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REAL ESTATE DEVELOPMENT FEASIBILITY BASED ON RISK ANALYSIS

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ABSTRACT

With the civil construction scenario becoming increasingly competitive, companies must work with a small profit margin. With this, any unforeseen event or uncertainty can make the investment unviable. Companies have implemented risk management in their planning, and since 2015, this has also become a mandatory requirement of the ABNT NBR ISO 9001 standard. This study aims to identify and statistically analyze the risks of incorporation using a methodology proposed in light of the PMBOK. A literature review on modeling and risk assessment was conducted, as well as a case study, starting with document analysis and a survey of costs, revenues, and initial assumptions, where a risk survey was conducted with the members of the incorporating company. The indexes were determined through a Monte-Carlo simulation using an Excel software program called @Risk. At the end of the study, the financial viability indicators were established, detailing the range of values and the probability of each of them occurring. Thus, it enabled the feasibility of the enterprise to be determined and understand the utmost importance that risk management has for the effectiveness of an enterprise.

Keywords: Risk; Risk Management; Incorporation; Financial viability; PMBOK Guide; Civil Construction.

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INTRODUCTION

Some companies have a tendency to tolerate various risks at the start of their activities, and this leads to their later bankruptcy within the first two years of their foundation. This bankruptcy happens because the risks are accepted without proper follow-up (Szymanski, 2017). The studies on this risk have grown over the years, so that its application and importance have grown on a large scale since the 17th century with the introduction of risks in the financial and insurance markets, through the Industrial Revolution with technological risks, to the present day (Dickinson, 2001; Joia *et al.*, 2013; Crovini *et al.*, 2021).

For many years, companies have transferred certain types of risk, such as catastrophes or human errors, to corporate insurance. However, it was found that some of these could be prevented or their impact reduced through effective prevention and control systems, so that they could be retained and financed within the company. This led to a broader approach to risk management (Dickinson, 2001; Cristofaro, 2019).

The construction industry is known to be exposed to more risks compared to other industries due to its complexity. These risks can cause reduced performance, increased costs, delays, and project failures. The construction scenario has become increasingly competitive over the past decades; therefore, for companies to survive, it is necessary to identify unforeseen events or uncertainties that may affect the feasibility of the investment (Zou *et al.*, 2017; Shojaei and Haeri, 2019).

In this context, this research aims to identify and analyze the risks of incorporation in the technical and economic feasibility phase through a methodology proposed in light of the PMBOK for determining economic and financial viability.

THEORETICAL FRAMEWORK

According to ABNT NBR ISO 31000 (ABNT, 2009) and Raz et al. (2002), uncertainty is the state of partial or complete lack of information on a given event. Meyer et al. (2002) highlight the existence of four types of uncertainty: variability, where small identifiable and measurable influences impact a given event; predicted uncertainty, where events are identifiable and measurable; unanticipated uncertainty, where events are unidentifiable; and chaos, where events are unaffected.

Identifiable and measurable uncertainties are called risk, and it can be related to both positive and negative uncertainties (Joia *et al.*, 2013; Abraham, 2012; Okudan *et al.*, 2021).

The Project Management Institute (PMI) through the PMBOK guide (PMI, 2013) and the ABNT ISO 31000: Risk Management - Principles and Guidelines (ABNT, 2009) converge in their definition of risk by saying that it is the consequence arising from uncertainty in a given event.

However, contrary to the definition given from the etymology of the word risk, PMI (2013) and ABNT ISO 31000 (ABNT, 2009) point out that risks can bring positive and negative impacts to the project. The risks that generate negative impacts are called threats, while the risks that can bring positive impacts are called opportunities (Schieg, 2006; Oduoza *et al.*, 2017).

The ABNT NBR ISO 31000 (ABNT, 2009) defines risk management as coordinated activities to guide an organization concerning the identifiable and measurable uncertainties of its activities, in which those of the unforeseen and chaos types are left aside. **Figure 1** shows the relationship between project or enterprise management and the types of existing uncertainties, that is, the relationship between uncertain-

Figure 1. Uncertainty x Impact Ratio

Source: Joia *et al.* (2013)

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ties (known or not) and those that may or may not affect the project. Within the scope of project management, the only types of uncertainty that are manageable are the known uncertainties that may affect the project (Joia et al., 2013). One of the difficulties in obtaining uncertainties in construction is related to the undertaking being a one-off, i.e., a unique and non-serial product (Taroun, 2014).

Risk management is an efficient way to reduce operating costs as it enables negative risks to have their impact and likelihood diminished while boosting positive risks (Schieg, 2006; PMI, 2013; Serpella *et al.*, 2014; Hwang *et al.*, 2014).

The Brazilian Association of Technical Standards (ABNT) has recognized the utmost importance of risk management. With this, in 2015, ABNT made it mandatory to perform risk management to obtain the certificate of ABNT NBR ISO 9001: Quality management systems – Requirements. However, knowing at what point risk management is required in the enterprise is just as important as carrying it out. **Figure 2** shows the company's ability to influence the project's costs over time. From this graph, it can be seen that costs are more likely to change in the project feasibility study.

Figure 3 shows the relationship between impact and risk uncertainties regarding time. By means of the image, it is verified that many uncertainties exist in the initial phase of the enterprise but which cause minor impacts, while in the final phase, few uncertainties are observed, which can cause very significant impacts.

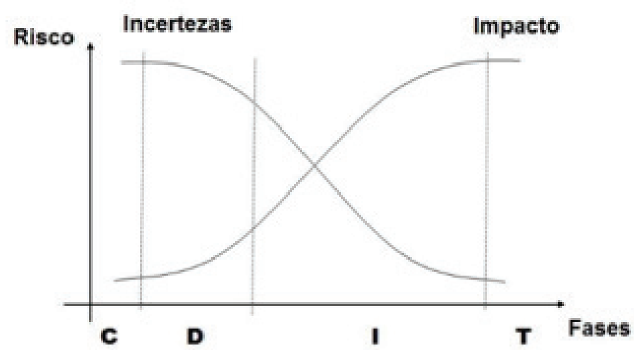

Figure 3. Uncertainty versus Risk Impact in the Product Life Cycle
Source: Dinsmore (2003)

By relating the graphs in **Figure 2** and **Figure 3**, it is possible to see that risk management should be conducted in the project feasibility stage, thus enabling the recognition of uncertainties pertinent to the project and the creation of an action plan to prevent risks from happening, thereby reducing their costs (Okudan *et al.*, 2021).

Although civil construction developments are always unique, they have risk categories in the development that generally are: protest risks; risks related to soil; risks related to the calendar; equipment failure risks; employee shortage risks; employee quality risks; materials, supplies, and personnel management risks; materials ordering risks; materials quality risks; standardization risks; lack of control risks; risks of increasing the scope of work; risks of poor work organization; financial risks; and project risks (Keshk et al.,

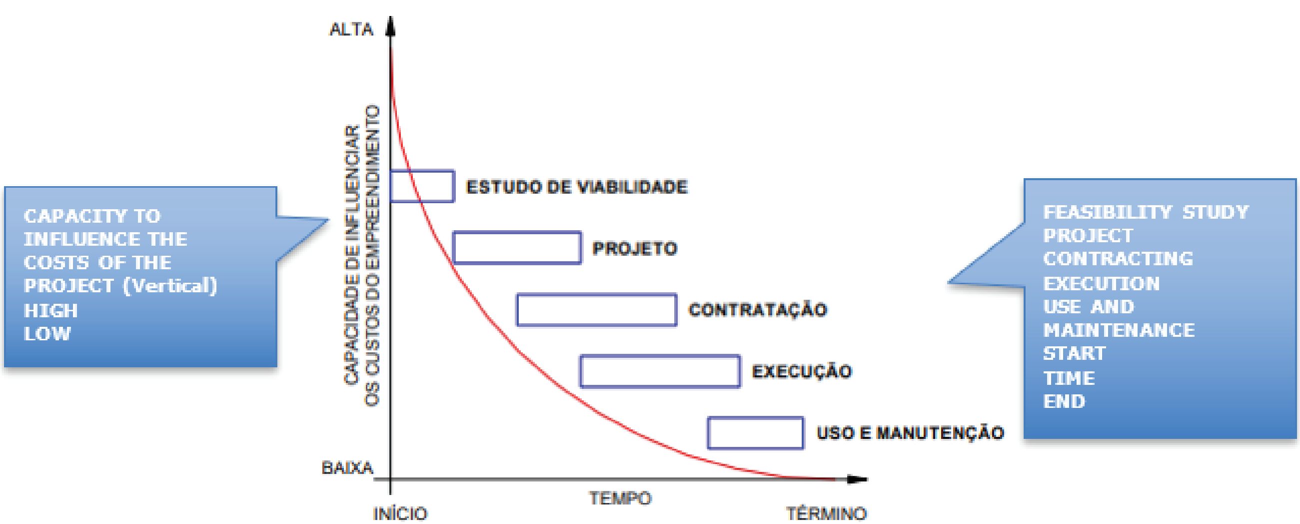

Figure 2. Ability to Influence Cost x Time

Source: CII (1987) *Apud* Melhado (1994); Dickmen and Birgonul (2006); Schieg (2006)

Figure 2. Ability to Influence Cost x Time
Source: CII (1987) *Apud* Melhado (1994); Dickmen and Birgonul (2006); Schieg (2006)

2018; Kumar and Narayanan, 2021). Thus, the importance of risk management in the project feasibility phase is remarkable (Dziadosz et al., 2015; Oduoza et al., 2017). With it, it is possible to reduce the operational costs of the venture, besides projecting a more accurate result for the project, making the company more competitive within the Brazilian civil construction scenario.

According to PMI (2013), risk management is formed by six stages, where the inputs required for its development, the tools used, and the outputs generated are identified (Scofano, 2011; Yildiz et al., 2014). Thus, risk management by PMI (2013) consists of the following steps: planning risk management, identifying risks, performing qualitative risk analysis, performing quantitative risk analysis, planning risk responses, and controlling risks. Firstly, a plan of what needs to be done is carried out to raise the existing risks, followed by their analysis. After this step, planning is done to minimize the risks, followed by monitoring during all the stages of the project (Oduoza *et al.*, 2017; Keshk *et al.*, 2018). With this, the project in question will be carried out based on risk management from the process proposed by PMI (2013) in the PMBOK. In addition to knowing the factors for deciding a risk and its types that affect a company, it is also important to understand how this risk relates over time (Serpell *et al.*, 2015).

In the initial stage of a project, the uncertainties are significant. However, the impacts that accompany these uncertainties are minor. Thus, should any risk materialize in the project's initial phase, its impact on the project will be small. On the other hand, as time goes by, the uncertainty or impact ratio is inverted, so that at the end of the project, those responsible for it have few uncertainties, but if a risk does occur, the impact tends to be much greater (Dikmen et al., 2008; Dinsmore and Neto, 2014).

METHODOLOGY

The work in question is an applied scientific and quantitative study with an explanatory objective carried out through bibliographic research and case study. In addition, a phenomenological and statistical methodology is used.

first stage of the research, the scientific mapping was performed by segmenting documents, with elements such as: authors, journals, and words in different groups, from the CAPES/MEC Periodical Portal. Thus, a set of basic documents was filtered based on the fields of Article Title, Abstract, and Keywords. The separate documents were examined in detail, highlighting the findings to reach valid conclusions (Aria; Cuccurullo, 2017). After the literature review, an object company was selected and defined based on the following requirements: being a small-sized developer, being located in Greater Vitória, and having a project in the feasibility stage.

Data collection from the company was conducted similarly to that proposed by Kartam and Kartam (2001) and Kumar and Narayanan (2021), employing meetings, interviews, and document requests made with the semi-structured company. With this, the risks were categorized using a Risk Analytical Framework (RAS). The RAS is built in levels, defining the broadest categories and detailing them at each level established. Next, the identification of possible risks that may occur during the entire incorporation process, from the conception of the development to the delivery of the clients' units, was performed together with the technical staff of the construction site. Thus, the identification of possible risks was based on the developer's experience in previous projects, the technical opinion of the department/area of construction, and project and budget assumptions.

The Brainstorm methodology was used to identify the risks, aiming to raise the largest possible number of risks and filter those most appropriate for the enterprise. This methodology had the categorization of risks through the RAS as a reference. Thus, the meeting participants should raise possible risks for each RAS category. After being identified by the team, each risk was discussed to decide if it was relevant. The qualitative and quantitative risk survey was determined jointly with the company's management (Kartam and Kartam, 2001; Kumar and Narayanan, 2021). It is also important to point out that since the main purpose of the work is to carry out the feasibility program, a complete survey of the project risks was not carried out. Thus, a maximum of three risks were defined for each category, and a specific category in which the partners had more experience and which was perceived to be better used in the management for a more detailed survey was chosen.

The ratings to be placed for each risk previously raised and the probability and impact matrix can be seen in **Figure 4**. It followed the methodology for assessing the likelihood and impact of risks along with the probability and impact matrix proposed by PMI (2013) and ABNT NBR ISO 30001 (ABNT, 2009). In addition, the quantitative impacts that each risk would cause on the enterprise should it happen were also defined. This impact was defined through the team's experience, the project's cost surveys, and market research.

The types of responses to threats (preventing, mitigating, transferring, and accepting) and the four types of responses to opportunities (exploring, improving, sharing, and accepting) were defined for this work (Joia et al., 2013; PMI, 2013; ABNT, 2015). Thus, all risks raised and analyzed in the meetings were discussed, and possible responses to each risk were determined. Based on these responses, new levels of risk probability and impact were determined, in addition to the cost of each risk response and the new impact value of

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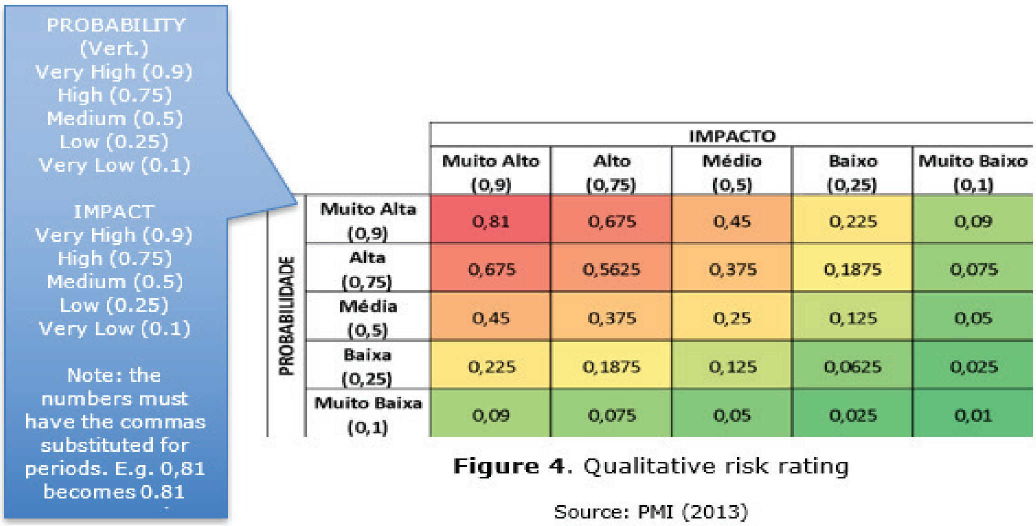

	IMPACTO				
	Muito Alto (0,9)	Alto (0,75)	Médio (0,5)	Baixo (0,25)	Muito Baixo (0,1)
Muito Alta (0,9)	0,81	0,675	0,45	0,225	0,09
Alta (0,75)	0,675	0,5625	0,375	0,1875	0,075
Média (0,5)	0,45	0,375	0,25	0,125	0,05
Baixa (0,25)	0,225	0,1875	0,125	0,0625	0,025
Muito Baixa (0,1)	0,09	0,075	0,05	0,025	0,01

Figure 4. Qualitative risk rating
Source: PMI (2013)

the original risk.

The analysis of the results was carried out through the input-transformation-output process, where the inputs are all the input data of the project (inputs), the transformations are the operations that compile and interpret the inputs, and the outputs are the output data of the process, i.e., the products or services (Marques, 2013). This process is represented through the schematic illustration in **Figure 5**.

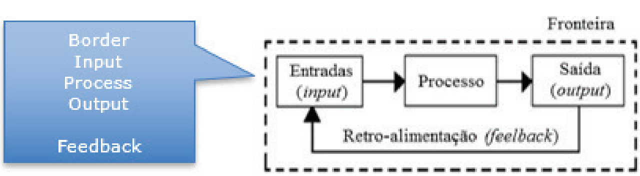

Figure 5. Representative scheme of a production system
Source: Slack *et al.* (2009)

The inputs were all the information used as input data to obtain the results, as follows: land cost; land sale value per square meter; annual Minimum Attractiveness Rate (MAR); annual Internal Rate of Return (IRR) (bad, regular, good, and excellent); Profitability Index (PI - bad, regular, good, and excellent); square footage of the enterprise units; sales forecast for the enterprise units; sales installment method for the enterprise units; sales commission percentage; indirect expenses of the enterprise; funding or loan forecast; construction budget; enterprise risk management.

The Net Present Value (NPV) and IRR methods are classic methods of deterministic nature for assessing all types of investments, fundamentally considering the fixed and known cash flows over the project's useful life (Melo, 2012). Studies to analyze the feasibility of investments based on IRR techniques were also conducted by Fanti et al. (2015) and Silva et al. (2007), who performed a financial feasibility analysis complemented by risk simulations of a real estate investment project.

The NPV consists of bringing all costs, expenses, and revenues related to a project to the initial date of the venture, i.e., the first moment when there was cash movement in the project, discounting the determined interest rate, which is the MRA in the case of a feasibility project (Rebelatto, 2004; Vancin and Kirch, 2020). The NPV can be determined through the model presented in **Equation 1** below (adapted from Gitman, 2010):

$$VPL = \sum_{j-1}^{n} \frac{FCj}{(1+TMA)^{j}} - FC_0$$

Where:

FC_j is the expected cash flow for each time interval [FC_j];
FC_0 is the cash flow in the first month of project investment [FC_0];
J is the number of past periods [J].

The Internal Rate of Return (IRR) is the interest rate considered in the NPV calculation that takes this value to zero, i.e., it is the value that equals the entire estimated cash flow to the initial investment (Ross, Westerfield, and Jaffe, 2003). IRR can be determined using the model presented in **Equation 2** below (adapted from Gitman, 2010):

$$\sum_{t=1}^{n} \frac{FCt}{(1+TIR)^t} - I_0 = 0$$

Where:

FCt is the expected cash inflow in each period [FCt];
TIR is the internal rate of return or periodic equivalent rate of return [TIR];
Io is the amount of the investment at the time [Io].

With the results of NPV and IRR, it is possible to draw a conclusion about the project. If the calculated value is greater than zero, it means that the project's return is greater than the expected return through IRR. If the value is equal to zero, it will make no difference what investment you make. Finally, if the NPV is negative, the project is not viable because the return will be lower than an investment with an IRR (Melo, 2012; Carvalho et al., 2009).

One can see from the IRR formula that the result is obtained by solving a polynomial function. Thus, it is important to note that this index is subject to error, so that the function may produce multiple or nonexistent roots (Kassai, 1996).

The Modified Internal Rate of Return (MTIR) was created to eliminate possible errors. This rate is calculated by bringing all negative flows (or investments) to a Present Value (PV) at a compatible financing rate and bringing all positive flows to a Future Value (FV) at a compatible reinvestment rate (Kassai, 1996; Souza, 2003), determined through the model presented in **Equation 3** below:

$$FV = PV * (1+i) * n$$

Where:

FV is the future value of positive cash flows [FV];
PV is the present value of negative cash flows [PV];
MTIR is the interest rate (MTIR) [I];
n is the number of months between the initial and final month [n].

The profitability index is the ratio between the Net Present Value of the investment and the initial investment made by the investor. Thus, this index seeks to demonstrate a factor that determines how much a real invested at the beginning of the project will become at the end of it (ABNT, 2002), as determined by the model presented in **Equation 4** below:

$$IL = \frac{VP_{CASH\ FLOW}}{VP_{INVESTMENT}}$$

Where:

$VP_{CASH\ FLOW}$ is the cash flow discounted from the project (VPL) [$VP_{CASH\ FLOW}$];
$VP_{INVESTIMENT}$ is the Present value of the investment made [$VP_{INVESTIMENT}$].

Thus, it is possible to realize that when the IL is higher than one, the project can be approved. If the IL is lower than one, the project must be rejected (ABNT, 2002).

Nevertheless, it is necessary to realize that this indicator is not the only one necessary for decision-making. For viability to be completed, it is necessary to analyze all the previously demonstrated indexes.

Considering the economic environment complexity, the process of producing the outputs to consider the risk in investment analysis uses the Monte Carlo Simulation (MCS) technique through @RISK, as used by Silva et al. (2007). This (Monte Carlo) method is widely used, where input values are declared, and the project model runs several simulations (iterations). Some input values are selected at each iteration, and the probability distributions of these variables are used (Akintoye and MacLeod, 1997; PMI, 2013).

While filling in the risks and the risk response, it was necessary to determine their probability distribution and their minimum, probable, and maximum values.

The minimum risk value was considered zero in all cases. The probable value was determined by multiplying the factor found through the probability versus impact matrix and the impact determined by the team. The maximum value was defined as the full impact of the risk. Thus, these values allowed us to find the probability distribution of the expected value for the risk. The expected risk value was also transmitted to the enterprise's costs and revenues, its cash flow, and, finally, the enterprise's report indices.

In this context, the project's outputs were generated, namely: the Modified Annual Internal Rate of Return (MTIR), the Enterprise Profitability (EP) Index, and the Enterprise Net Present Value (NPV). It should be noted that the values set in the outputs were not fixed figures but rather ranges of probabilities of values. These results' analysis require studying each output individually to determine the probability of the minimum value established for each one occurring.

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If the partners consider the probability of all the indices to be acceptable, the viability of the venture is accepted. Otherwise, it is necessary to study ways to improve the venture's financial conditions, either by redoing risk management or by changing the venture's sales, overhead, or budget.

RESULTS

The company participating in the case study is located in Vitória, ES. The enterprise operates in the area of real estate development and construction, with its area of operation in the Greater Vitória. It is composed of two partners, and according to the Complementary Law No. 123/2006 (BRASIL, 2006), the company is classified as a microenterprise for having gross revenue equal to or less than R$ 360,000.00. The study enterprise is located in Jacaraípe, ES.

Mobilization of the development began in April 2019, and construction was scheduled to begin in August 2019 with completion in March 2020. The venture consists of four units with 74.4 m² of built area each. The square meters of the constructed area will be sold for R$ 2,420.00. The foundation was composed of footings, radiers, and baldram beams, while the structure was made of reinforced concrete. The construction site's vertical seal was made of conventional masonry. The enterprise's feasibility analysis parameter was defined together with the company: the project's Minimum Rate of Attractiveness (MRA) is 15% per year, corresponding to 1.17% per month. In addition, the company also classified the Internal Rate of Return (IRR) and the Enterprise Profitability (EP) Index into ranges denominated as bad, regular, good, and excellent, as shown in **Chart 1**.

Parameter	TIR (anual)	Índice de lucratividade
Bad	15%	1.00
Regular	17%	1.20
Good	20%	1.40
Excellent	40%	2.00

Chart 1. IRR Analysis Parameters and EP Analysis Parameters
Source: Authors

The limit proposed by the company for the IRR is in line with what is proposed by Carvalho et al. (2009), whereas the IRR below the Minimum Rate of Attractiveness (MRA) determined should be considered bad, susceptible to project unfeasibility. Regarding the Profitability Index, the ABNT Standard NBR 14653-4:2002 proposes rejecting projects with an EP lower than one, as proposed by the company. Lastly, the Net Present Value of the project must be higher than 0 for the project to be approved, as proposed by Silva et al. (2007), Carvalho et al. (2009), Oliveira and Kayo (2020), and Vancin and Kirch (2020). First, to categorize the risks, a flowchart of the entire incorporation process was made, listing the participating parties in each step of the flow (**Figure 6**).

The structure is similar to that proposed by Neto and Nobre (2017) and Martins et al. (2012), with the presence of a basic structure composed of the conception of the product or project, land analysis and choice, project realization and approval, project launch, construction, and post-construction. Thus, with the categories in each phase of the process listed, it was possible to put them together and build the Risk Analytical Structure (RAS).

Analyzing the created RAS (**Figure 7**) and comparing it with the one proposed by Lima (2017), it is possible to notice similarities in its structure. Although the categories are not the same, if the RAS is analyzed as a whole, it is possible to realize that the essence of the categories and risks that will be listed in the future are similar. Moreover, it can be seen that the constructed RAS contains several risk categories proposed by Szymanski (2017), Dziadosz et al. (2015), and Keshk et al. (2018). In addition, it resembles the categories of the case study by Barreto and Andery (2015).

According to Rasool et al. (2012), the hierarchical description of risks through RAS is a very practical tool, thus making management easier as it groups the identified risk events into different levels following a bottom-up approach.

The identification of risks was made through a brainstorming session with the team, in addition to the use of the partners' previous experiences in other enterprises. During the identification of risks, they were also defined as opportunities or threats to the enterprise, and the possible consequences of these risks were identified. Next, the risks' quantitative impacts were identified (**Chart 2**).

Some relevant points were raised for the survey. The first is that the project's execution did not vary over time, remaining within the eight months initially proposed by the company. Thus, the risks that would cause delays in the work impacted an increase in the number of personnel. Regarding the second point, the risks that directly affect the project's sales process were quantified as the impact on the unit's square meter value [R$/m²].

Another important point is that the risks that impact the financial return of the venture and possible interest were determined in percentages. Finally, the remaining risks were calculated through the experience of the company's partners, based on the project's budget and with research on analogous examples. From this, it was possible to determine

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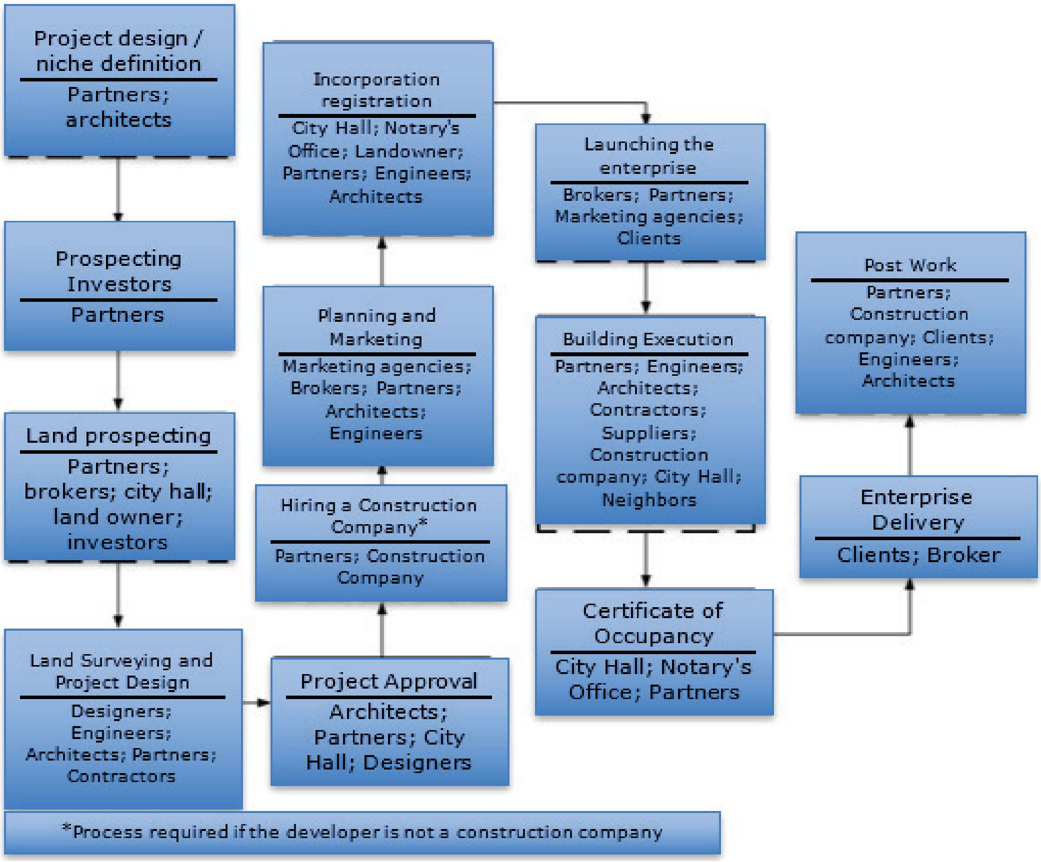

Figure 6. Flowchart of the incorporation process

Source: Authors

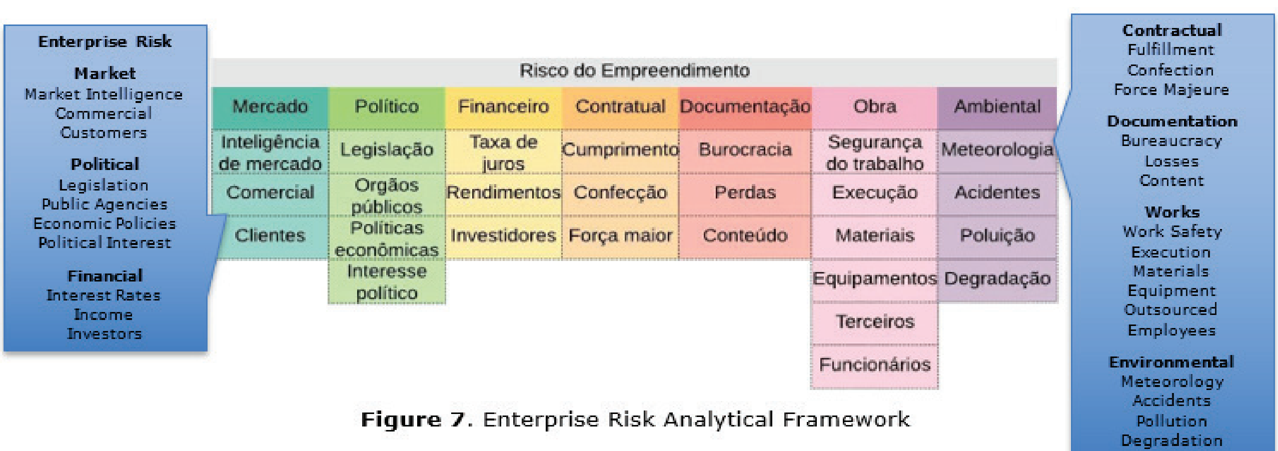

Figure 7. Enterprise Risk Analytical Framework

Source: Authors

the minimum, probable, and maximum values for the Monte-Carlo distribution. The probable value was determined by multiplying the quantitative impact and the qualitative probability raised for the risks, and the maximum was the value of the quantitative impact determined, as shown in **Table 1**.

The probability curves for all risks were triangular to ensure a more evenly distributed probability between the minimum and maximum value, with the peak being at the probable value, as shown in **Figure 8**. The exception is the risks impacting the yield and interests of the enterprise, which were determined using a PERT probability curve to ensure

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Item	RAS	Risk	Consequence	Type
1	MAR	Delay in selling units	Reduction in the square meter sales price	T
2	MAR	Products not meeting demands	Reduction in the square meter sales price	T
3	MAR	High demand for units	Increase in the square meter sales price	O
4	POL	Change in the legislation of the “Minha Casa, Minha Vida” (“My house, My life”) program	No program financing	T
5	POL	Interest rate increase	Daily liquidity fixed rents with higher yields	O
6	POL	Strikes by unions and associations	Delay in construction	T
7	FIN	Income due to cash on hand	Capital growth for the enterprise	O
8	FIN	Need for a loan	Interest	T
9	FIN	Delay in the payment of third parties	Interest	T
10	CON	Variation in the value of services rendered	Unplanned expenditures	T
11	CON	Project designers delay delivery	Construction delay	X
12	CON	Enterprise delay	Fine	T
13	DOC	Documentation approval delay	License delay	T
14	DOC	Land not legalized	Land value renegotiation	O
15	OCS	Employee accidents	Delay in the construction and compensation to employees	T
16	OCS	NR-18 irregularities	Fines	T
17	OCS	Occupational diseases	Delay in the work and compensation	T
18	EXE	Incorrect allocation of foundation	Rework	T
19	EXE	Infiltration in the constructive elements	Rework	T
20	EXE	Presence of drills in the structures	Rework	T
21	MAT	Concrete not reaching the planned resistance	Collapse of the structure	T
22	MAT	Infiltration in walls	Pathologies in the vertical sealing	T
23	MAT	Plastering not meeting the expected requirements	Pathologies in the plaster	T
24	EQP	Equipment theft	Delay in construction and extra costs	T
25	EQP	Uneven wall	Rework	T
26	EQP	Idle rented equipment	Unnecessary costs	T
27	THP	Non-compliant projects	Project approval delay	T
28	THP	Concrete does not meet requirements	Concrete pouring delay	T
29	THP	Material was not supplied according to specifications	Product returns and construction delay	T
30	EMP	Employee strikes	Construction delay	T
31	EMP	Delays in performing services	Construction delay	T
32	EMP	High employee productivity	Construction precommissioning	O
33	ENV	High rainfall rate	Construction delay	T
34	ENV	Embargo of the work by environmental agencies	Construction delay	T
MAR: Market; POL: Political; FIN: Financial; CON: Contractual; DOC: Documentation; OCS: Occupational Safety; EXE: Execution; MAT: Materials; EQP: Equipment; THP: Third Party; EMP: Employees; ENV: Environmental; T: Threat; O: Opportunity				

Chart 2. Identification of Enterprise Risks

Source: Authors

Table 1. Qualitative and Quantitative Analysis of the Enterprise's Risks

Item	Qualitative Evaluation			Quantitative Evaluation				Vuse	Unit
	Prob	Imp	Factor	Imp	Vmin	Pv	Vmax		
1	M	H	0.375	135	0	67.5	135	67.5	R$/m²
2	A	VH	0.675	135	0	101.25	135	101.25	R$/m²
3	B	M	0.125	135	0	33.75	135	33.75	R$/m²
4	B	H	0.1875	50	0	12.5	50	12.5	R$/m²
5	A	L	0.1875	0.13%	0	0.09%	0.13%	0.08%	%
6	M	M	0.25	703,8	0	351.9	703,8	351.9	R$
7	MA	L	0.225	0.59%	0	0.45%	0.5%	0.38%	%
8	B	VH	0.225	3%	0	0.75%	3%	1%	%
9	B	VL	0.025	0.10%	0	0.03%	0.10%	0.03%	%
10	A	H	0.5625	7000	0	5250	7000	5250	R$
11	A	M	0.375	4000	0	3000	4000	3000	R$
12	M	H	0.375	50	0	25	50	25	R$/m²
13	MA	H	0.675	15000	0	13500	15000	13500	R$
14	A	VH	0.675	40000	0	30000	40000	30000	R$
15	M	H	0.375	1595	0	797.5	1595	797.5	R$
16	MA	H	0.675	4400	0	3960	4400	3960	R$
17	B	M	0.125	1595	0	398.75	1595	398.75	R$
18	M	VH	0.45	10000	0	5000	10000	5000	R$
19	B	M	0.125	1000	0	250	1000	250	R$
20	M	M	0.25	400	0	200	400	200	R$
21	B	VH	0.225	800000	0	2000000	80000	2000000	R$
22	MB	M	0.05	500	0	50	500	50	R$
23	M	L	0.125	400	0	200	400	200	R$
24	B	L	0.0625	2000	0	500	2000	500	R$
25	A	L	0.1875	500	0	375	500	375	R$
26	MB	L	0.025	300	0	30	300	30	R$
27	MA	M	0.45	7500	0	6750	7500	6750	R$
28	B	L	0.0625	350	0	87.5	350	87.5	R$
29	B	L	0.0625	350	0	87.5	350	87.5	R$
30	MB	L	0.025	703	0	70.3	703	70.3	R$
31	M	H	0,375	15000	0	7500	15000	7500	R$
32	B	H	0,1875	15000	0	3750	15000	3750	R$
33	M	H	0,375	7500	0	3750	7500	3750	R$
34	B	H	0,1875	400	0	100	4000	100	R$
M: Moderate; H: High; L: Low; VH: Very High; VL: Very Low; Prob: Probability; Imp: Impacto; Vmin: Value minimum; Vmax: Valor maximum; Pv: Probable value; Vuse: Value used; Unit: Unity									

Source: Authors

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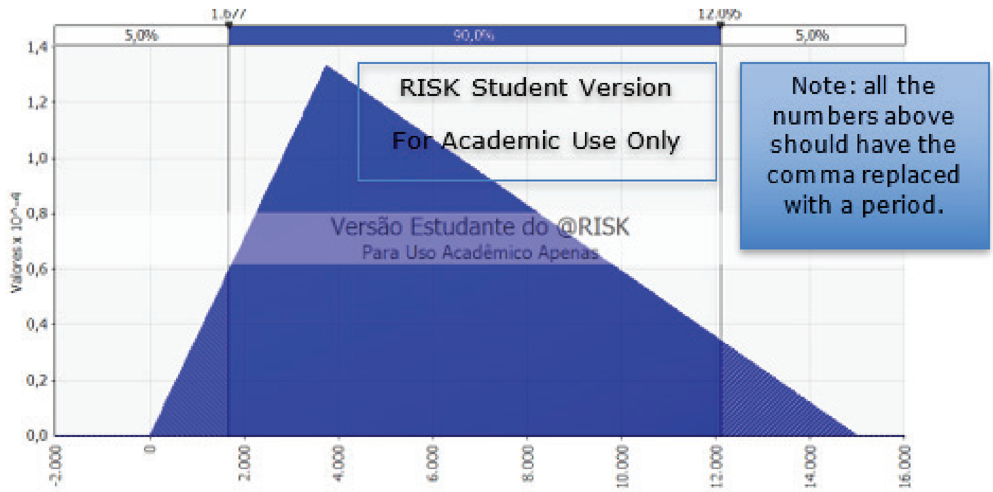

Figure 8. Triangular probability curve by @Risk
Source: Authors

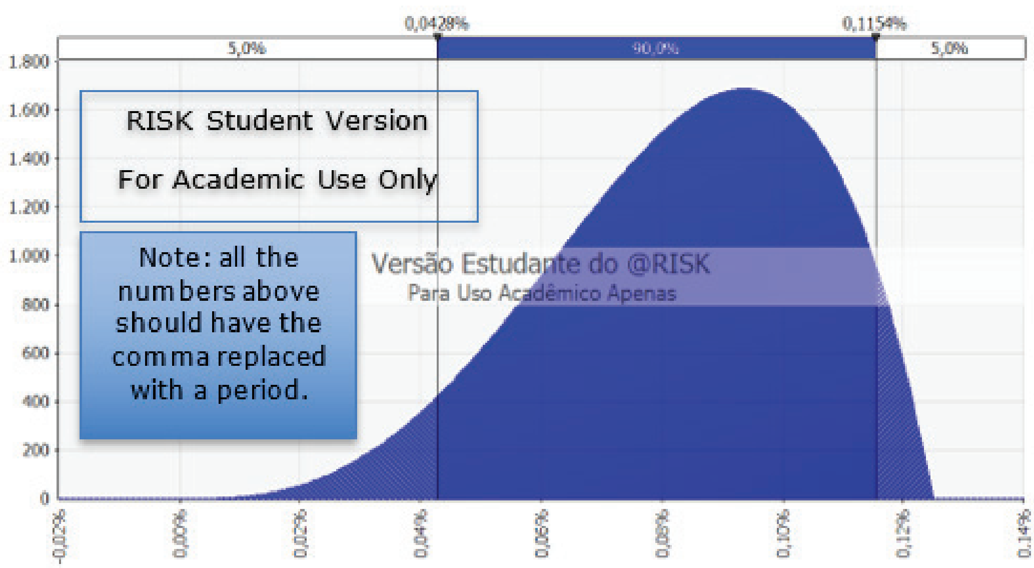

Figure 9. PERT Probability Curve by @Risk
Source: Authors

a steeper probability range near the probable value of the risk, as shown in **Figure 9**.

Both curves show the probability of a certain value happening given the minimum, probable, and maximum values, in addition to the type of probability curve. Thus, at the time of the Monte-Carlo Simulation, several iterations were performed in which all risks had their values altered between the minimum and maximum values according to the likelihood of each value happening.

With the qualitative and quantitative analyses of the risks raised, the risk response plan was carried out as established by PMI (2013), as presented in **Table 3**.

With the risk responses surveyed and quantified, the qualitative and quantitative risk analyses were redone, considering the changes that risk responses can provide, as shown in **Table 2**.

With the risk management methodology completed, it was necessary to perform a Monte-Carlo simulation using the @RISK program. The VBA program prepares all the cells in the spreadsheet in question so that it is only necessary to define the number of iterations and then run the simulation. Thus, 10,000 different scenarios were run, where each risk presented a different final impact. With this, 10,000 results were generated for the MTIR, PI, and NPV, which were presented in a probability curve for each indicator.

Item	Risk to be addressed	Type of response	Response to risk
1	Delay in selling units	Accept	Constant sales monitoring
2	Products not meeting demands	Mitigate	Efficient market research
3	High demand for units	Improve	Efficient market research
4	Change in the legislation of the “Minha Casa, Minha Vida” (“My house, My life”) program	Mitigate	Align projects with other banks’ programs
5	Interest rate increase	Accept	Political-economic monitoring
6	Strikes by unions and associations	Accept	Better relationship with syndicates
7	Income due to cash on hand	Explore	Profitability x liquidity options
8	Need for a loan	Prevent	Search for a solid investor portfolio
9	Delay in the payment of third parties	Prevent	Program to manage the financials
10	Variation in the value of services rendered	Mitigate	Hiring lawyers
11	Project designers delay delivery	Transfer	Clause in the contract with a fine
12	Enterprise delay	Mitigate	Efficient work planning
13	Documentation approval delay	Mitigate	Hiring a forwarding agent
14	Land not legalized	Improve	Create a solid base with brokers
15	Employee accidents	Mitigate	Monitoring and awareness of the use of PPEs and CPEs
16	NR-18 irregularities	Prevent	Consulting with an occupational safety technician
17	Occupational diseases	Mitigate	Developing the risk map of the work
18	Incorrect allocation of foundation	Mitigate	Engineer to check gauge
19	Infiltration in the constructive elements	Mitigate	Engineer to check waterproofing
20	Presence of drills in the structures	Mitigate	Employee training
21	Concrete not reaching the planned resistance	Mitigate	Technological control
22	Infiltration in walls	Accept	Tests on piping before plastering
23	Plastering not meeting the expected requirements	Mitigate	Tests on the plaster
24	Equipment theft	Mitigate	Constant stock control
25	Uneven wall	Mitigate	Creation of service check sheet
26	Idle rented equipment	Accept	Day-ahead rental
27	Non-compliant projects	Prevent	Integrated project offices
28	Concrete does not meet requirements	Accept	Concrete companies with good track record
29	Material was not supplied according to specifica-tions	Accept	Supplier with good track record
30	Employee strikes	Accept	Employee relations policy
31	Delays in performing services	Prevent	Employee training program
32	High employee productivity	Improve	Employee bonus
33	High rainfall rate	Mitigate	Rainy day planning
34	Embargo of the work by environmental agencies	Prevent	Correct destination of residues

Chart 3. Responses to enterprise risks

Source: Authors

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Table 2. Evaluation of responses to the Enterprise's risks

Item	Amount spent to answer	Qualitative Evaluation			Quantitative Evaluation - Monte-Carlo Simulation				Vuse	Unit
		Prob	Imp	Factor	Imp	Vmin	Pv	Vmax		
1	0	M	H	0.375	135	0	67.5	135	67.5	R$/m²
2	3.5	L	M	0.125	80	0	20	80	20	R$/m²
3	3.5	H	M	0.375	135	0	101.25	135	101.25	R$/m²
4	0	L	L	0.0625	25	0	6.25	25	6.25	R$/m²
5	0	H	L	0.1875	0.13%	0%	0.09%	0.13%	0.09%	%
6	0	M	M	0.25	703.8	0	351.9	703,8	351.9	R$
7	0	VH	M	0.45	0.65%	0%	0.59%	0.65%	0.59%	%
8	0	L	L	0.0625	1%	0%	0.25%	1%	0.25%	%
9	100	VL	VL	0.01	0.1%	0%	0.01%	0.1%	0.01%	%
10	750	VL	H	0.075	7000	0	700	7000	700	R$
11	750	M	VL	0.05	1000	0	500	1000	500	R$
12	13.45	L	L	0.0625	10	0	2.5	10	2.5	R$/m²
13	1500	M	M	0.25	7500	0	3750	7500	3750	R$
14	3000	H	VH	0.675	40000	0	30000	40000	30000	R$
15	0	L	H	0.1875	1595	0	398.75	1595	398.75	R$
16	1000	VL	VL	0.01	0	0	0	0	0	R$
17	0	VL	M	0.05	1595	0	159.5	1595	159.5	R$
18	200	VL VL	VH	0.09	10000	0	1000	10000	1000	R$
19	200	VL	M	0.05	1000	0	100	1000	100	R$
20	100	VL	M	0.05	400	0	40	400	40	R$
21	500	L	L	0.0625	50000	0	12500	50000	12500	R$
22	0	VL	M	0.05	500	0	50	500	50	R$
23	0	VL	L	0.025	400	0	40	400	40	R$
24	0	VL	L	0.025	2000	0	200	2000	200	R$
25	0	VL	L	0.025	500	0	50	500	50	R$
26	0	VL	L	0.025	300	0	30	300	30	R$
27	3000	VL	VL	0.01	0	0	0	0	0	R$
28	0	L	L	0.0625	350	0	87.5	350	87.5	R$
29	0	L	L	0.0625	350	0	87.5	350	87.5	R$
30	0	VL	L	0.025	703	0	70.3	703	70.3	R$
31	2000	VL	VL	0.01	0	0	0	0	0	R$
32	5000	H	H	0.5625	15000	0	11250	15000	11250	R$
33	0	M	M	0.25	5000	0	2500	5000	2500	R$
34	2000	VL	VL	0.01	0	0	0	0	0	R$

M: Moderate; H: High; L: Low; VH: Very High; VL: Very Low; Prob: Probability; Imp: Impacto; Vmin: Value minimum; Vmax: Valor maximum; Pv: Probable value; Vusa: Value used; Unit: Unity

Source: Authors

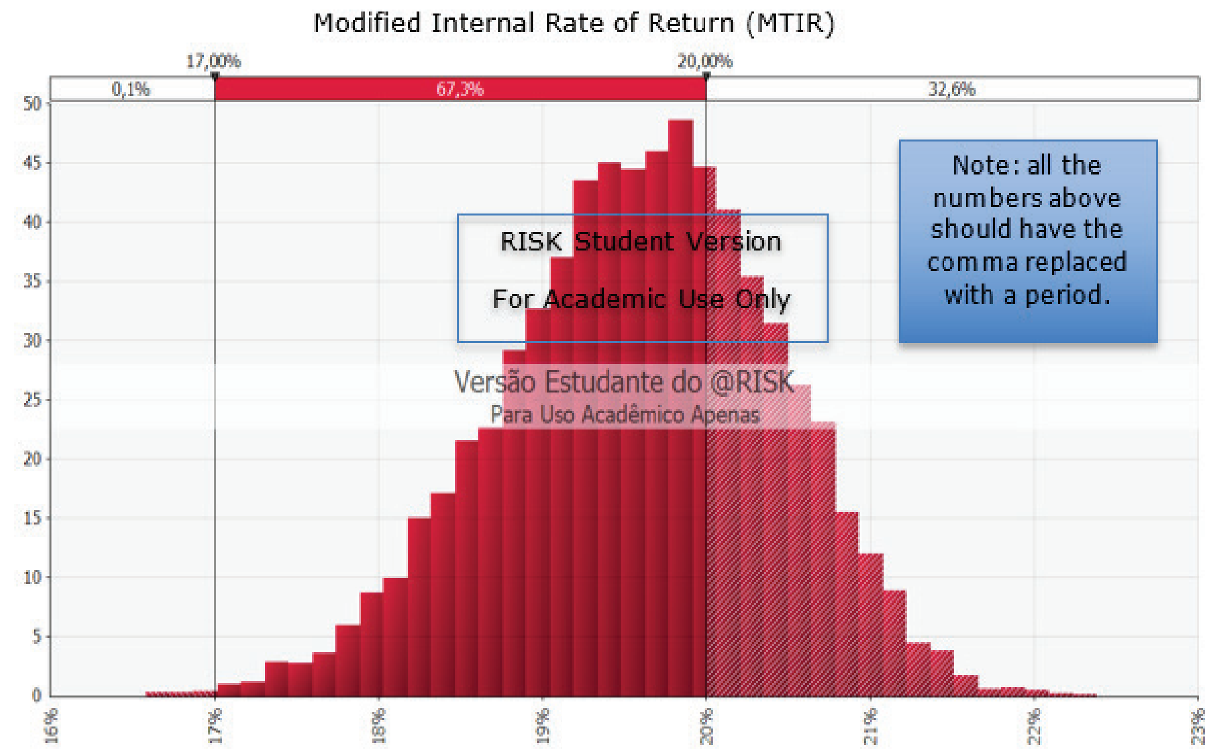

Figure 10. MTIR Probability Curve
Source: Authors

Figure 10 shows the Modified Internal Rate of Return, which has a 0% probability of reaching a bad result (less than 0%), while there is a 0.10% likelihood of the result being regular (between 15% and 17%). In addition, the highest chance is that the MTIR is considered good (between 17% and 20%), with 67.30% against a 32.60% chance of being excellent (greater than 20%).

The results are shown in **Table 3**, along with the maximum, minimum, mean, mode, median, and standard deviation values.

The profitability index presented the highest likelihood of occurrence among the range determined as good by the company (between 1.2 and 1.4), with an 89.60% chance of occurrence, as shown in **Figure 11**.

Furthermore, there is a 0% chance of the index reaching a bad result (less than 1), a 4.90% chance of an even result (between 1 and 1.2), and a 5.50% chance of an excellent result (higher than 1.4). These results are shown in **Table 4**, along with the minimum, maximum, mean, mode, median, and standard deviation values.

Thus, it is possible to see that all the enterprise's financial indicators met the minimum requirements proposed by the company, since all of them presented their highest probability and average between the good and bad ranges determined.

Table 3. MTIR Probability Curve General Information

General Data		Values	
Minimum	16.58%	<15% (Bad)	0%
Maximum	22.38%	15% - 17% (Regular)	0.10%
Mean	19.59%	17% - 20% (Good)	67.30%
Mode	19.66%	>20% (Excellent)	32.60%
Median	19.63%		
Standard Deviation	0.84%		

Source: Authors

Table 4. General EP Probability Curve Information

General Data		Values	
Minimum	1.09700	<1% (Bad)	0%
Maximum	1.52059	1% - 1.2% (Regular)	4.90%
Mean	1.30362	1.2% - 1.4% (Good)	89.60%
Mode	1.28991	>1.4% (Escellent)	5.50%
Median	1.30504		
Standard Deviation	0.06132		

Source: Authors

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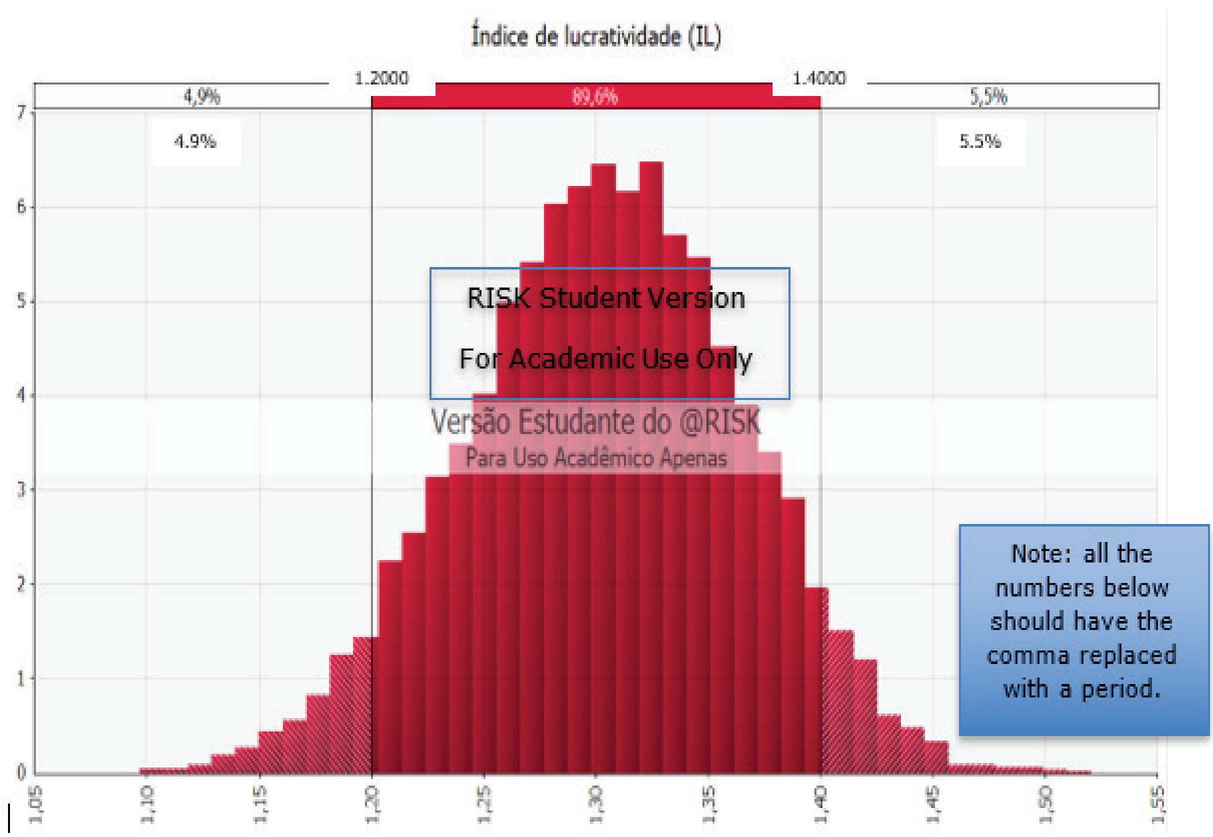

Figure 11. EP Probability Curve

Source: Authors

CONCLUSION

The case study made it possible to perceive several important aspects pertinent to risks in the development format. Firstly, the impact size of the risks within a development could be observed. The simple occurrence of a risk with a very high impact can put the viability of the entire enterprise in check.

Secondly, it should be noted the paramount significance of risk management's role within a project's viability. If feasibility relied solely on the identification of risk and considering its impacts, all projects would be unfeasible. Therefore, risk management is essential for identifying the highest-impact risks and dealing with them to reduce their likelihood of occurrence or impact.

Third, the risk management requirement for obtaining the ISO 9001:2015 certificate has changed the project feasibility landscape. Although risk management in the feasibility stage makes the project safer and more accurate, it also makes it malleable, so that the information obtained in the feasibility study is no longer fixed values but rather probabilities of occurrence. Thus, the feasibility study becomes much more complex and technical.

In short, for companies to remain competitive in the market, it is essential to implement a culture of risk management in the project feasibility phase. Only in this way will it be possible to intervene in all project costs and revenues and analyze the real probability of a project's success. In addition, the strategic process helps managers look for areas that can be improved.

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