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Methodology for the Construction of the Efficient Border For Selecting Investment Projects: A Multi-Index Approach

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ABSTRACT: *Given the perceived need of firms to identify the risks that may jeopardize the return of investment projects and the methods and tools to aid decision making, acceptance, rejection and ranking of these projects, this article presents the methodology for the construction of efficient frontier investment projects Will identify projects of the best risk-return ratio, ie projects with the best returns for the same level of risk or projects with the lowest risk degree for the same return, the portfolio of projects best for the firm. It established an applied research; Descriptive and purposeful in relation to their goals; Multicase as to approach the problem;Documentary and cross-section as the technical procedures of data collection and quantitative procedures. From the universe consists of 110 investment projects that used the Multi - Index Methodology in his assessment and that were presented the partial requirement for completion of the Undergraduate Program in Business Administration from the Catholic University of Paraná in the years 2009, 2010, 2011 and 2012 , A sample of 29 projects that had the minimum requirements, selected by convenience was used. For data analysis, we resorted to the Multicriteria Analysis to be more suitable for dealing with small samples.*

The operation was performed by the software called Walker to reveal additional and innovative features compared to traditional Promethe method, such as the Gaia Space Walk and 3D feature, allowing Monte Carlo simulation to evaluate the sensitivity of the classification of projects due to small variations Introduced in the windows of risk and return associated with them. Methodology proposed in the return is represented by two dimensions (monetary and non-monetary) while the risk is represented by five dimensions (financial risk, operational risk, environmental risk, risk management and business risk). Each dimension is characterized by a set of indicators aligned with the central feature dimension. The proposed methodology, in conjunction with the Walker software, resulted in the creation of the risk-return efficient frontier, facilitating greatly in the decision making process

Keywords: *Investment Projects. Methodology Multi-Index. Efficient Frontier.*

I. INTRODUCTION

The dynamics in the business environment have implied, in investment decision-making processes, the need to visualize the company as a whole, highlighting its strategies of competitiveness, continuity and future growth. According to Penrose (2006), this is based on the observation that capital investment decisions are determined by the opportunities to increase profit and maximize wealth, that is, to invest in projects with long-term profitability expectations , Equal to or greater than current profitability. These capital investment decisions, according to Souza and Clemente (2008), typically belong to the strategic level in which, the objective is to maximize return on invested capital for the same risk perception. The concern in most strategic decisions is the uncertainty about the expected results.

Uncertainties or risks are part of the strategy selection process, because even if you are aware of possible risks, you cannot predict when, how and to what extent they will occur. For Souza and Clemente (2008), decisions should be based, as far as possible, on scenarios and their relevant implications, without, however, claiming that uncertainties and risks will be totally eliminated. Penrose (2006, p.25) also advocates that "some information guide on expectations should be sought to reduce the degree of uncertainty."

In another context, Assaf Neto (2003) points out that in practice financial investment decisions are made in an environment of total uncertainty regarding their results, and because these decisions are fundamentally forward-looking, it is imperative to introduce the variable uncertainty As one of the most significant aspects of the study of investment project analysis.

In view of the perceived and growing need of firms to better understand the risks that may jeopardize the return of investment projects, more recently, Souza and Clemente (2008) developed the Multi-Index Methodology to support the decision-making process in accepting or rejecting projects Which assesses the risk in a multidimensional way, which considers that the decision maker is better supported by a set of indicators than by a single indicator. Although it has rescued the need to discuss risk in the evaluation of investment projects, the Methodology has also not been effective when applied in the situation that the company or agent needs to choose investment projects among the various viable alternatives, forming a project portfolio that respects Its limitations or scarcity of resources and guarantee greater return with less risk, thus raising the problem of selecting the best investment options in a context of uncertain scenarios, limited resources and limited rationality.

Given the "N" set of investment projects in which both return and risk have multidimensional characteristics, how can we select a subset of investment projects that show the best projects for each level of perceived risk?

Thus, assuming, according to Souza and Clemente (2008) that the investment decisions are an integral part of the strategic process, this article presents a methodology for the construction of an efficient frontier, that allows to improve the process of selection of projects of when investment returns and risks are characterized by multiple dimensions, supported in Multi-Index methodology for project analysis and *software* for *Walker* Multicriteria analysis.

By identifying groups of feasible indicators that best represent the dimensions of return and risk, the study presents a better portfolio of investment projects considering that these alternatives tend to present a minimum level of risk for a given level of return, thus composing A balanced portfolio of risk and return (efficient frontier) for the alternatives of investment projects, which served to establish the efficient frontier.

II. THEORETICAL FOUNDATION

2.1 Theory Of Growth Of Signature

Strategic decisions have always been at the heart of capitalist dynamics, as is its ability to generate and accumulate profits, which ensures the creation of value, as discussed by Penrose (1959) in the theory of the firm 's growth. For this author, the main reason for the growth of firms can be explained from the fact that investment decisions are determined by opportunities to increase profit, that is, for a long-term return expectations.

In the search for business strategies that aim at new levels of profitability, it is increasingly required a better understanding of the scenarios that identify the risks and uncertainties associated with them. Penrose (2006) already pointed out that the fact that the future can not be accurately known means that business planning is based on expectations about the future, which are handled with varying degrees of confidence and that such expectations are in themselves essentially Estimates on several possible future outcomes of one of the action or a series of actions.

Yet, for this author, in appraisals of investment projects, it is generally assumed that entrepreneurs simply make adjustments to their cost and revenue calculations from deliberate use, referring to risks or uncertainties as estimates of minors Demands or higher costs. Thus, investment decisions are being made in increasing risk and uncertainty environments, implying the need to improve project evaluation methodologies.

With the global economic scenario and the current conditions of competitiveness, companies increasingly aim to generate profits and accumulate them, in a generic approach to value creation and growth, it can be said that the creation of value for the company Result of a set of simultaneous and stepped-up investment decisions. Investment decisions aimed at wealth creation are complex in nature and can be considered as strategic decisions in the search for competitive advantage.

Chandler (1998) points out that strategic decisions aim at distributing, in the long term, existing resources and developing new and essential resources as a way of ensuring the continued health and future growth of the enterprise, in which the nature of investments in these Resources will determine the direction and growth of the firm.

2.2 Decision-Making Processes In The Evaluation Of Investment, Risk And Return Projects

In this decision-making process involving questions of identification and viability of opportunities, through the selection of investment projects, the increase of profit in a long-term return expectation refers to the creation of wealth, that is, to increase the value of the company involving the identification, Evaluation and selection of resource application alternatives.

According to Souza & Clemente (2008); Assaf Neto (2003) and Gitman (2004), financial decisions, especially those related to investments, are focused on the growth of the firm via wealth maximization, where the firm's value depends on its expected performance in function of the selected strategies.

These investment decisions are made in the expectation of future economic benefits and as they are not certain of the future realization of profits, it involves risk and must be evaluated in terms of the risk-return relationship, prior to it, based on carefully analyzed information. Amorim, Lima and Murcia (2012) describe that one of the crucial points in asset valuation, in this case investment projects, is to know the level of risk to which this asset is subject.

Because these investment decisions compromise a company's resources for the long term and often the group of investor managers does not have the same reading about these expected returns and the degree of risk involved, distinct valuations of an investment opportunity occur, which justifies The improvement of evaluation methodologies.

According to Souza and Clemente (2008), investment decisions can either consolidate an expansion path, when timely and timely, or jeopardize the company's own survival, thus indicating that such decisions are guided, whenever possible, by the greatest number Of information relevant to the scenarios that are identified, adopting a proactive behavior in relation to risks.

Since the decision to invest is baptized in the *a priori* analysis of the risk-return ratio, the search for improvement in the risk perception is required. Penrose (2006, p. 107) justifies this improvement when he questions whether passive acceptance of risk and uncertainty is the only possible business response. These investment project decisions, considered strategic in pursuit of competitive advantage, even when based on forecasts and calculation of all relevant implications, are subject to errors of estimates and unexpected events that may affect the expected results.

In the selection of investment projects, Securato (1993), Gitman (1997), Assaf Neto (2003) and Groppelli and Nikbakht (2005), among others, mention the risk in a generic way, Possibility of loss, interpreted by the level of uncertainty associated with an event.

Souza and Clemente (2008) point out that when generic risk is mentioned, one is actually using less precise language because one is not distinguishing between two significantly different situations:

a. risk situation, where possible events and their probabilities of occurrence are known;

b. Situation of uncertainty, in which it is not known what the possible events are or if events are known, but their probabilities of occurrence are not known.

The expressions Risk and Uncertainty can be differentiated as risk when the variables are subject to a known probability distribution. It is an uncertainty that can be measured, while uncertainty is when the probability distribution can not be assessed; Involves situations of non-repetitive occurrence, is a risk that can not be evaluated.

Groppelli and Nikbakht (2005) point out that risk and return are the basis on which rational and intelligent investment decisions are made, therefore, the ability to measure these variables may be the competitive differential of a firm.

Regardless of the context, the two dimensions risk and return, are present in investment decisions. Thus, to support the decision-making process in investment projects, some methods or criteria, from economic engineering, have been applied.

2.3 Methods Of Evaluation Of Investment Projects

The evaluation of investment projects commonly involves a set of techniques that seek to determine their economic and financial viability, considering the opportunity cost, from several approaches. According to Nogas, Souza e Silva (2011, p.45), "the so-called methods of investment analysis can be classified into three broad strands: Classic Method, Real Choice Theory and Multi-Index Methodology."

The so-called classical method originates in economic engineering and has its origins in publications under the name of capital budget or capital application theory.

Nogas, Souza e Silva (2011) emphasize that the main feature of the classic method is to express the risk as a *spread* in the discount rate of cash flow. Thus the discount rate called hurdle rate (TMA) is made up of almost risk - free rate plus a risk premium expressed as a *spread* that attaches under the TMA. The analysis metrics invariably focus on the Net Present Value (NPV) and the Internal Rate of Return (IRR). In this approach if NPV> 0, then TIR> TMA, and the investment project is considered financially viable.

According to Dixit and Pindyck (1994), Copeland (2003) and Nogas, Souza and Silva (2011), the Real Options Theory (TOR) is a more concrete approach to reality, since it A measure that presents the capacity to measure the value of the managerial flexibilities existing in the business and the growth opportunities in the whole process. Based on methods applied in the financial market for the analysis of equity investments, the Real

Options method is an amplified approach to NPV in the valuation of real assets, considering that, in the option to invest, it must be taken into account that the investment can be A cost (partially or totally) irreversible.

Within the objective of subsidizing the decision-making process regarding the acceptance and rejection of investment projects, Souza and Clemente (2008) developed the Multi-Index Methodology, in which both return and risk are addressed in a multidimensional manner. This methodology is characterized by the deepening of the discussion of the risk assessment and its confrontation with the expectation of return and by the use of several indicators grouped in sets that result in more consistent information than the isolated use of any of them or of a subset of them. These indicators are divided into two groups: the first is used to evaluate the perception of return and the second to improve the perception of risk.

Although the Multi-Index Methodology developed by the authors results in more consistent information to support the decision-making process based on the use of these various indicators and allows for a multidimensional risk analysis, it is still limited in the acceptance or rejection of a certain investment project, not presenting When you have several alternatives and you expect to select a subset of them.

Based on this approach, Souza and Clemente (2008) developed the Multi-Index Methodology to support the decision-making process in the acceptance or rejection of a certain investment project, using discounted cash flow and context analysis, using two groups Of indicators.

The first set, formed by VP (Present Value); NPV (Net Present Value); VPLA (Annualized Net Present Value); IBC (Benefit / Cost Index) and ROIA (Additional Return on Investment), is used to improve the perception of return.

The second set, formed by TMA / TIR (Minimum Attractiveness Rate / Internal Rate of Return); *Payback* / N (Payback Period / Horizon Periods Project); Degree of Commitment to Revenue (GCR); Risk Management and Business Risk, aims to improve the perception of project risk. When comparing the perceptions of return and risk, in the Multi-Index Methodology, the indicators are interpreted from new approaches.

Nogas, Souza and Silva (2011) emphasize that the Multi-Index methodology differs from other methodologies because it does not use the concept of risk premium and defends the idea that risk is multidimensional and therefore must be analyzed by a set of indices , Thus forcing the decision maker to a confrontation between the perceptions of return and risk.

2.4 Analysis And Software Multicriteria Walker

Multicriteria approaches are applicable to investment projects and are forms of modeling decision processes, in which they are present: a decision to be taken, unknown events that may affect results, possible courses of action, and the Results.

Gomes, Araya, and Carignamo (2004) point out that the essence of the method is based on a differentiated approach to problems and starts acting in the form of decision support, involving not only a multidimensional representation of problems, but also incorporating a series of Well defined characteristics in relation to its methodology.

The Walk methodology consists in the application of PROMETHEE as an innovative proposal of decision support methodology based on multicriteria analysis methods in conjunction with probabilistic and Monte Carlo simulation methods called Walker.

According to Frega (2010, p.6) one of the characteristics of the WALK methodology is the possibility of observing the decision problem in a space of three-dimensional configuration alternatives, by means of its projection in a Gaia Space representation (3D). Contribute to the multidimensional perception of risk.

THE application of Walker also allows the generation of a Perceptual Map, whose main function, according to Lemos (2010, p.154), "is to enable the variation of the weights assigned to the criteria in the *Software* WALK [ER], which shows indicators considered more or Less important, making it possible to verify the sensitivity of the indicators ".Lemos (2010) also emphasizes that, in cases of pseudo-balance between dimensions, this function does not need to be used.

In its graphical presentation of the Perceptual Map of Sensitivity Analysis, with blue background, as an alternative occupies a space, it has a yellow color, and in each cell (square) is recorded the number of times each Alternatively occupies each classification according Frega (2010 *apud* Lemos 2010).

The analysis of the behavior of the variables can be observed from the qualitative analysis of the graphic representation of Gaia Space (3D), visualized in the communal, idiosyncratic and intermediate patterns.

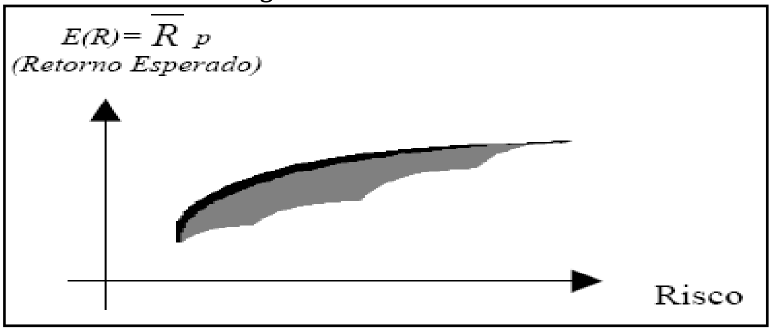
2.5 Efficient Border Risk And Return In Investment

In his theory, Markowitz (1952) pointed out that to be considered efficient, he should have the highest return for a certain level of risk, or the lowest level of risk for a given rate of return, reporting efficient border formation. This author (1952) also points out that the efficient frontier can be defined as the best possible set of portfolios within the risk-return relationship, that is, for each level of risk the investor obtains the highest return, in which it is demonstrated graphically by the superior Of the edge formed by the whole set of combinations of wallets.

Thus, the efficient frontier can be described as the best possible set of portfolios, that is, all portfolios have the minimum risk for a given level of return. Investors would focus on selecting a better portfolio at the efficient frontier and would ignore the others considered inferior, in which the purpose of applying portfolio optimization models is to provide more risk-return relationships that are more advantageous to the investor.

According to the Efficient Frontier analysis (Figure 1), for portfolios located below the curve, there will always be another portfolio that presents a higher return to the same level of risk.

Figure 1- Efficient Frontier



Source: Markowitz (1952)

Although Markowitz used a historical series of assets to determine the covariance structures that allowed the investigation of portfolio risks in efficient border formation, the essence of the theory and its graphical representation, in which there is a limit in the graph between expected return And portfolio variance, representing the highest possible return for any risk rate, in which its profile would depend mainly on the correlation coefficient between the assets, forming an efficient boundary can be applied in the evaluation of investment projects when there are several alternatives .

III. Metodology

3.1 Proposed Conceptual Model

The proposed conceptual model for constructing the efficient risk and return frontier in investment projects consists of two sets of indicators presented in the Multi-Index methodology and the underlying hypothesis of the idea of Risk being multidimensional.

The first set related to the perception of the return is composed by the net present value (NPV), the annual net present value (NAV), the Profit / cost index (IBC) and the Additional Investment Return (ROIA). The second set on the perception of risk, comprises the index TMA / TIR Index *payback* / N, Degree of revenue commitment, Management Risk and Business Risk, all measured on a scale from zero (risk of Absence) a (Maximum risk).

Following the return dimension was divided into monetary return and non-monetary return, As can be seen in Table 1.

Frame 1- Sub-categories and indicators of the Return Dimension

Retorno	Indicadores
Monetário	1. VPL – Valor presente líquido
	2. VPLa – Valor presente líquido anualizado
	3. ROIA – Retorno adicional sobre o investimento
	4. Lucro líquido total em relação à receita total (todo o projeto)
	5. Lucro líquido total em relação ao investimento total
Não monetário	1. Total de postos de trabalhos ou número de empregos gerados
	2. Total da folha de pagamento em relação ao número de empregos gerados
	3. Total da folha de pagamento em relação ao valor do ativo operacional
	4. Total dos impostos e contribuições gerados

Source: Prepared by the author (2013)

In the generation of new perceptions of risk, from the Multi-Index methodology, five risk dimensions were characterized: financial, operational, environmental, management and business , As can be seen in Table 2.

Frame 2 - Subcategories and indicators of the Risk Dimension

<table>
<tr><th>Risco</th><th colspan="11">Indicadores</th></tr>
<tr><td rowspan="4">Financeiro</td><td colspan="11">1. TMA / TIR – taxa mínima de atratividade em relação à taxa interna de retorno</td></tr>
<tr><td colspan="11">2. Capital de terceiros em relação ao capital próprio</td></tr>
<tr><td colspan="11">3. PAY BACK N - Período de recuperação do investimento</td></tr>
<tr><td colspan="11">4. Total do capital de giro em relação ao investimento social</td></tr>
<tr><td rowspan="4">Operacional</td><td colspan="11">1. GCR - Grau de comprometimento da receita</td></tr>
<tr><td colspan="11">2. Grau de concentração em fornecedores de matéria-prima em unidades monetárias em relação ao valor total dos fornecedores</td></tr>
<tr><td colspan="11">3. Grau de influência do câmbio (dólar) no custo da matéria-prima</td></tr>
<tr><td colspan="11">4. Grau de influência do câmbio (dólar) no custo preço de venda prima, na escala 0 para nula e 1 para máxima influência,</td></tr>
<tr><td rowspan="5">Ambiental</td><td colspan="11">1. % de energia utilizada não renovável, em escala de 0 a 1</td></tr>
<tr><td colspan="11">2. % de água utilizada não renovável, em escala de 0 a 1</td></tr>
<tr><td colspan="11">3. Grau de impacto na utilização de jazida (recursos minerais) em escala de 0 a 1</td></tr>
<tr><td colspan="11">4. % de resíduos reciclados, em escala de 0 a 1</td></tr>
<tr><td colspan="11">5. Grau de efeito estufa, em escala de 0 a 1</td></tr>
<tr><td rowspan="5">Grupo Gestor</td><td colspan="11">1. Aspectos econômicos</td></tr>
<tr><td colspan="11">2. Indústria ou segmento</td></tr>
<tr><td colspan="11">3. Processo produtivo</td></tr>
<tr><td colspan="11">4. Negociação</td></tr>
<tr><td colspan="11">5.Estratégias de comercialização</td></tr>
<tr><td rowspan="2">Negócio</td><td colspan="4">PEST</td><td colspan="5">5 FORÇAS DE PORTER</td><td colspan="2">SWOT</td></tr>
<tr><td>Econômico</td><td>Sócio cultural</td><td>Tecnológico</td><td>Demográfico</td><td>Entrantes</td><td>Substitutos</td><td>Fornecedores</td><td>Clientes</td><td>Concorrentes</td><td>Pontos Fracos</td><td>Ameaças</td></tr>
</table>

Source: Prepared by the author (2013)

From the multi - criteria analysis and *software WALKER*, indicators of the monetary return size and non - monetary, have been reduced to a single number between 0 and 1 for the return dimension. The same procedure was applied to the indicators of the financial, operational, environmental, management and business risk dimension, reduced to a single number between 0 and 1 for the risk dimension, In order to enable the construction of the efficient risk and return frontier in investment projects in a multidimensional approach.

3.2 Research Design

The research design is related to the proposed theme and aims to identify the method to be used in this research that can be classified in various forms.

As to the nature, it is classified as applied, being the descriptive and propositive objective. As for the approach to it is characterized as lifting, whose technical procedures for data collection is documentary where data analysis is quantitative and the periodicities of the *Cross-sectional* data - cross.

Thus the universe of this research was constituted of the investment projects of the years 2009, 2010, 2011 and 2012 of the Pontifical Catholic University of Paraná, Center of Applied Social Sciences, works of conclusion of course presented to the Course of Graduation in Administration, composing a population Of 110 investment projects.

The sample of this work is characterized as an intentional non-probabilistic sample, also called convenience sample, since there is a deliberate choice of the population elements, being intentionally chosen a group of investment projects, that fulfilled the minimum requirements: belong to the segment industry; Estimated period of the project for at least 5 years; Estimated value to be invested in excess of R $ 280,000.00.

The industry segment was chosen due to the greater economic and financial coverage of the products traded, in relation to the limitation of trade activity or service rendering.The estimated period for the project of at least 5 years was chosen because it represents a period that can be considered in the medium-long term, being more subject to risks, because it does not allow abandonment or change of segment in the short term and recovery Of the invested capital, while the estimated value of R $ 280,000.00 refers to the value of an investment higher than the billing threshold of the micro-enterprise classification.

Initially, 35 projects were pre-selected. Six projects were excluded because they did not present data consistency or incomplete, in the data related to the lack of presentation of suppliers by raw material, energy consumption in the activity and other natural resources, which would the analysis.

In this way, 29 selected investment projects that met the minimum requirements, presented in Table 3, were analyzed.

Frame - List of selected projects in the sample

N humerus	INVESTMENT PROJECTS
1	Fabrica tion of concrete artifacts - blocks
2	Fabrica tion of accessories for adapting environments for disabled
3	Ind Austria underwear
4	Ind ústrias upholstery for trucks
5	Ind ústrias *jeans*
6	Ind Austria of metal structures for public housing
7	Power plant and res íduos solid
8	Cosmetic Ind Austria
9	Ind Austria pasta - pasta
10	Ind Austria residential paints
11	Ind Austria cakes and pies *diet*
12	Ind cosmetic and hygiene products Austria
13	Ind ústriade dietetic foods - pasta
14	Ind Austria of microbrewery
15	Ind Austria energy drink
16	Ind Austria rationalized plates for construction
17	Ind Austria ecological tiles
18	Ind Austria concrete blocks
19	Ind Austria kitchens
20	Ind Austria shirts
21	Publishing company
22	Ind Austria yarn
23	Ind Austria covers
24	Ind Austria special doors
25	Ind Austria upholstery
26	Ind Austria frozen food
27	Ind Austria of treadmill
28	Ind Austria paper macaws and cardboard
29	Ind Austria industrial belt

Source: Prepared by the author (2013)

3.3 Data Processing

For each of the seven dimensions, two return dimensions (monetary and non-monetary) and five dimensions of risk (financial, operational, environmental, business and management), the indicators addressed is attributed in Multi-Index methodology, plus the incorporation other proposed indicators.

From the classification and separation of the size and allocation of indicators, the scale need verification was carried out be maximized or minimized.

Next, to construct the validation we used the *Walker software* . At this stage, through Space Gaia 3D analyzes of aggregate indicators in the same *cluster* and geometric distances of the criteria pairwise if refined it initially conceived model. Finally classified projects, analyzes the sensitivity of this classification and assigned a *score* to each project in this dimension.

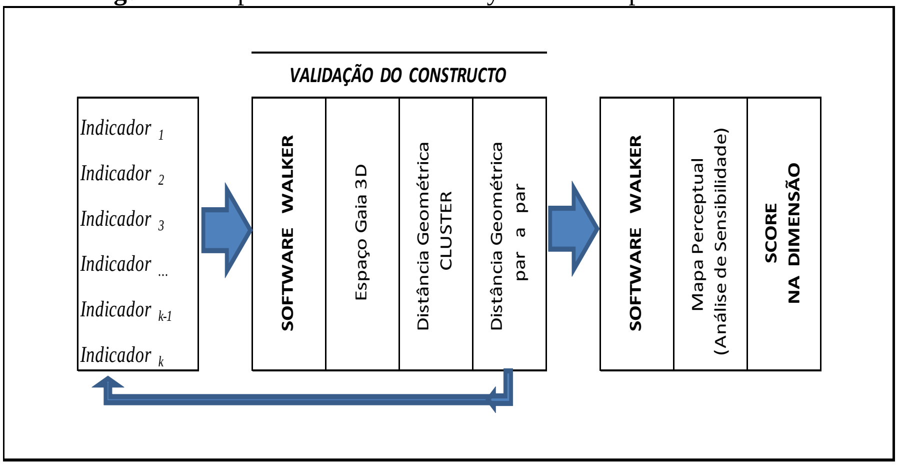
The characterization of the construct by means of the Gaia space (3D) in *Walker*, initiated by the sensitivity of the variance explained its three main components due to the exclusion criteria within a *cluster* that have very similar geometric distances. The exclusion of indicators was given in terms of what it actually is and their contribution to the total variance. Parallel to this was also used information from a *ranking* and the spatial arrangement of the projects under review. The best projects were characterized by larger circles and lighter colors (yellow). The worst classified projects were represented in smaller circles and in darker colors (blue). Finally we sought to identify the common standard, idiosyncratic and intermediate.

Validated the construct was passed to the next stage of analysis of the sensitivity of the classification obtained in the face of variations of ± 20% in the input parameters (the indicator values). For this we used the Perceptual Map *Walker software*. The purpose of this analysis was to determine whether the projects rated were robust and not lose position in the face of these changes. Once accepted classification, it produced a *score* that was used to classify the projects that best met all the criteria representative of the size in question.

Mutatis mutandis, the same procedure was applied to all dimensions of the model until you reach a *score* (extracted from the text file *Walkstats* generated by *Walker software*) to return size and *score* for risk dimension.

The confrontation of these two *scores*, project by project, then results the efficient frontier of the proposed model. Figure 2, below, illustrates this situation.

Figure 2 - Representation of the analysis and interpretation of data



Source: Prepared by the author (2013)

IV. METHODOLOGY FOR RISK EFFICIENT FRONTIER OF CONSTRUCTION AND RETURN ON INVESTMENT PROJECTS

The construction of the efficient frontier of risk and return on investment projects was carried out from the projection of *scores* between 0 and 1of each alternative (projects) in the return size and risk, calculated by applying the *Walker* as described above.

The following are the *scores* of each alternative (projects) in the return size and risk, validation of the construct and modeling.

4.1 Presentation of Data

Construction of Efficient Frontier Risk and Return, were raised the *scores* obtained on the scale return and risk. Table 1 presents *the scores* of each alternative (projects) in these dimensions.

Table 1 - *Scores* of each alternative (project) the scale return and risk

Projetos de investimentos (Indústrias)	Score Dimensão retorno	classificação na dimensão retorno	Score Dimensão risco	classificação na dimensão retorno
1	0,837	27º	0,400	11º
2	0,761	24º	0,780	25º
3	0,433	12º	**0,022**	**2º**
4	0,194	7º	0,379	10º
5	0,538	14º	0,308	9º
6	0,805	25º	1,000	29º
7	0,549	16º	0,226	6º
8	0,625	19º	0,803	26º
9	1,000	29º	**0,175**	**4º**
10	0,237	8º	0,778	24º
11	0,320	9º	0,414	12º
12	**0,155**	**3º**	0,419	13º
13	0,724	22º	**0,000**	**1º**
14	0,434	13º	0,996	28º
15	0,725	23º	0,548	17º
16	0,855	28º	0,432	14º
17	0,716	21º	0,764	22º
18	0,368	10º	0,481	15º
19	0,653	20º	0,633	20º
20	0,589	18º	**0,203**	**5º**
21	**0,184**	**5º**	0,290	8º
22	**0,000**	**1º**	0,487	16º
23	0,547	15º	0,627	19º
24	0,578	17º	0,764	23º
25	0,383	11º	0,672	21º
26	**0,020**	**2º**	**0,125**	**3º**
27	**0,176**	**4º**	0,624	18º
28	0,190	6º	0,245	7º
29	0,817	26º	0,937	27º

Source: Prepared by the author (2013).

4.2 Construct Validation and Modeling

To validate the construct and construction of efficient risk border and return on investment projects was implemented *in software Walker* a new routine, in order to demonstrate the straight behavior or curve, according to the behavior of the return variable (Y) with the risk variable (X).

In this routine, the *scores* risk dimension appear on the horizontal axis and the *scores* of the return scale on the vertical axis. Each alternative (projects) investment appears as the graphical point defined by the *scores* of both dimensions for that alternative (projects).

To the extent the higher the return value of the *score* best position of the design (alternative), while for the risk dimension smaller the value of the *score* best position of the design (alternative).

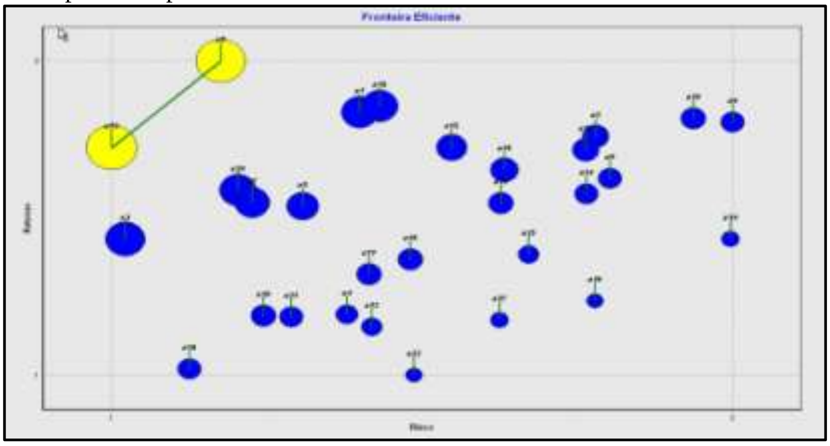
4.3 Graphical Representation (3D)

Dimensions return and risk are presented in a graphical representation (3D), which is on the horizontal axis (X) to determine the risk and the vertical axis (Y) the corresponding return.

From the relative X and Y shown in curved line, the efficient frontier is the limit and the area where the projects for a certain level of risk, to get the best possible return.

The results obtained in the graphical representation (3D) are shown in Figure 3.

Figure 3 - Graphical Representation Efficient Frontier Risk and Return on investment projects



Source: Adapted by the author (2013)

In the graphic representation (3D), projects (alternative) are represented by the letter "a" as shown in Table 2.

Table 2 - Projects (alternative) Dimension return and risk

	Projetos de investimentos (Indústrias)	
1	Blocos de Concreto	a1
2	Acessórios para adaptação de ambientes para deficientes	a2
3	Roupas íntimas	a3
4	Estofamentos para caminhões	a4
5	Calças *jeans*	a5
6	Estruturas metálicas para habitações populares	a6
7	Usina de energia e resíduos sólidos	a7
8	Cosméticos	a8
9	Massas – macarrão	a9
10	Tintas residenciais	a10
11	Bolos e tortas *diet*	a11
12	Cosméticos e produtos higiene	a12
13	Alimentos dietéticos - massas	a13
14	Microcervejaria	a14
15	Bebida energética	a15
16	Chapas racionalizadas para construção	a16
17	Telhas ecológicas	a17
18	Blocos de concretos	a18
19	Cozinhas	a19
20	Camisas	a20
21	Editora	a21
22	Fios	a22
23	Coberturas	a23
24	Portas especiais	a24
25	Estofados	a25
26	Alimentos congelados	a26
27	Esteira ergométrica	a27
28	Araras de papel e papelão	a28
29	Esteira industrial	a29

Source: Prepared by the author (2013).

The Graphical Representation (3D) of the routine implemented in *Walker* shows that the projects top-ranked 13 and 9 in larger and yellow circles define the upper limit of the efficient frontier, represented by industry investment projects pasta noodles (a13) and Industry of dietetic foods (a9).

Blue circles, but higher than the others, represent the portfolio of assets (projects) ranging in size due to the proximity of the border. Close to the upper limit, represented in these circles are the industry investment projects of underwear (a3), Industry shirts (a20), Production of concrete artifacts - blocks (a1), plant energy and solid waste (a7) industry plates rationalized construction (a16) and industry Pants *jeans* (a5).

The more distant from the border limits, smaller circles, demonstrating projects less attractive investment, in this case representing the wireless industry (a22), wake Industry ergometer (a27), Industry residential paints (a10) and Industry microbrewery (a14).

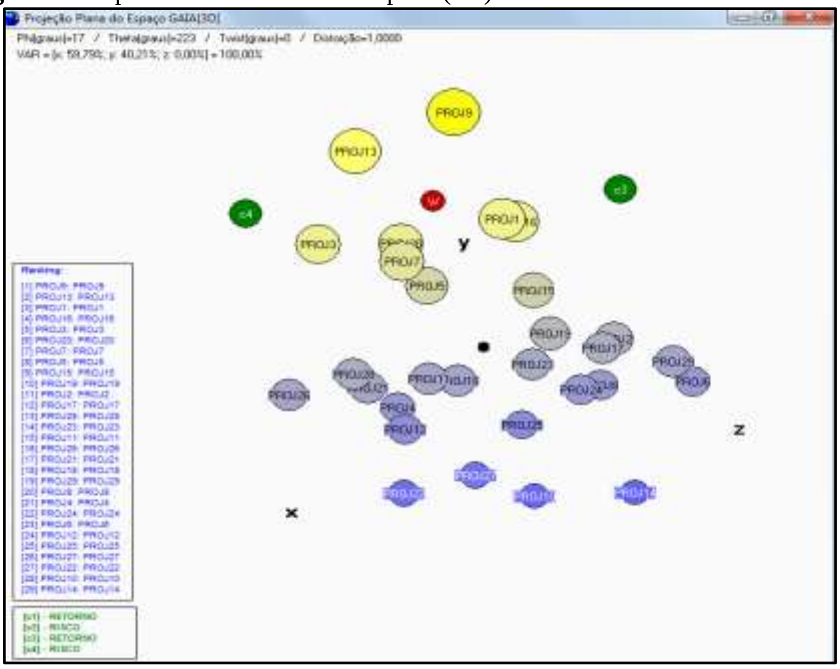
Thus, the application of the concept of the efficient frontier of risk and project ROI, allows you to select one or more investment that has, for a given return with the lowest possible risk, whereas the projects, however, the variation of required return does not have a linear relationship to the measure of risk, since there will always be the decision whether to continue the development of a project.

4.4 Representation of Gaia Space (3D)

Still, in addition to validating the construct of building the efficient frontier of risk and return on investment projects, it was inserted *in the software Walker* the *scores* of the dimensions of return and risk as shown in Table 1.

For better visualization of the efficient frontier of risk and return, aiming to confirm the construct of the methodology and Graphic Representation (3D) Efficient Frontier Risk and Return on investment projects, we used the rotation of space GAIA [*3D*]. The results obtained in Gaia area (3D) are provided in Figure 4.

Figure 4 - Representation of the Gaia space (3D) - Efficient Frontier Risk and Return



Source: Adapted by the author (2013)

The representation of the Gaia space (3D) in *Walker* demonstrates the projects rated 9:13 in larger circles and lighter colors, make up the upper limit of Efficient Frontier Risk and Return, similar Graphical Representation of Risk Efficient Frontier and Return on projects investment (Figure 3), whereas the designs 1, 16, 3, 20, 7 and 5 present in the coverage area thereof.

The *ranking* on the classification of alternatives (selected projects) in descending order of attractiveness shows the view of the top-ranked projects in the field of Efficient Frontier Risk and Return on investment projects.

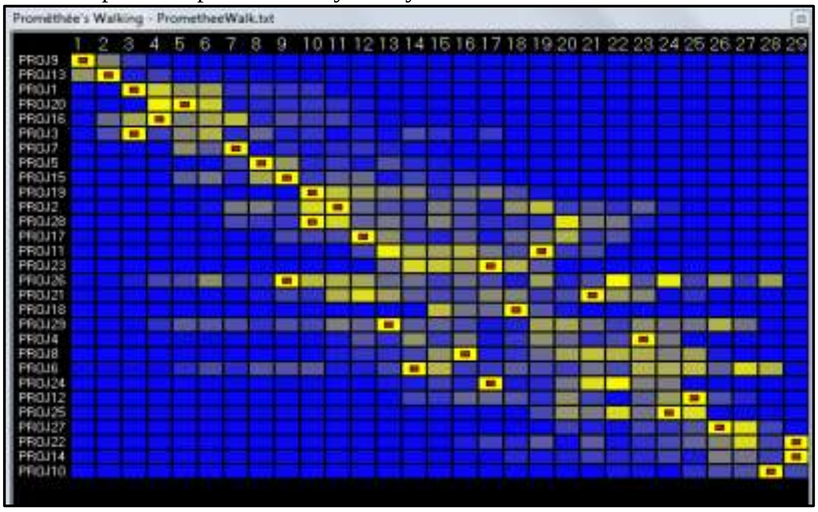
The explained variance of 100% and a significant accumulation of variance on the X axis (59.79%) shows a great consistency of indicators and *scores* as training a construct.

Qualitative analysis of the distribution of criteria (*scores*) in relation to the representation of Gaia Area (3D), we note that there is a common pattern, where projects (alternatives) are distributed almost along the x axis, establishing even an order of preferably well - defined, in which conflicts among alternatives are greatly minimized and preferences have become more apparent, thus confirming the construction methodology.

To validate the construct and modeling, they were not appreciated the presence of *clusters* and the pair geometric distances along because it is two antagonistic dimensions (risk and return).

The Perceptual Map, extracted from the *Walk* for the construction of Frontier Risk Return Efficient and demonstrates the sensitivity of the project to the variation of the values held by Monte Carlo simulation. Figure 5 shows the number of times each alternative (projects) is positioned in each classification.

Figure 5 - Perceptual Map - Sensitivity Analysis for the Efficient Frontier Risk and Return



Source: Adapted by the author (2013)

The projects rated (9, 13, 20, 16, 3, 20, 7, 5 and 15), as the intensity of their color (yellow) are robust with respect to variations (± 20%) in the input parameters and practically maintained their positions in the *ranking* . The worst ranked projects (10, 14, 22, 27, 25, 12, 24, 6, 8, 4, 29 and 18), although more sensitive confirmed status worst ranked. The other projects that are in an intermediate position, have high sensitivity to the values of the input parameters, but not enough to change their *status* .

Graphic statements demonstrate an order of preference rather clearer, conflicts between alternatives are greatly minimized and preferences are quite evident.

4.5 Validation Methodology Construction of Efficient Frontier Risk and Return

The Border Graphic Representation Efficient Risk and Return on investment projects (alternatives) shows that the upper limits are the best alternatives, represented by Industry pasta noodles (a13) and Industry of dietetic foods (a9), while the balanced portfolio risk and return understood as the efficient frontier, is composed by the alternative of industry investment projects of underwear (a3), Industry shirts (a20), Production of concrete artifacts - blocks (a1), plant energy and solid waste (a7), Industry plates rationalized construction (a16) and Industry Pants *jeans* (a5), with higher expected return to their level of risk).

Thus, these investment projects (alternatives) make up the best possible set of portfolios where the alternatives tend to have a minimum level of risk for a given level of return.

As for the alternative investment projects: Industry Industrial mat (a29), Cosmetics Industry (a8), Gaskets industry for trucks (a4), special doors Industry (a24), Industry metalware affordable housing (a6) Industry Cosmetics and hygiene products (a12), Industry Upholstery (a25), Mat Industry ergometer (a27), Wire (a22), Industry residential paints (a10) and Industry Microbrewery (a14), outside the area of efficient frontier correspond to the worst alternatives in relation to higher return and lower risk.

The validation of the methodology for the construction of efficient frontier of risk and return on investment projects can observe the application of the theory that the individual risk of an investment project (alternative) is not as important as the set of all investment projects a portfolio.

The validity of the methodology to build the efficient frontier of risk and return on investment projects is achieved, confirming that the risk of an investment project (alternative) kept out of a portfolio is different from your risk when included in the portfolio and the risk a portfolio depends on how its elements are related.

From the concept of efficient frontier (1952), it can be confirmed using the methodology presented for the construction of the efficient frontier of risk and return for investment projects, which you can define a better set of portfolios (projects) within the risk ratio return, ie, for each level of risk the investor gets the highest return, thus confirming that the efficient frontier is the best possible portfolios set (projects), where all portfolios (projects) have the minimum level of risk for a given level return, allowing investors to focus on the selection of a better portfolio on the efficient frontier and ignore the others considered inferior, optimizing portfolios, thus providing relationship between risk and return more advantageous for the investor.

The proposed methodology allows you to select a K <N subset of investment projects, in which both the return and the risk have multidimensional characteristics, highlighting the best projects for each level of perceived risk.

V. CONCLUSIONS

From the review of the concepts of classical methodology of evaluation of investment projects and the theory of real options (TOR), it was found that they did not sufficiently address the multidimensionality of the problem of return risk perception, making it difficult to decision-making process, especially when addressing a situation that the decision maker (individual or group) have to select investment projects in both the return and the risk have multidimensional characteristics.

In multi-level methodology developed by Souza and Clemente (2008), although it presents an analysis of the multidimensional risk with the use of multiple indicators grouped into two sets, the decision process is the acceptance or investment right project rejection from discounted cash flow analysis and context, using these two groups of indicators.

Thus, in view of the need for decision makers at the strategic level of the company, to make capital investment, investment projects, the methodology presented for the construction of an efficient frontier of risk and return, supported by Multi-Index methodology and the multi-criteria approach enabled us to identify a portfolio of projects that respects resource constraints and to select investment projects with better returns for the same risk level or select projects with lower risk for the same level of return by reducing the complexity of the relationship risk and return the two indicators.

This study confirmed that addressing the problem of multidimensionality in the perception of return and risk, from the combination of Multi-Index Methodology and Multicriteria analysis with application of Walker software, that given a set "N" of investment projects that both return and risk have multidimensional characteristics you can select a K <N subset composed of the best designs for each level of perceived risk.

From the Multi-Index methodology that addresses two groups of indicators, which reflect the return expectations and risk perceptions associated with an investment project, it was possible to identify best indicator groups represent the return of dimensions, subdividing into two large groups: monetary return and non-monetary as well as the best indicator groups represent the dimensions of risk, subdividing into five major groups: financial, operational, environmental, management and business.

Thus, the investment projects that have achieved the best ratings in the dimension monetary return are those with better performance to VPL indicators ANPV, IBC, ROIA, Net income Total / Total Revenue and Total Net income / Total Investment, as well as size no monetary return, investment projects that responded better to the jobs numbers generated indicators, Payroll / value of machinery, payroll / number of jobs and taxes and contributions total / Total investment.

In the financial risk dimension the first ratings of investment projects are those that best met the indicators TMA / TIR, third-party capital / equity, Payback / N and working capital / total investment, while the scale operational risk met the indicators degree of revenue commitment, the degree of concentration on suppliers of raw materials, degree of influence of the exchange rate in the cost of raw material and degree of influence of the exchange rate on the sales price. In the dimension environmental risk these best rankings are occupied by investment projects that responded best to% Energy indicators used non-renewable, nonrenewable% water used, degree of impact on the use of deposit,% recycled waste and degree greenhouse.

The use of multiple indicators to form each of the return dimension group and risk, as previously demonstrated was consistent in multidimensional analysis of risk and return, resulting in improved perceptions, providing a better basis in the decision making process, when you have several alternatives and expects to select a subset of them.

These results were made possible by Multicriteria approach, since the decision-making process in the evaluation of investment projects involved choosing the best decision or best decisions, taking into account multiple criteria, factors or goals, effectively contributing to the project evaluation stage, where how the alternatives are evaluated and the criteria considered, it is a very important point for the growth of the firm.

Thus, the Multicriteria approach proved ideal in order to model the decision-making in investment projects, from the use of various indicators to compose each group of dimension return and risk.

This application of Multicriteria approach in decision-making in investment projects was perfectly adequate, since the method Multicriteria Decision Support possible to evaluate and include several criteria simultaneously in the analysis of the complex situation of perceived risk and return.

Moreover, the method for building the border constructed from the indicators of the size money return and no currency reduced to a single number between 0 and 1 for the back dimension and indicators of financial risk size, operational, environmental management and business, reduced to a single number between 0 and 1 for the risk dimension, supported by Multi-Index and from the Multi - criteria analysis methodology in multidimensional approach was only possible by the application of *WALKER software.*

The application of *WALKER software* enabled analyze the problem more broadly than traditional forms, considering that the criteria are the parameters by which the choices were evaluated, corresponding in this case the indicators that make up each dimension proposed as alternatives corresponded to each one of the solutions to the problems that met the criteria in this case, the investment projects that can be selected.

The possibility to observe by the application *software WALKER* the decision problem in a three-dimensional configuration alternatives space, through its projection on a flat representation of the Gaia space (3D), contributed in the multidimensional perception of risk and return, as well as interpretation of the representation of the Gaia space (3D) in*Walker* visually by plotting circles, expanding the limited rationality of decision makers involved in decision-making investments.

Additionally, it can be considered that the methodology for the construction of efficient frontier for selection of investment projects presented allows the inclusion of other indicators in each dimension of monetary return and non-monetary as well as other return dimensions. Regarding the risk although it used the financial risk, operational, management and business and the inclusion of environmental, methodology and allows inclusion of other indicators, as well as other dimensions, as shown in Figure 38.

The biggest advantage is the multi-dimensional analysis of the two dimensions of risk and return, where the proposed methodology allows you to select a K <N subset of investment projects, in which both the return and the risk have multidimensional characteristics, highlighting the best projects for each level of risk got that.

Construction of the efficient frontier of risk and return on investment projects allows the light of several future scenarios to present to decision-makers the project portfolio that presents the best risk-return ratio, looking beyond the strategic aspects of the decision-making opportunities investment that will result in future benefits that increase the wealth of investors.

The analysis of return and risk associated with the portfolio that is on the efficient frontier of risk and return reveals more information than when treated separately, providing the expansion of rationality limits **.**

The multidimensional approach can be extremely useful also for individuals or legal entities that have limited capital for investment, but they have several options to make the choice more represented in the reliability analysis of the efficient frontier of risk and return.

Also where resources are greater than the opportunities, diversification of investment projects it is important to improve the risk / portfolio return, making it more efficient, for both financial institutions specializing in long-term credit (for example, development banks) when the release of funds and require a broader analysis about risk and return, thus exercising their goals.

5.1 Considerations

In evaluating projects numerous methods can be used, from the simplest to the more sophisticated. However, these methods converge on your goal: help the manager in making the decision to invest or not in a given project, and the construction of an efficient frontier of risk and return on investment projects, leading to better decisions than traditional approaches, in order to contribute to the evolution of the form of investment project selection, mainly by highlighting the return and risk in a multidimensional approach hitherto only discussed in the Multi-Index methodology.

Moreover, for this multidimensional approach, the Multi-criteria analysis feature proved ideal, allowing generate a comparative analysis projects, in order to meet the inclusion of multiple criteria simultaneously, an approach of a complex situation of risk and return, so multidimensional.

The consolidation of the dimensions Multicriteria approach allowed the evaluation criteria that can not be transformed into final values, thus recommending its application, since it proved appropriate to compare projects of investment alternatives in the construction of the efficient frontier of risk and return.

The methodology presented for the construction of the efficient frontier of risk and return, and highlight the need for risk discussion in the evaluation of investment projects, assesses the risk in a multidimensional way, thus proving that the decision maker is better supported by the use of various indicators grouped into sets that result in more consistent information than the single use of any one or a subset of them.

These features allow a better evaluation of the perception of return risk, contributing effectively in the decision-making process of selecting investment projects, especially in the situation that the company or agent must choose investment projects among several viable alternatives, forming a portfolio of projects that respect its limitations or scarce resources and ensure higher return with less risk.

The decision problems in investment projects in these conditions for a multidimensional, both in the aspect of alternatives, as the criteria and also the decision-makers, demanding adequate treatment for better decision possible by building the methodology of efficient frontier risk and return.

Even as a recommendation, it is emphasized that investment projects even following a certain pattern for development in some cases may have lack of detail or depth of data and information used to compose an indicator. In view of this fact evidenced during data research to compose this thesis, it is recommended that the evaluator and / or decision maker use not only their knowledge, seeking data and information about the investment projects object in several other expert sources in order to achieve quality and reliability to what is collected, effectively corresponding to the selected dimensions.

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