being positive, that is, the possibility of this occurring if the intensity with risk factors are reduced with the progress of the project and with prevention and mitigation actions of managers under them, creating the possibility that the project may be viable in the light of the multicriteria analysis developed for the period in which it was carried out.

Specifically, it was identified that the project had an average NPV_A of –R$255.51 with value at risk between -R$1,050.95 and R$1,050.57, in which case there is the possibility of adding value and obtaining R$795.06 net, if the maximum gain is realized. Through the sensitivity analysis, it was possible to identify the risk factors that most contribute to the variability of NPV_A (Figure 3).

Figure 3 - NPV_A risk factor sensitivity analysis by project

As identified in Figure 3, planning (F_1) is the factor that most contributes to the variability of the results of the value generated, in 95% suit, this result is in agreement with what Kadareja (2013) and Samantra et al. (2016), in which the estimates made at the beginning of the project must take into consideration all the possibilities of the courses of action that may occur from the creation of the technology until its commercialization, and this is absolutely the most critical factor in this type of project.

5 - Conclusions

The integrated methodology used in this research proved to be suitable for a quantitative assessment of financial risks in innovative projects in micro and small companies, especially in identifying and classifying sources of financial losses. It can be concluded that the use of the Non-Traditional Capital Investment Criteria (NCIC) method, based on the methodology used, was consistent for the intended analysis, quantifying in current currency unit and ranking the impact of each risk factor on the projects (in terms of net present value).

It was identified that the project was viable when analyzed only under the financial criterion (NPV) approach, but, when the financial risks were added in the analysis, through the multicriteria analysis used, it was no longer viable because it had a negative average NPV_A and a probability of 67.044% to remain in this situation. Above all, the risk factor related to the planning and estimation of the benefits that can be generated by the project contributes mainly to the project becoming unviable, as identified by the steps used in this research.

This no-available situation found, highlights the importance of the innovation planning process, especially at the moment of idea selection and the verification of the initial viability of the project. It was also identified that, in the analyzed project, risks considered critical by the literature in innovative IT projects such as those related, for example, the technical part and labor (SAMANTRA et al., 2016; ZHANG, 2016; MIORANDO et al., 2014; KADAREJA, 2013; TONG-LU et al., 2012) were not a priority in this analysis.

Those risks mentioned before were not analyzed because Porto Digital is a center of excellence in the production of its technologies, making the relationships established in this niche strengthen the quality of the software developed by the companies that compose it and the great availability of manpower, minimizing costs for businesses.

Therefore, in this case, the study of an innovative small business project, given the limited resources that micro and small businesses have, managers, must direct efforts and action plans for risk factor F_2 in future technology-based projects.

For future studies, the use of the ELECTRE TRI method for risk classification is suggested according to the manager's preference thresholds for risk, whether it is risk aversion or risk propensity aligned with its financial loss.

In addition, a method developed in this paper can be applied to innovation projects in other countries, such as China, and a comparison of the most impacting risks can be performed between Brazil and China, as a mapping of risk mitigation management practices.

References

ABBASSI, M.; ASHRAFI, M.; TASHNIZI, E.S. Selecting balanced portfolios of R&D projects with interdependencies: a cross-entropy based methodology. **Technovation**. v. 34, n. 1, p. 54–63, 2014.

AGÊNCIA BRASILEIRA DE DESENVOLVIMENTO INDUSTRIAL (ABDI). **Arranjo produtivo serviços em TIC'S, no estado de Pernambuco:** o caso do Porto Digital em Pernambuco/Brasil. Brasília, 2013.

ASSMUTH, T.; HILDE, A. T.; BENIGHAUS, C. Integrated risk assessment and risk governance as socio-political phenomena: a synthetic view of the challenges. **Science of the Total Environment**, v. 408, n. 18, p. 3943–3953, 2010.

BOUCHER, T. O.; GOGUS, O.; WICKS, E. M. A comparison between two multiattribute decision methodologies used in capital investment decision analysis. **The Engineering Economist,** v. 42, n. 3, p. 179-202, 1997.

BOUCHER, T. O.; MACSTRAVIC, E. L. Multiattribute evaluation within a present worth framework and its relation to AHP. **The Engineering Economist**, v. 37, n. 1, p. 1-32, 1991.

CHEN, T.; ZHANG, J.; LAI, K. K. An integrated real options evaluating model for information technology projects under multiple risks. **International Journal of Project Management**, v. 27, n. 8, p. 776-786, 2009.

CHITTOOR, A. **What is a Risk Matrix?** 2013. Disponível em: <http://network.projectmanagers.net/profiles/blogs/what-is-a-risk-matrix>. Acesso em: 19 abr. 2016.

COSTA, H. R.; BARROS, M. O.; TRAVASSOS, G. H. Evaluating software project portfolio risks. **Journal of Systems and Software**. v. 80, n. 1, p. 16–31, 2007.

DAMODARAN, A. **Gestão estratégica do risco**. Porto Alegre: Bookman, 2009.

ENTEKHABI, M.; ARABSHAHI, G. A. Classification of innovation projects. **Indian Journal of Innovations and Developments**. v. 1, n. 8. p. 1-14, 2012.

FANG, C.; MARLE, F.; XIE, M. An integrated framework for risk response planning under resource constraints in large engineering projects. **IEEE Trans. Eng. Manage**. v. 60, p. 627–639, 2013.

FERREIRA, M. O.; CARMO, C. M.; TÁVORA, L. E. M.; RAMOS, F. S.; CARVALHO, A. K. B. Ferramentas de seleção de projetos de P&D no setor elétrico brasileiro com base em modelos de decisão multicritérios. In: XXX Encontro Nacional de Engenharia de Produção. 30, 2010, São Paulo. **Anais do XXX ENEGEP**. São Paulo: Associação Brasileira de Engenharia de Produção, 2010, p. 1-11.

HAN, W. M.; HUANG, S. J. An empirical analysis of risk components and performance on software projects. **Journal of Systems and Software**. v. 80, n. 1, p. 42–50, 2007.

HOSSEN, M. M.; KANG, S.; KIM, J. Construction schedule delay risk assessment by using combined AHP-RII methodology for an international NPP project. **Nuclear Engineering and Technology**, v. 47, n. 3, p. 362 – 379, 2015.

KADAREJA, A. **Risks of incremental, differential, radical, and breakthrough innovation projects**. Innovation Management.se. 2013. Disponível em: < http://www.innovationmanagement.se/2013/07/29/risks-of-incremental-differential-radical-and-breakthrough-innovation-projects/>. Acesso em: 2 fev. 2015.

KIMURA, H.; SUEN, A. S. Ferramentas de análise gerencial baseadas em modelos de decisão multicriterial. ***Revista de Administração de Empresas***, v. 2, n. 1, p. 1-18, 2003.

KÖHLER, A. R.; SOM, C. Risk preventative innovation strategies for emerging technologies the cases of nano-textiles and smart textiles. **Technovation**. v. 34, n. 8, p. 420–430, 2014.

LUCENA, L. P.; KLIEMANN NETO, F. J.; MASSUIA, F. M.; FANTI, L. D. Avaliação multicriterial das fazendas verticais canadenses como modelos sustentáveis de agricultura urbana. **Revista de Administração e Inovação**. São Paulo, v. 11, n .1, p .181-202, 2014.

MARQUES, J.; LEITE, C. Clusters como novas possibilidades de regeneração urbana e reestruturação produtiva: O caso do Porto Digital, Recife. **Cadernos de Pós-Graduação em Arquitetura e Urbanismo**, v. 5, n. 1, p. 1-17, 2008.

MIORANDO, R. F.; RIBEIRO, J. L. D.; CORTIMIGLIA, M. N. An economic-probabilistic model for risk analysis in technological innovation projects. **Technovation**, v. 34, n. 8, p. 485-498, 2014.

NORRIS, G. A.; MARSHALL, H. E. **Multiattribute decision analysis method for evaluating buildings and building systems.** National Institute of Standards and Technology, 1995.

PAULO, W. L.; FERNANDES, F. C.; RODRIGUES, L. G. B.; EIDT, J. Riscos e controles internos: uma metodologia de mensuração dos níveis de controle de riscos empresariais. **Revista de Contabilidade e Finanças,** v. 18, n. 43. p. 49 – 60, 2007.

PROJECT MANAGEMENT INSTITUTE (PMI). **Um Guia do Conhecimento em Gerenciamento de Projetos -** Guia PMBOK, 2013.

SAATY, T. L. **The analytic hierarchy process**. New York: McGraw-Hill, 1980.

SAMANTRA, C.; DATTA, S.; MAHAPATRA, S. S. Interpretive structural modelling of critical risk factors in software engineering project. **Benchmarking:** An International Journal. v. 23, n. 1, p. 2-24, 2016.

SCARPELLINI, S.; VALERO-GIL, J.; PORTILLO-TARRAGONA, P. The "economic–finance interface" for eco-innovation projects. **International Journal of Project Management**, v. 34, p. 1012–1025, 2016.

SCHUMPETER, J. A. **A teoria do desenvolvimento econômico**. São Paulo: Nova Cultural, 1988.

SERVIÇO BRASILEIRO DE APOIO AS MICRO E PEQUENAS EMPRESAS – NACIONAL (SEBRAE/NA). **Sobrevivências das empresas no Brasil:** coleção estudos e pesquisas. Brasília, 2013.

SOUZA, J. S.; KLIEMANN NETO, F. J.; ANZANELLO, M. J.; FILOMENA, T. P. A non-traditional capital investment criteria-based method to optimize a portfolio of investments. **International Journal of Industrial Engineering**, v. 19, n. 4, p. 193-203, 2012.

TONG-LU, S.; HENG YU, S. Risk factors assessment for software development project based on fuzzy decision making. **International Journal of Information and Electronics Engineering**, v. 2, n. 4, p. 1-5, 2012.

WARKENTIN, M.; MOORE, R.S.; BEKKERING, E.; JOHNSTON, A. C. Analysis of systems development project risks: an integrative framework. **The Data Base for Advances in Information Systems,** v. 40, n. 2, p. 8–27, 2009.

WANG, J.T.; LIN, W.; HUANG, Y.H. A performance-oriented risk management framework for innovative R&D projects. **Technovation**. v. 30, n. 11-12, p. 601-611, 2010.

YIN, R. K. **Case study research**: design and methods. 4th. London: Sage, 2009.

ZHANG, Y. Selecting risk response strategies considering project risk interdependence. **International Journal of Project Management**, v. 34, p. 819–830, 2016.