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ABSTRACT

In earlier studies dealing with IT Portfolio Management (ITPM), the risk and return have not been treated concisely and in combination with the concept of portfolio. Real Options Theory (ROT) has been suggested as a way to analyze IT investments, assuming a dynamic positioning in relation to both these variables. Thus, the aim of this study is to analyze how the dimensions of ITPM combined with ROT help companies to justify and manage their IT investments, including the risks and returns. We performed a quantitative analysis in a company that invests intensively in IT. ROT was found to assist IT managers in the analysis of investments in the ITPM dimensions and allow greater flexibility in decision making and enhance the capacity to take advantage of market opportunities.

Keywords

Real options, IT portfolio management, dimensions, risk and return.

INTRODUCTION

Other than IT investments, no other type of investment made by organizations, represents such great expense and yet is made without adequate management, defined procedures and monitoring of the results (Maizlish and Handler, 2005). Thus, there is great interest in improving the IT management processes (Datz, 2003, Jeffery and Leliveld, 2004; Sherer, 2007; Wu and Ong, 2008), such as IT Portfolio Management (ITPM).

ITPM is not a new topic in IT research, having appeared in the academic literature in the 1970s, when researchers began to study systems within the context of the organization as a whole (Lucas, 1973). In the following decade the term portfolio began to be used in reference to the management of IT in the company, on account of the risk involved in the projects (Mcfarlan, 1981). From the perspective of IT management, however, few studies have been directly related to ITPM (Jeffery and Leliveld, 2004; Weill and Aral, 2006; Dolci, 2009). Kumar, Ajjan and Niu (2008), moreover, consider the concept to still be in development, in both the academic and in business mediums. Based on the ideas of Turner and Lucas (1985), Weill and Broadbent (1998), has been attributed four different dimensions related to ITPM: infrastructure, transactional, informational and strategic.

In the studies from Weill and Broadbent (1998), Aral and Weill (2007), which address the ITPM technique, risk and return are treated only superficially, almost rhetorically. Real Options Theory (ROT), using these variables, has been identified as one way of analyzing IT investments (Mun, 2006). Despite different studies using the concepts of IT Portfolio and ROT to analyze the risk and return variables of IT projects (for example: Bardhan, Sougstad and Sougstad, 2004; Benaroch, Lichtenstein and Robison, 2006; Peters and Verhoef, 2008), it is a remarkable fact that studies addressing ITPM dimensions have tended to neglect these variables (Weill and Broadbent, 1998; Aral and Weill, 2007).

Based on these findings, the following research question is raised: how do the ITPM dimensions, taking into account the risk and return, help companies to justify and manage their IT investments? In order to answer this question the following objective has been defined: to analyze how the ITPM dimensions, combined with ROT, help companies to justify and manage IT investments, including the risks and returns.

The analysis focuses on a petrochemical company, part of one of the largest business groups in Brazil (Computerworld, 2008; Revista Exame, 2008). The ITPM dimensions combined with ROT were used to analyze the risk and return on some investments made by the company in the IT area, and information was found on the transactional and strategic dimensions.

IT PORTFOLIO MANAGEMENT

IT Portfolio Management (ITPM) is defined as the management of IT as a portfolio of assets similar to those of a financial portfolio, with the purpose of improving the performance of the portfolio by balancing the risk and return of different investments (Jeffrey and Leliveld, 2004). It is a continuous process of managing IT investments, applications and infrastructure assets, and their interdependence, to maximize benefits, minimize risks and costs, and also ensure alignment with long-term organizational strategy (Kumar et al, 2008).

ITPM provides a means of monitoring and managing all IT investments in an organization so that benefits, costs and risks of individual investments can be evaluated to determine whether or not they are contributing significantly to organizational performance (Schniederjans and Schniederjans, 2004).

Moreover, IT investments can be structured in the form of an IT portfolio with four dimensions (Weill and Broadbent, 1998). These dimensions are presented below in accordance with Weill and Broadbent (1998) and Weill and Aral (2006). The IT infrastructure is the basis of the portfolio; it is the basis for the IT capabilities. Investments in this dimension are shared through IT services used by several applications: servers, network, laptops and the customer database. In the transactional dimension the systems process and automate the basic and repetitive business transactions. This includes systems that support order placement, inventory control, bank withdrawals, accounts receivable and accounts payable.

The systems within the informational dimension provide information for managing and controlling the company. Typically they support management control, decision making, planning, reporting and accounting. Finally, the strategic dimension has somewhat different goals from the other parts of the portfolio. They are investments made in order to gain competitive advantage or to position the company in the market, more generally by increasing sales or market share.

REAL OPTIONS THEORY

As mentioned above, the assessment of risk and return on IT investments is generally neglected in the technical literature on ITPM. With the aim of reducing this deficiency, this study combines the ITPM technique with Real Options Theory (ROT) to analyze the risk and return on IT investments. This is intended to help companies to better manage their IT budgets. Balasubramanian, Kulatilaka and Storck (2000) point out that IT investments have gained prominence in the capital budgets of organizations and the management of these investments is complex.

Traditional investment appraisal methods have proven unable to establish the value of the flexibility brought by IT investments, within a context of great dynamism and technological uncertainty (Cabral and Silva Jr, 2009). The major shortcoming of these methods lies in the fact that they analyze projects statically, and ignore any information that could emerge over the length of their execution, which alters the setting in which they are included (Dixit and Pindyck, 1994; Santos and Pamplona, 2005).

A variety of approaches towards evaluating IT investments has been proposed in the literature on IT (Kumar et al, 2008), and Real Options Theory (ROT) appears as an alternative to evaluate investment decisions in IT. ROT captures the uncertainty in the evaluation of projects, allowing the flexibility contained within them to be evaluated (Benaroch, Lichtenstein and Robison, 2006; Brasil, Freitas, Martins, Gonçalves and Ribeiro, 2007). Flexibility is understood to be ability to revise the initial strategy and change the investment plan in accordance with new environmental and economic conditions. A real option is a deferred alternative decision concerning real assets, thus incorporating flexibility into the decision-making process. Whenever new information arises, and the uncertainties regarding the cash flow come to light, administrators can make decisions that will positively affect the final value of a project (Dixit and Pindyck, 1994).

The term “real options” was created by Stewart C. Myers, from the Massachusetts Institute of Technology in 1977, after the publication of seminal papers by Black and Scholes (1973) and Merton (1973) on option pricing. The term contrasts “real” assets with financial assets that provide greater liquidity, and are usually negotiated in the financial markets, and which were the object of the attention of Black and Scholes (1973) and Merton (1973). ROT thus emerges as a theory capable of evaluating investments in real assets, not necessarily traded on the financial markets. It can be used to in the appraisal of fixed assets (machinery and equipment), intellectual property, exploitation of mineral resources, and research and development of new products (Pereira and Pamplona, 2006). Figure 1 illustrates the analogy between the variables used to price financial options and to evaluate other investments (Luehrman, 1998). The latter will be in the present study to analyze risk and return on IT investments.

Financial Option	Variable	Investment
Underlying asset value	S	Present value of the project
Exercise price	X	Initial investment
Time to expiration	T	Service life of the investment
Risk-free rate	r_f	Risk-free rate of return
Volatility	σ	Cash flow risk

Figure 1 – ROT and capital investment variables
Source: Adapted from Luherman (1998)

It should be pointed out that risk or uncertainty regarding the cash flow is difficult to estimate (Lewis and Spurlock, 2004), with values ranging between 10% and 30% being accepted and used in the literature (Panay and Trigeorgis, 1998, Santos and Pamplona, 2005). All the items in the investment column of Figure 1 are present in IT investment decisions. Thus, ROT is suitable for analyzing investments in each of the ITPM dimensions.

RESEARCH METHOD

A quantitative study was conducted using ROT to analyze the risk and return on IT investments and enhance the understanding of these variables in ITPM. A company that invests heavily in IT and uses the technique ITPM was selected. To facilitate the proposed calculations, the company was asked to supply documents showing all the investments in the IT area with as many details as possible regarding values. After, these investments were allocated to one of the ITPM dimensions and validated with the CIO of the organization.

The method of appraising the value of real options used in this study is presented by Panayi and Trigeorgis (1998) and Copeland, Koller and Murrin (2002), following a four-step process: (i) calculate the present value of the investment without flexibility through discounted cash flow (ii) calculate the present value of new investments, (iii) calculate the option value of each new investment, and (iv) choose the highest value from among those calculated.

First, the net present value of each investment was calculated from the annual cash flows data provided by the company, using Formula (1).

$$NPV = \sum_{t=0}^{n} (CFt)(e^{Kt}) \quad (1)$$

Where,

NPV = net present value;

CF = cash flow for each period;

K = cost of the company equity;

t = time of the investment.

The NPVs of the company's IT investments were calculated using the cost of the company equity, which is the discount rate used in cash flow for investment appraisal. The use Capital Asset Pricing Model (CAPM) is recommended when estimating the cost of equity (Damodaran, 1997, Copeland et al, 2002). The cost of the company equity (K), according to the CAPM model, was calculated according to Formula (2):

$$K = r_f + \beta_i (r_m - r_f) \quad (2)$$

Where:

K= cost of the company equity;

r_{m} = market rate of return (IBOVESPA);

r_f = risk-free rate (SELIC - Special System of Clearance and Custody);

β_i = sensitivity of the expected excess asset returns to the expected excess market returns

The variables r_m (25.08% p.a), r_f (15.06 % p.a), β_i (0.67) and the monthly values of the company's preferential shares were calculated with the ECONOMÁTICA and EXCEL software packages. A period window of sixty months was chosen for the calculation (October 2003 to September 2008) to avoid excessive valuations and depreciation. The value of the annual cost of capital of the company is 21.8%.

After, the net present value of the following investments was calculated and the total investment identified. Based on the option value of subsequent investments compared to net present values, the best was selected. The equation of Black-Scholes was used o calculate the values of options of the projects (Formula 3):

$$C_0 = S_0 N(d_1) - Xe^{-r_f T} N(d_2) \qquad (3)$$

Where,

$$d_1 = \frac{\ln(S/X) + r_f T}{\sigma\sqrt{T}} + \frac{1}{2}\sigma\sqrt{T}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

C_0 = value of the option;

S_0 = current market price;

$N(d_1)$ = standard normal cumulative distribution function of the variable d_1;

N(d2) = standard normal cumulative distribution function of the variable d_2;

X = initial investment;

T = time of the investment.

r_f = risk-free rate of return;

e = base of the natural logarithms;

σ = uncertainty about the cash flow or volatility.

The values used in the formula are the NPV for the price of assets in cash, the initial investment in the respective dimension, the period of the investment in years, the annual average SELIC and the risk-free rate of return and uncertainty about the cash flow or volatility.

A further analysis was made to measure the impact of volatility using decision trees with randomly generated probabilities using Excel software. The odds were 50% to increase investment and 50% to reduce it. A normal distribution was considered with 300 cases, following the central limit theorem which indicates a normal approximation of the sample by a large number of observations.

DATA ANALYSIS

The analyzed petrochemical company is ranked among the top 100 business groups in Brazil, among the 100 largest publicly traded companies in the country and among the 25 largest in the Southern Region (Revista Exame, 2008). The company invests heavily in IT, with annual expenditures over the past three years, of over nine million *reais* and an IT budget of 0.6% to 1% of its revenues (Computerworld, 2008).

The documents presented were: a list of all the systems used in business, with their functions, data on spending and investment in the year 2008 and cash flows of different investments that were classified according to the ITPM dimensions.

The aim in using these dimensions in combination with Real Options Theory aims is to analyze the risk and return on different IT investments and provide a tool to help IT managers make better decisions. The investments in the ITPM dimensions were analyzed according to Panayi and Trigeorgis (1998) and Copeland et al (2002).

The company provided the cash flows from different investments in the transactional and strategic dimensions. According to information from the CIOs, there was no investment in infrastructure and the investment in the informational dimension was based on subjective and qualitative analyses.

The NPVs of each investment was prepared based on the cash flows. First, the investments to be made in the transactional dimension were stipulated in order to then have the option to invest in the systems considered strategic for the company. This approach was based on reports in the literature (Weill and Broadbent, 1998; Weill and Aral, 2006) as well as on the opinion expressed by the respondents that the transactional dimension must be consolidated prior to investing in systems for strategic purposes. It is noteworthy that the investments chosen do not prejudice or affect the performance of the others, the analytical focus being the decision to continue investing or change the IT investments in the light of the risk and return of each.

Furthermore, it was predicted that the option to make subsequent investments would be made before ending the first investments. The investment options in the strategic dimension in the fourth year were analyzed, after investments in the transactional dimension, due to market opportunities, business needs or business strategies, such as increased sales and market positioning. The comparison values used were the NPVs of the five years and the values of options in the zero period. All the company's figures have been modified by multiplying a constant to prevent the publication of the organization's actual values.

The NPVs were calculated according to Formula 1, using the cost of the company equity. The volatility initially used was set at 20% due to the difficulty in measuring this variable as mentioned in section 3. This variable is used in the Black-Scholes equation (Formula 3) and sensitivity analyses of the options are presented in relation to the volatility to measure the impact on the managers' decision. In addition, different of volatility values were simulated for the IT investments to verify the changes that this variable may produce in future decisions on investment in technology. The options for each of the IT investments were calculated using the Black-Scholes equation.

To illustrate IT investment decisions based on the use of ROT combined with the ITPM technique, two simulations of different dimensions of investment in ITPM are presented. The risks of investment are illustrated by the volatility and the returns provided by the cash flow entries.

Simulation 1

Example 1 consists of a first investment in the transactional dimension and the option to invest in two strategic investments in the fourth year. The investments were:

Investment	Transactional 1	Strategic 1	Strategic 2
Description	System for managing the delivery date of products requested by the market	Improvement to the accounts receivable accounts payable processes through a customer–sales staff relations web site	Import, export, drawback, finance exchange rate, import exchange rate and export exchange rate processes
NPV (R$)	137,285.64	182,782.13	17,403.40

The NPVs indicate that Strategic 1 is the best investment choice, as it has a higher value than the others, and that investments in Transactional 1 should stop. From this analysis, the calculation was made of investment options to compare the results and provide greater flexibility to the decision maker. The variables used for the calculation of options Strategic 1 and Strategic 2 are shown in Table 1.

STRATEGIC 1			STRATEGIC 2	
Current market price	R$ 227,849.10		Current market price	R$ 234,161.26
Initial investment	R$ 345,000.00		Initial investment	R$ 525,000.00
Time	5.00		Time	5.00
Volatility	20.00%		Volatility	20.00%
Risk-free rate of return	15.06%		Risk-free rate of return	15.06%
d1	0.4437		d1	(0.4340)
d2	(0.0035)		d2	(0.8812)
N(d1)	67.14%		N(d1)	33.21%
N(d2)	49.86%		N(d2)	18.91%
Value of the option	**76,369.82**		**Value of the option**	**36,340.23**

Table 1 - Calculation of the options in Simulation 1

It can be seen that the initial decision to make the investment in Strategic 1 is not confirmed by the calculation of the options, which indicates rejection of strategic investments and continued investment in Transaction 1 (137,285.64 > 76,369.82> 36,340.23). The illustration of the analysis is presented in Figure 2.

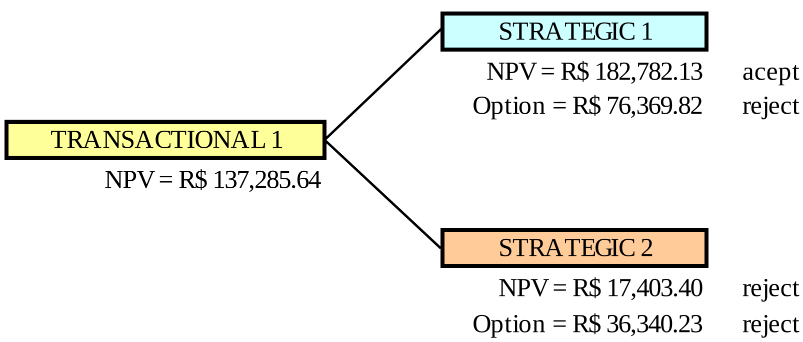

Figure 2 – Analysis of the options in Simulation 1

Sensitivity analysis was carried out with different values for the volatility of the investment to verify the behavior of the options. This analysis was performed with the values of the options of Strategic 1 and 2 with different volatility values, while the other variables remained unchanged. With the increased volatility in Strategic 1, the option to make such investments would become attractive with volatility higher than 63.94%, while, Strategic 2 would become attractive only with 75.3% volatility. The two cases can be seen to be unfeasible, because the level of volatility that makes them acceptable as options is very high.

Analysis of the IT investments was also carried out to illustrate the effect of volatility over the years and show the importance of this variable. It was found that the higher the volatility, the greater the impact on investment over the years and, consequently, the greater the risk. An analysis of 300 cases was made and the best and worst of cases involving Strategic 1 and Strategic 2 after 5 years are shown (Table 2) with volatilities of 20, 30 and 50%.

	Strategic 1			**Strategic 2**		
Investment (R$)	345,000			525,000		
Volatility	20%	30%	50%	20%	30%	50%
Lowest value (R$)	105,175	57,545	23,895	164,938	96,400	10,478
Higher value (R$)	1,154,096	2,049,711	5,265,009	1,832,314	3,185,550	14,834,126

Table 2 - Effect of volatility on Simulation 1

In the Simulation 1, using only the NPV values, it is indicated to accept Strategic 1 investment instead of Transactional 1 and reject Strategic 2, because Strategic 1 have higher NPV value than the others. However, using ROT, it is perceived that the two alternatives of investment (Strategic 1 and Strategic 2) have lower option value than NPV. Thus, analysis of Simulation 1 suggests that the original investment made in the transactional dimension should be retained and the options to invest in the strategic dimension rejected.

With the sensitivity analysis, the possibility of accepting the strategic options of both Strategic 1 and Strategic 2 was identified, but with a very high value of the investment risk. This risk was expressed by the impact analysis that volatility in investment leads to over the period analyzed, for example, volatility of 50% may result in a loss of fifty times the value invested, constituting an increased risk greater than the chance of return (twenty-eight times the initial investment). Thus, it was found that increased volatility increases the risk and return on the investments over the projected five years and that it should be carefully analyzed at the time of making the calculation of the option and the choice from among different investments.

Simulation 2

The second simulation consists of a first investment in the transactional dimension and the option to invest in two strategic investments in the fourth year. The investments were:

Investment	Transactional 2	Strategic 1	Strategic 3
Description	System to analyze blocked sales orders	Improvement to the accounts receivable accounts payable processes through a customer–sales staff relations web site	e-procurement site for relations with suppliers
NPV (R$)	282,004.30	182,782.13	1,009,529.81

Traditional calculations of NPVs of each of the investments point to the choice of Strategic 3, as it has a higher value than others. Based on this analysis, the calculation of options was performed to invest in each of the systems considered strategic and compare them with Transaction 2. The variables used for the calculation of the options of Strategic 3 and Strategic 1 are shown in Table 3.

STRATEGIC 3			STRATEGIC 1	
Current market price	R$ 504,049.47		Current market price	R$ 227,849.10
Initial investment	R$ 196,000.00		Initial investment	R$ 345,000.00
Time	5.00		Time	5.00
Volatility	20.00%		Volatility	20.00%
Risk-free rate of return	15.06%		Risk-free rate of return	15.06%
d1	3.4834		d1	0.4437
d2	3.0362		d2	(0.0035)
N(d1)	99.97%		N(d1)	67.14%
N(d2)	99.88%		N(d2)	49.86%
Value of the option	**411,744.59**		**Value of the option**	**76,369.82**

Table 3 - Calculation of the options in Simulation 2

It can be seen that the investment in the Strategic 1 is rejected, both using the traditional NPV and with the use of options (76.369,82 <282,004,30). However, the analysis points to the choice of Strategic 3 as an opportunity for the organization to invest, and confirmed by using ROT, where the option value is higher than the NPV of Transaction 2 (411,744.59> 282,004.30). The illustration of the analysis is presented in Figure 3.

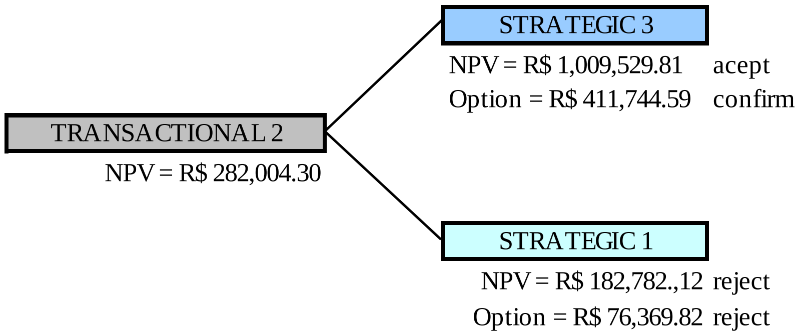

Figure 3 – Analysis of the options in Simulation 2

Sensitivity analysis was carried out with different values for the volatility of the investment to verify the behavior of the options. It was noticed that a decline in the volatility reduces the value of the option of strategic 3, showing little sensitivity and, as from 15.6%, the option value remains unchanged, resulting in no change to the decision to accept this option. Moreover, the rejection of Strategic 1 is maintained, because even with a sharp increase in volatility, the value of the option remains attractive.

Analysis on/of the IT investments was also carried out to illustrate the effect of volatility over the years and show the importance of this variable. It was found that the higher the volatility, the greater the impact on investment over the years and, consequently, the greater the risk. An analysis of 300 cases was made and the best and worst of cases involving Strategic 1 and Strategic 3 after 5 years are shown (Table 4) with volatilities of 20, 30 and 50%.

	Strategic 1			**Strategic 3**		
Investment (R$)	345,000			196,000		
Volatility	20%	30%	50%	20%	30%	50%
Lowest value (R$)	105,175	57,545	23,895	69,818	29,067	4,216
Higher value (R$)	1,154,096	2,049,711	5,265,009	694,433	1,511,812	3,652,276

Table 4 - Effect of volatility on Simulation 2

In the Simulation 2, using the NPV values, it is indicated to accept Strategic 3 investment instead of Transactional 2 and reject Strategic 1, because Strategic 3 has higher NPV value than the others. Moreover, using ROT, it is perceived that alternative investment Strategic 2 has lower NPV value than Transactional 2 and the Strategic 3 option value confirms the choice in this investment. Thus, analysis of Simulation 2 suggests that investment in the Strategic 3 should be prioritized over the continuation of Transactional 2, because the value of the option is advantageous.

The sensitivity analysis did not indicate any change in the decision to invest in Strategic 3. Moreover, it can be noted that the increase in volatility leads to an increase in the value of the option, but the limit being the net present value of investment used for the calculation of the real options. The results of the impact of volatility in investment over the years in simulation 2 corroborate simulation 1 and point to a sharp increase in the risk and return, when the value of volatility rises, with the extreme volatility of 50%, the risk of decreasing investment forty-six times and the chance of increasing eighteen times and half the investment. Therefore, IT managers should consider the risks involved in investments before making the calculation of the value of the options in the different ITPM dimensions.

CONCLUSION

ROT was selected as a financial technique to be combined with the ITPM dimensions due to certain characteristics: flexibility in decisions over time, ease of comparison between investments (in the case of this study, they were the different ITPM dimensions), scope of the return of cash flows and risk measured by volatility (PEREIRA and PAMPLONA, 2006).

Thus, two simulations were performed with investment of transactional and strategic dimensions, where a traditional technique (NPV) and the comparison with a new technique (TOR) were presented, highlighting two possibilities: one about the rejection option and the other about acceptance option to invest in strategic dimension. From the simulations and results of the research, through the use of ROT in the company, combined with the transactional and strategic dimensions, it was possible to draw some conclusions:

(a) The combination of real options on the ITPM dimensions provides a tool for IT managers to better justify investments because it enables a longitudinal analysis over the years and the possibility of changing the company's strategies in the face of market opportunities, increasing the flexibility of the decisions in relation to risk (Benaroch et al, 2006).

(b) Increased volatility accentuates the risk (or uncertainty) and the return on investment in the dimensions over time.

(c) The option value is largely insensitive to the value of volatility, it can be noted that in Simulation 1, that an increase of 219.7% in the volatility of the Strategic 1 represents an increase of 81% in value of the option, while in 2 Strategic an increase of 276% in volatility increased the value of the option 278%, indicating a greater sensitivity of the latter. In Simulation 2, it can be noted that the values of the options were not very sensitive to increases and decreases in volatility: Strategic 3, a decrease of 22% in the volatility does not significantly alter the value of the option, while in Strategic 1, an increase of 2705% in volatility only increased 198%.

Moreover, the use of ITPM together with ROT has been accepted by the CIO of the company where the technique was applied with the dimensions, and was recommended as a form of aid for IT managers involved with planning IT investments in the organization and to compare different types of long-term investment and choose the most appropriate for the company's strategies in the face of uncertainty. This is also in agreement with Brasil *et al* (2007), who points out that the use of ROT is interesting when there is evident managerial flexibility in a highly uncertain situation. In addition, the technique ITPM is also used to justify investments, especially when it examined the risks and returns in the case with the use of ROT to assist managers in their choices about different investments and resources in enterprises.

The limitations of this research include: (1) the lack of data on investments in other dimensions, and (2) though the use of qualitative aspects is recommended in ROT, these aspects were not taken into consideration due to the complexity and time required to perform this type of analysis. Therefore, future research should look into the qualitative aspects of the investment by using the ROT combined with the ITPM dimensions through analysis of investments in different dimension together with the company’s CIO (s).

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