RISK MATRIX FOR PROJECTS OF ELETRIC ENERGY TRANSMISSION

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To all my family who helped in my absence and did the best for my son, Henzo.

“Insanity: doing the same thing over and over again
and expecting different results.”

Albert Einstein

“All models are wrong but some are useful.”

George Box

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ABBREVIATIONS

1. Brazilian Electricity Regulatory Agency
   (Agência Nacional de Energia Elétrica) ANEEL
2. National Bank of Economic and Social Development
   (*Banco Nacional de Desenvolvimento Econômico e Social*) BNDES
3. Capital Asset Pricing Model – CAPM
4. Cost of Debt – Kd
5. Cost of Equity – Ke
6. Engineering, Procurement and Construction – EPC
7. Internal Rate of Return – IRR
8. Treasury Notes Type B – NTN-B
9. Political Risk Insurance – PRI
10. Monte Carlo Simulation – MCS
11. Special Purpose Company – SPC
12. Weighted Average Cost of Capital – WACC

1) ABTRACT

This study covers subjects affecting decision-making in electric energy transmission business ventures in Brazil. Because this sector is so capital intensive, it is notably monopolistic and, therefore, new entrants must follow diverse norms issued by the regulatory agency.

This directly influences the price formation required for each project. Therefore, a solid process to set price and identify project-related risks helps maximize performance of the business venture and optimize Project Financing.

This study proposes an alternative method of creating risk matrices to map and quantify all project-related risks, whether transferrable or not, and incorporating them into opportunity costs to mitigate such risks when necessary.

The study shows an evaluation metric that considers not only shareholder opportunity costs but also the risks associated with the project. To achieve this, the study covers aspects of evaluating the expected return on electric energy transmission business ventures, aggregating statistical components to the analysis. The Weighted Average Cost of Capital (WACC) is used to measure the required return of each project.

In addition, a statistical evaluation using the Monte Carlo method, which consists of randomly producing "*n*" samples for a chosen variable, all of which are tested against a statistical model, is incorporated into the analysis.

Based on these results, it is possible to create a tridimensional risk matrix that shows the probability of occurrence and its impact on the return of the project.

The composition of probabilities associated with the tridimensional matrix allows for more control over alternative decisions, which leads to more security in carrying out and managing the project. Therefore, given the risk of each alternative, it is important to incorporate such analysis into new electric energy transmission projects in Brazil to mitigate risks and optimize the operationalization of the *Project Finance*.

Key Words: risk matrix; project finance; weighted average cost of capital; transmission; electric energy.

2) EXECUTIVE SUMMARY

This paper explains how regulation in the Brazilian electric sector works and how new entrepreneurs can enter this sector and mitigate risk. Electricity transmission assets require huge initial investments and risk, which lead to fewer agents interested in investing in this sector. Business formatting is one way to reduce risk and get good project finance.

To increase cash flow and profits, investors look to maximize returns. Knowing the revenue, costs, taxes, etc. is extremely important in understanding and forecasting future profitability. But how do investors know the impact of project delays? How can they mitigate risk?

This paper proposes answers to these issues by introducing the Weighted Average Cost of Capital (WACC) method to find the rate of return of the project; however, other factors, which this tool cannot measure, influence project profitability.

This study contributes by adding one step to project valuation. It is possible to forecast the probabilities of certain risks occurring by using historical information from finished projects. Using historical data, however, does present challenges, the biggest being sample size and how these data behave.

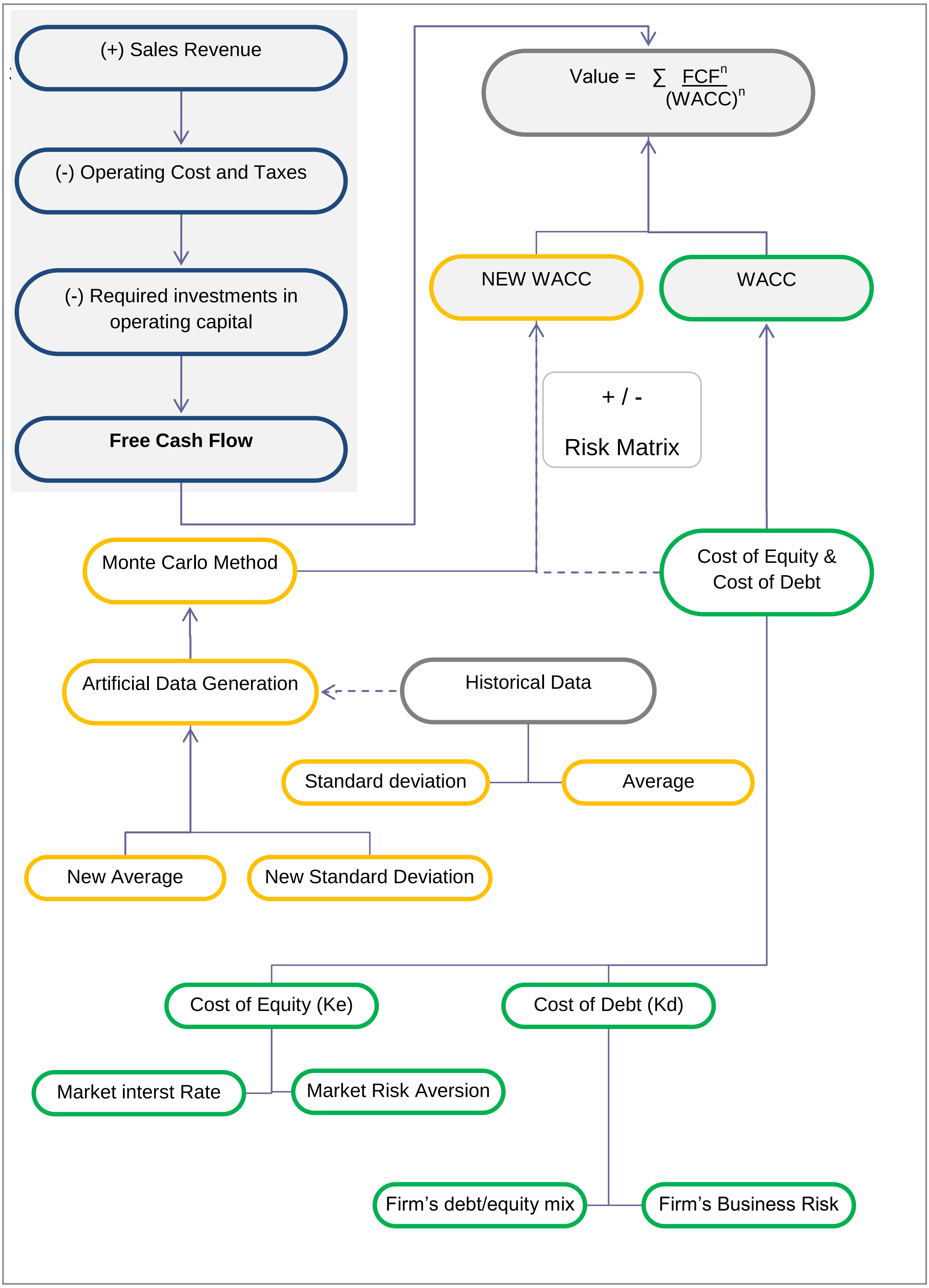
One way to solve these problems is to use statistical models capable of producing infinite numbers of samples. After producing the samples of new projects, one can determine the ranges of valuation. Each range has its own probability and its own impact on the WACC.

Flowchart 1 shows how new project valuation works.

The first step is to forecast all investments, revenues and costs that affect the project. The next step is to find the goal to rate the project with WACC. The last step is to get all similar projects and discriminate the sensitive points that are too difficult or expensive to transfer to others.

This paper explains in detail how to build a risk matrix for some uncertainties and how these variables affect project profitability.

A three-dimensional risk matrix is then presented with which the entrepreneur can measure the risks involved and define, according to his or her risk profile, what decision to make regarding the continuation of the project.



Flowchart 1 – Basic decision-making flowchart

INTRODUCTION

Managing risks associated with infrastructure projects, specifically Electric Energy Transmission Lines has become increasingly broader in scope principally for operationalizing Project Finance. In the past ten years, the Electric Energy Sector has experienced deep regulatory changes, which oblige large businesses acting in the sector to adhere to this new work philosophy.

Brazilian Law 11.079, published on December 30, 2004, allows state companies to enter joint ventures through Private Public Partnerships (PPP). This has made it possible for public entities to take part in Special Purpose Companies (SPCs) created specifically to meet the needs of a given activity.

These changes made designing an excellent form of financing for SPCs possible. SPCs would have their risks mitigated due to the segregation of cash flows associated with the project and, thus, reduce the costs of financing.

As regulation in the electric energy sector has changed, the history of Project Finance, in modern financial engineering, has evolved in its conceptualization. The literal sense of the term Project Finance is associated with financing the project and, in and of itself, says little; however, it does delimit the field of discussion regarding the amplitude of the concept. Project Finance deals with the viability of financing the projects and the safety of future cash flows.

Project Finance, in segmenting and sharing the risk of a venture with clarity and precision, allows each investor to choose the risk level desired and receive a corresponding return. It is a technique of contractual structuring that separates or segments the diverse standards of risk-return of a venture among its participants.

Given the universal relationship of Risk *vs*. Return, the higher the level of independence of the project in relation to its rights holders, considered as shareholders, the more important the lower financing costs, to which the venture is subject, become. It follows that identifying and allocating risks is essential in elaborating Project Finance.

In this ambience, measuring risk becomes fundamental in adequately structuring a solid funding portfolio and, thus, completing the project. Relevant points such as: time limits for clearing Environmental Licenses; signed contracts or pre-contracts of Engineering, Procurement and Construction – EPC; contracts for Operation and Maintenance – O&M; geology associated with the construction project; mapping of the regulatory environment; and even time limits for clearing the financing, influence project profitability (HOFFMAN, 2007).

Aspects such as these, if measured, help administrators make the most suitable decision for the entity and maximize shareholder return.

Within this context, the study proposes measuring the potential risks related to ventures in electric energy transmission in such a way, profitability of the project reflects all risks assumed. This minimizes the costs of structuring project financing.

4) OBJECTIVES

A) GENERAL OBJECTIVES

Develop a financial risk management model with statistical components and mitigatory aspects by mapping all phases of construction and operation of transmission ventures to create a Risk Matrix associated to the venture that favors the structuring of the Project Finance.

Elaborating a Risk Matrix will help administrators make more informed decisions and provide a clearer vision of project-related risks.

For Public Companies, specifically those in the electric energy transmission segment, reliable measurement of risks provides security to public administrators in the decision-making process, which, in turn, provides society with project quality and modicity of tariffs and prices that are consistent with the market.

B) SPECIFIC OBJECTIVES

To evaluate all events that can impact profitability of the ventures, the study proposes introducing historical data verified in projects already undertaken or currently under construction.

Through statistical tools, the method described in this study can measure what the inherent risks of the project phases are and, using this information, estimate a safety margin within which shareholders can maximize their returns. To do this, it is necessary to verify historical data and market benchmarks to project the variations of risk for each item indicated. Once done, a risk management model can be created that can predict with a certain reasonableness which points of development of the project may produce more financial uncertainty for the shareholder, which leads to lower costs in the financial structuring.

Finally, a simulation will be carried out on a hypothetical electric energy transmission project and the respective cost of reasonable opportunity, given the previously identified risks.

5) JUSTIFICATION

Electric energy is of public interest and, therefore, is amply regulated at all hierarchical levels in Brazilian legal regulations. The Brazilian Constitution of 1988 in article 21, clause 7, paragraph b, determines that it is the responsibility of the Union to explore, directly or through authorization, concession or permission, the services of electric energy installations and the use of water resources to produce energy with States in which potential hydro energy resources exist.

Another important point about the electric sector involves its monopolistic nature.

> "In perfect competition, firms are price takers. In other words, firms are numerous enough to ensure that no single seller affects the market price. Monopoly is the polar opposite of perfect competition in that it describes a market with a single seller. A monopoly firm faces the market demand curve for its product because it is the sole seller of the product. Since it faces the market demand curve, the monopoly firm has control over the market price: it can choose any price-quantity combination on the market demand curve" (BROWNING, et al., 2011).

According to classic economic theory, free competition produces the best social well-being possible compared with all other forms of market (CARVALHO, 2011). However, in activities of interest to the State and related to infrastructure in which the initial investment is high, the natural monopoly makes more sense including to establish rate modicity.

Specifically, in this business sector, there are natural monopolies highly regarded as companies providing a good or service to an entire market at a lower cost than would be available if there were two or more companies in the market (MANKIW, 2009).

Being a market that is eminently monopolistic and of high interest to the Union, the Federal Government created the Brazilian Electricity Regulatory Agency (*Agência Nacional de Energia Elétrica*) – (ANEEL) on December 26, 1996 through Law 9.247. The chief objective of this Law is to regulate and monitor the production, transmission, distribution and commercialization of electric energy in compliance with the policies and guidelines of the Federal Government.

ANEEL is attributed with promoting bidding procedures that seek reasonable rates for taxpayers and providing quality and timeliness in the delivery of services. This is accomplished through delegation, the grant plan and policies approved by the Concessionary Power.

Therefore, if a company wants to participate in the ‘monopolistic’ energy market, it must, necessarily, meet a series of requirements set out by the Regulatory Agency. One way to enter this market is by taking part in bids[1] to construct and operate Transmission Lines to obtain authorization for the concession of a determined transmission asset.

Transmission auctions are defined by a series of rules whose principal objective is to provide the lowest cost (or rate) to the end consumer. A fundamental characteristic of a transmission bid in Brazil is the use of the Price Cap concept, in which the regulator defines a maximum amount of revenue to be offered for a specific asset. The winning bidder is the company willing to construct it with the lowest revenue, respecting the technical characteristics and quality required by the Regulatory Agency.

The auction used in the Brazilian market is the Anglo-Dutch[2], which begins with a sealed bid for the first price. The first two or all bidders who made offers within 5% of the lowest, return to bid in an oral *descending price auction.*

Therefore, the entrepreneur must offer the lowest revenue possible but also ensure a return on invested capital that is in line with the required cost of opportunity. It is at this stage when the importance of a solid price structure based on a thorough analysis of all potential project-related risks becomes obvious.

At present, after the auction, the regulator requires the winning company to set up a Special Purpose Company (SPC) to construct and operate the assets which are the object of the concession. This type of partnership allows revenue and expense flows to be separated, facilitating the structuring of financing and, thus, maximizing performance of the venture of a typical *Project Finance*.

Within this context, companies increasingly seek ways to increase auction competitiveness without taking on excessive risks to develop the project and, after that, build and operate it. This said, companies need tools that can map the entire risk chain associated with the ventures to decide how much to bid in energy transmission auctions.

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[1] Public bidding is an economic mechanism of negotiation defined by a series of rules to specify the form of determining the winner and how much the winner must pay. One notable characteristic of the auctions is the presence of asymmetrical information, which makes the characterization of this mechanism become necessary, since different types of auctions can lead to divergent results.

[2] Descendent (Dutch): The auctioneer begins the auction with an extremely high value and reduces it continuously. The first bidder to accept the current bid obtains the item. A bid equivalent to the value of opportunity of the agent maximizes his or her probability of success in the transaction, the benefit being no difference between the value of opportunity and the closing price. The possibility of increasing gains grows as the price is reduced. The Dutch auction requires an evaluation of the market and of the value of the asset being auctioned. Neglecting to carry out this evaluation beforehand increases the chance that the agent will not make a deal.

6) THEORETICAL RATIONALE

First, a brief explanation is necessary of the theoretical reasoning used to determine the price in transmission auctions and risk mitigation for structuring *Project Finance*.

Simply put, deciding what to offer in the auction involves elaborating an economic-financial evaluation model, which aggregates diverse information about the venture, for example:

$$Profit = Income - Expenses$$

Table 1 – Basic Assumptions for Project Evaluation (Illustrative Table)

1) Investment
2) Forecast Revenue
3) Operational Expenses
4) Pre-operational Costs
5) Sectorial Charges
6) Taxes
7) Dates
Environmental Licenses
Release of Financing
Enter into Commercial Operations
End of Concession
8) Financing Conditions
9) Investment Curve
10) Residual Value
11) WACC

Once the basic premises of the project are known, the Discounted Cash Flow projection method is used, which states: the value of any asset is the present value of expected cash flow, discounted from an adequate rate return of the cash flows that are being discounted (DAMODARAN, 1997).

$$\sum_{i=0}^{n}\left(\frac{FCFF}{(1+WACC)^{n}}\right) - I$$

Where:

$NPV = Net\ Present\ Value$

$FCFF = Free\ Cash\ Flow\ to\ Firm$

$WACC = Weighted\ Average\ Cost\ of\ Capital$

$I = Investment$

Therefore, if the value of an asset is its capacity to generate discounted cash flow at an attractive rate, one should find the opportunity cost to the company for such a discount.

What would the opportunity cost be? For Mankiw, the opportunity cost of an item is that which you give up to obtain such an opportunity. In other words, it is the return investors could receive from another investment of similar risk and time.

Browning & Zupan (2011), state that when you pursue one goal, you limit the extent to which you can pursue others.

It is a question of resource scarcity in which the investor considers what prioritization he or she will give to his or her money, while demanding a return at least equal to that which could be earned from another investment.

To facilitate calculating the opportunity cost, the Weighted Average Cost of Capital is used, which is defined by weighing the costs of equity and cost of debt.

$$WACC = Ke * \frac{Equity}{Equity + Debt} + Kd * \frac{Debt}{Equity + Debt} * (1 - T)$$

$WACC = Weighted\ average\ cost\ of\ capital$

$Ke = Cost\ of\ equity$

$Kd = Cost\ of\ debt$

$Equity = \text{Market Value}\ Debt = \text{Bonds with the Total Market Value}$

$T = \text{Corporate Tax Rate}(34\%)$

However, to obtain the WACC, the costs of equity and cost of debt must be evaluated. The cost of debt is determined by the cost of getting a new loan for the project under evaluation whereas the cost of capital is determined by the expected return of the shareholder. This expectation becomes difficult to measure (i) because shareholders' preferences vary and (ii) due to the risk of the activity involved in the operation.

One solution to measuring the cost of equity is to use a capital pricing model; the most widely used in modern finance is the Capital Asset Pricing Model (CAPM) which offers an accurate prediction of the relation between risk and the expected return on an asset. The model was developed in 1964 in articles written by William Sharpe, John Lintner and Jan Mossin (BODIE, et al., 2009).

As with every model, CAPM is based on a series of assumptions, which are abridged in the table below:

Table 2 – CAPM Assumptions

Assumptions	
1.	No transaction costs or taxes on transactions exist;
2.	No investor (borrower or lender) is strong enough to provoke oscillations in market rates;
3.	All investors are rational;
4.	Future returns are known or predictable;
5.	Information flows freely, is known and is accessible to all, without cost;
6.	No restrictions exist on investments;
7.	Investors are risk averse;
8.	There is no overvaluation or undervaluation of securities;
9.	Investors behave similarly toward investments;
10.	No restrictions exist to the entry of new investors in the Market, and new investors can lend or borrow if they have resources or can afford current market interest rates;
11.	The prices of securities are adequate and the expected returns are equal to the returns required.

Clearly, the asset pricing model involves many assumptions to simplify the analysis; however, it is, at present, considered an excellent parameter in defining opportunity costs of shareholders.

Copeland says that CAPM states the cost of equity capital is the risk-free return plus a risk adjustment that is the product of the return on the market as a whole multiplied by the beta risk measure of the individual firm or project.

The fundamental premise on which CAPM is based is that potential investors will invest their resources, which are scarce, in companies that offer a return over that of the return of a zero-risk investment. In other words, the investor will demand a premium for investing his or her capital based on the risk associated with the venture.

$$CAPM = RF + (RM - RF) * \beta$$

$$Risk\ Premiun = (RM - RF)$$

$$\beta = Cov(r_i, r_m)/(\sigma_m^2)$$

$$CAPM = Capital\ Assets\ Pricing\ Model\ (Ke)$$

$$RF = The\ expected\ risk - free\ return\ in\ that\ market\ (government\ bond\ yield)$$

$$RM = The\ historical\ return\ of\ the\ stock\ market/\ equity\ market$$

$$\beta = The\ sensitivity\ to\ market\ risk\ for\ the\ security$$

$$Cov = Covariance\ between\ return\ on\ the\ evaluated\ asset\ and\ market\ return$$

The cost of debt (Kd) can be calculated by taking the rate of a risk free bond whose duration matches the term structure of the corporate debt, then adding a default premium. This default premium will rise as the amount of debt increases. Since in most cases debt expense is a deductible expense, the cost of debt is computed as an after tax cost to make it comparable with the cost of equity. Thus, for profitable firms, debt is discounted by the tax rate. The formula can be written as (Rf + credit risk rate)*(1-T), where T is the corporate tax rate and Rf is the risk free rate. On the other hand, the cost of debt (Kd) can be estimated by using the cost of issuing a new loan for the new venture. In this paper, we use the second option because Electric Energy Transmission projects are highly regulated by ANEEL, with segregation of cash flow, which minimizes the risk of nonperformance and allows for reduced costs of raising funds and generally the loans come from BNDES.

Table 3 – General Conditions of BNDES Financing for Energy Transmission Companies

1) Finance Cost
Direct Support = Finance Cost + Basic Remuneration of BNDES + Credit Risk Rate
Indirect Support = Finance Cost + Basic Remuneration of BNDES + Credit Risk Rate + Remuneration of Accredited Financial Institution
Basic Remuneration of BNDES = 1.3% per annum
Credit Risk Rate = up to 4.18% per annum depending on credit risk of client
2) Maximum Participation of BNDES
Up to 70% of bankable items
3) Total Term of Contract
14 years
Interest can be capitalized during the grace period, which is up to six months after the project enters into commercial operation.

Source: (BNDES)

In this study, we used the costs of issuing debt for Electric Energy Transmission projects provided by the National Bank of Economic and Social Development (BNDES) which has specific lines of financing for this activity.

The financial support for Electric Energy to the segment of transmission is based on the guidelines of the product BNDES FINEM, with some specific conditions described in Table 3.

Once the method applied to the cost of debt and the cost of equity is defined, it is necessary to establish the method to the Project's Cash Flow.

Damodaran states that, in general, a company's cash flow are cash flows left over after paying operational expenses and taxes, but before paying rights holders.

Table 4 describes the structure and differentiation of the cash flows for each type of rights holder.

Therefore, to apply the method, the project's cash flow was used, in which the entire curve of revenue and payments directly related to the project are analyzed since the cost of the debt is considered in the Weighted Average Cost of Capital.

To estimate the impact of quantifiable risks on the project, a model of economic-financial evaluation was drawn up in which various projection assumptions to calculate the cash flow of the project are incorporated.

Table 4 – Estimated Cash Flows

Rights Holders	Cash Flows for Rights Holders	Discount Rate	Method
Investors in Net Assets	Net Cash Flows of Shareholders	Cost of Net Assets	CAPM
Creditors	Interest expenses (1-tax rate) + Payment of Principal - New Issues of Debts	Cost of Debt after Tax	Cost to issue new Debts
Preferred Shareholders	Preferred Dividends	Cost of Preferred Shares	
Company = Investors in Shareholder's Equity + Creditors + Preferred Shareholders	Net Cash Flow of the Company	Weighted Average Cost of Capital	WACC

Source: (DAMODARAN, 1997)

To apply the method, the cash flow of the project is used, where the entire curve of receipts and payments directly related to the project is considered.

One of the fundamental factors of a solid structuring of a Project Finance is to know and evaluate the risks of the venture and, based on this, seek to measure them to establish a new opportunity cost to discount from the cash flow.

According to Bonomi, a typical way of classifying risks is dividing them into two large groups: *systemic* and *project-related*. It is also possible to structure the risk based on project phases.

Systemic Risk is that which is outside the control of the entrepreneur and refers to the economic, political, regulatory, environmental and social system. *Project-Related Risk*, on the other hand, refers to the activity itself and is related intrinsically to the project.

For Hoffman, due to the importance of allocating risk in structuring the Project Finance, organizing risk identification as well as knowing the techniques of allocating and mitigating risk is extremely beneficial.

In this sense, an infinite number of matrices capable of translating the desire for risk in each transaction can be constructed. Due to this wide scope of possibilities, when creating the matrix, we suggest dividing it into a qualitative risk matrix and a quantitative risk matrix.

The Qualitative Risk Matrix does nothing more than identify risk, where it will be allocated, what form of mitigation to use, and what its effect is on the financial agents (lenders) and shareholders in each stage of project construction. Annex I presents an example of a Qualitative Risk Matrix for projects of Electric Energy Transmission.

The Matrix of Quantitative Risks measures the impact on the profitability of the project if the quantified risk occurs. In general, most quantitative risks can be transferred to third parties through insurance. A problem arises, however, when such a transfer becomes excessively burdensome. It then becomes necessary to measure the probable impact and quantify it adequately in defining the rate of return of the project.

Despite the detailing of the Quantitative Risk Matrix, some risks are completely mitigable or do not apply to the segment of electric energy transmission in Brazil. Examples of such risks are: exchange rate risk, interest rate risk, risk of nonpayment, political risk, regulatory risk, etc.

To mitigate such risks, there are, for example, hedge operations for exchange rates and interest rates.

Regarding the risk of nonpayment, at present, the regulatory system in the transmission segment has a full performance rate of nearly 100%. Therefore, we disregard it in this risk evaluation. Moreover, such contracts are associated with a contract of concession of exploration of transmission, which improves the level of guarantees of the project.

In addition, insurance to protect against political risks is also available (Political Risk Insurance – PRI). Instruments also exist in the market that insure against profit cession and that cover engineering risks (Performance Bonds).

Because of these aspects and in a purely didactic form, regarding risk mitigation, we chose to develop a quantifiable risk matrix for the project delay, which results in a delay in entering commercial operation and an alteration in the volume of resources to conclude the project. Therefore, it is not the objective of this study to work with the entire range of risks of the transmission project.

For the simulation, the Monte Carlo method was used to measure the risks. This method consists of a simulation of the statistical distribution of chosen variables by generating random numbers.

The name “Monte Carlo” was idealized by S. Ulam and Nicholas Metropolis during the Manhattan Project of World War II, because of the similarity of statistical simulation to games of chance, and because the capital of Monaco was a center for gambling and similar pursuits. Monte Carlo is now used routinely in many diverse fields, from the simulation of complex physical phenomena such as radiation transport in the earth's atmosphere and the simulation of the esoteric subnuclear processes in high energy physics experiments, to the mundane, such as the simulation of a Bingo game or the outcome of Monty Hall's vexing offer to the contestant in “Let's Make a Deal.” (Drakos, 1995)

A Monte Carlo method is a technique that involves using random numbers and probability to solve problems. The term Monte Carlo Method was coined by S. Ulam and Nicholas Metropolis in reference to games of chance, a popular attraction in Monte Carlo, Monaco (Hoffman, 1998; Metropolis and Ulam, 1949).

7) METHODOLOGY

The economic financial viability of any venture is fundamental to any decision in implementing Project Finance. In this sense, cash flow becomes vital information to lenders.

For Bonomi, at least two additional pieces of information are as important as cash flow: (i) whether the risks are appropriately identified and measured so they can be mitigated or assumed (the participant requiring a return on investment given the risk assumed); and (ii) whether each participant is adequately compensated according to the expected return considering *shareholder value creation*.

The predictive model of profitability, therefore, should consider all project-related risks. Their measurement is fundamental to stakeholders. One of the ways of measuring these is the Fischer formula, originally used to measure the risk of inflation. This formula is described below:

$$1 + T\,nominal = (1 + Tinflation) * (1 + Tefetiva)$$

After defining the profitability of the project, considering the weighted average cost of capital proposed, the profit is increased or decreased according to the risk evaluated.

As previously explained, the extensiveness of the Quantifiable Risk Matrix will be reduced for:

- ✓ Risk of Alteration of Investment;
- ✓ Risk of Delay in Entering into Commercial Operation.

After defining the Weighted Average Cost of Capital of the venture, a differentiated approach will be proposed regarding the risks of alteration of investment and of the date of entering into operation. The intention is to measure each risk and add it to the Weighted Average Cost of Capital to mitigate the impact if it occurs.

But how are such risks measured? A reasonable solution is to examine the verified occurrences in previous projects and, considering the number of projects evaluated, estimate the impact on the profitability of the project. If the quantity of data is relatively high, the alternative is viable. However, what if the number of observations of previous projects is not representative? In this case, the solution would be to produce a new sample artificially using statistical tools designed for this purpose.

The tool used to produce these calculations was the Monte Carlo Simulation (MCS). Theoretically, the simulation is grounded in the Law of Large Numbers, which states: the higher the number of observations in the sample, given by 'n,' the sample estimates, such as average and variance, tend to converge toward the true parameters of the population in question. The logic of MCS is to synthetically produce many observations (n tending to infinity) in this case, to obtain the parameters of the average and variance to perform statistical inference.

8) RESULTS

Initially, as proposed, the Weighted Average Cost of Capital of Eletrobras (ELET3) shares was calculated. A five-year period (2007-2011) was used to evaluate daily returns. The returns of IBOVESPA were used as the market return to calculate the Capital Asset Pricing Model (CAPM) (Figure 1).

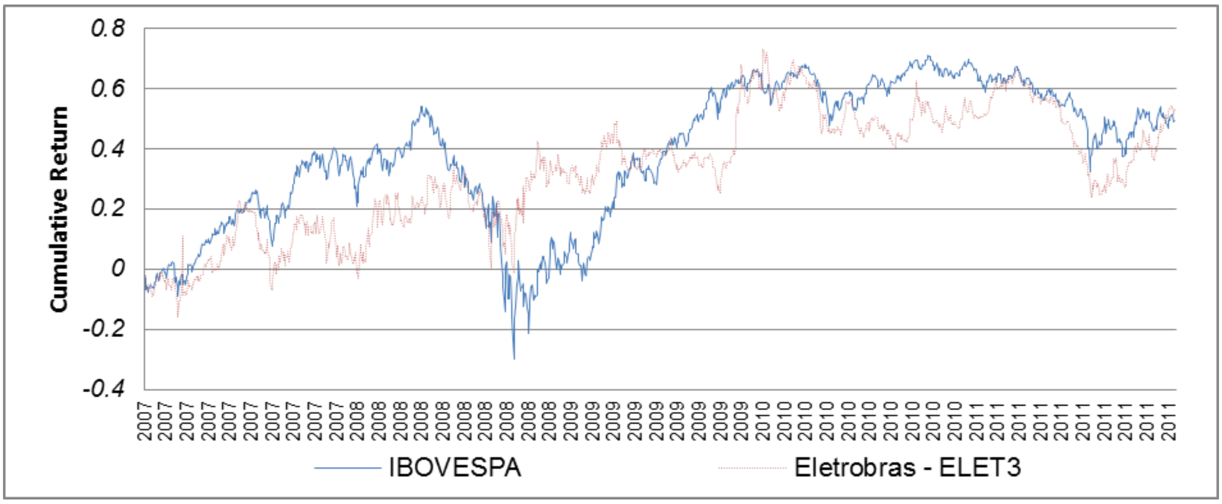

Figure 1 – Accumulated Return on IBOVESPA and ELET3

After collecting daily data, the correlation between the Eletrobras share and that of IBOVESPA was calculated to estimate the probable future movement of the shares in relation to the market. Table 5 shows the explicatory capacity of the regression model is relatively low (33.4%), in other words, approximately 66.6% of variations in Eletrobras shares is not explained by the variations in IBOVESPA. However, the correlation presented between the shares is 0.68514 in the period evaluated.

Table 5 – Evaluation of the Regression - ELET3

Regression Statistics (ELET3)	
R multiple	0.5782
R-Squared	0.3343
R-squared adjusted	0.3338
Standard Error	0.0200
Observations	1257

	Coefficients
Intersection	0.00016
Variable X 1 (β)	0.68514

With the data collected from 2007 through 2011, it was possible to stratify the average market return according to the data presented in Table 6.

In statistics or econometrics, linear regression is used to estimate the conditional (expected value) of a variable y, given the values of some other variables x. The regression, in general, estimates a conditional expected value.

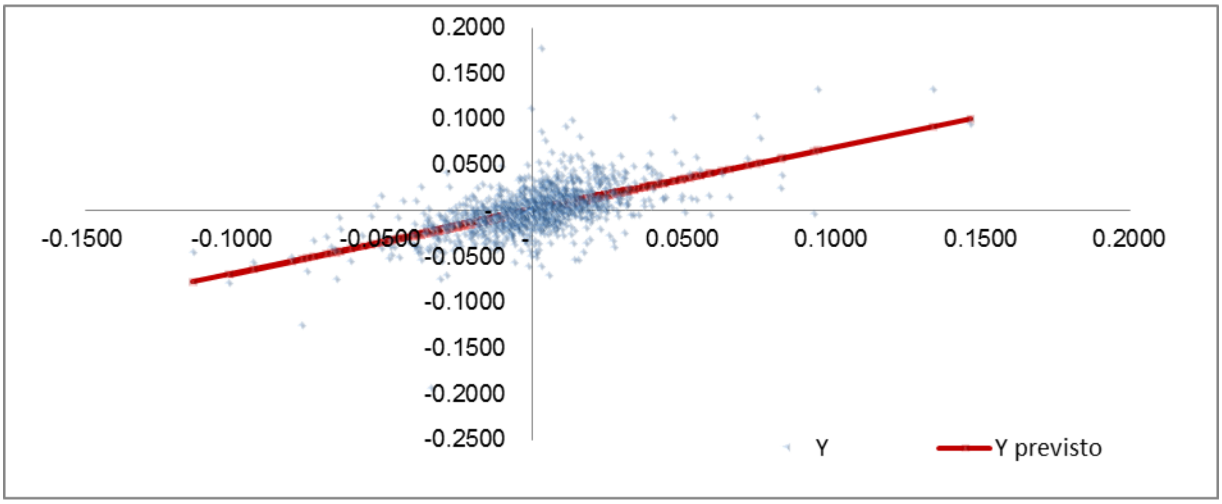

Figure 2 – Linear Regression ELET3

To estimate the expected value, the equation below determines the relationship between both variables.

$$Y_i = \alpha + \beta X_i + \varepsilon_i$$

In which: Variable explained (dependent); is the value one wants to reach;

$\alpha = constant$

$\beta = constant, represents\ the\ slope\ of\ the\ line$

$X_i = explanatory\ variable$

$\varepsilon_i = error\ of\ measurement$

One can see that between 2008 and 2011, the average market return was strongly affected by the 2008 Crisis and its subsequent consequences in 2011. However, in 2009, the stock market came back strong in Brazil, which somewhat diluted the average return of the period.

Table 6 – Market Return from 2007 through 2011

IBOVESPA	Points	Return	Days of Operation
Total	73,016,570.42	0.49	
# of observations	1,258	1,236	
Average	58,041.79	0.040%	
2007		44%	245.00
2008		-26%	249.00
2009		82%	246.00
2010		2%	247.00
2011		-16%	248.00
Average Annual Rate		16.94%	

To calculate the risk free return in Brazil, Treasury Notes Type B (NTN-B) with a maturity date of 2045 were used. This is because: (i) NTN-B remuneration is calculated using the official correction index used by the government to measure inflation (IPCA); and (ii) as the evaluation of the venture is associated with electric energy transmission projects with a thirty-year Government concession, it fits with the term of maturity of the federal government securities.

Table 7 – Average Return for NTN-B with Maturity in 2045

Risk Free Return	
Year	Return
2007	6.67%
2008	7.19%
2009	6.77%
2010	6.20%
2011	5.87%
Average	6.54%

After a systematic evaluation of the risk-free return, an average remuneration rate of 6.54% per annum was verified.

With this data, the cost of equity for electric energy transmission projects can be calculated. This was estimated at 13.67% per annum, as Table 8 shows.

Table 8 – Capital Asset Pricing Model

Capital Asset Pricing Model (CAPM)
$CAPM = RF + (RM - RF) * \beta$

Eletrobras Beta (β)		0.685
Risk-Free Rate (RF)		6.54%
Market Return (RM)		16.94%
CAPM	**Nominal**	**13.67%**

The cost of debt is the return that lenders of debt of the company demand to make new loans, seen in the financial markets, whether in a direct or indirect form. It should reflect, in the most realistic form possible, the optimal conditions of financing in the market.

Two lines of action exist to estimate the cost of third-party capital:

Financial benchmarking: The cost of financing of a company can be estimated through current private debt securities of the sector in which the company belongs, commercialized in the internal and external financial markets.

CAPM of the debt: this method, commonly used in regulatory as well as in finance, is consistent with the general model of CAPM used to calculate the cost of the company's using its own capital.

To define the cost of third-party capital, a benchmark of the national market was used as a parameter. For an electric energy transmission project, raising resources through BNDES is generally considered because it offers more attractive costs than the private financial market. An 11.48% per annum maximum total cost was used, as described below.

Table 9 – Basic Conditions for Financing Electric Energy Transmission Projects

Basic Conditions for Financing – BNDES		
Cost of Financing		
Basic Spread	1.30%	
Spread of Risk	4.18%	(up to 4.18% depending on risk analysis of the client)
TJLP[3]	6.00%	
Final Cost	**11.48%**	
Maximum Leverage	**70.00%**	
Term	14	Years
System	System constant amortization	

(BNDES)

After calculating the cost of equity and the cost of debt, it is necessary to define the capital structure to calculate the Weighted Average Cost of Capital. Because the

[3] TJLP – Interest rate of long-term

ventures are structured under the logic of *Project Finance* with a structure of reduced costs and under strong State regulation in terms of reduced shareholder participation, it is not plausible to consider the initial leverage of the project when calculating the Weighted Average Cost of Capital; however, it is plausible to use the average leverage for the period during the debt service payment.

Table 10 – Structure of the Estimated Capital during the Debt Service Payment

Amortization Curve for an average leverage of 70%			
Investment of $ 100			
Year	**Debt ($)**	**Equity($)**	**Average Leverage (%)**
0	70	30	35
1	65	35	35
2	60	40	35
...	...	...	...
14	0	100	35

Table 10 shows the average leverage of a project with an initial debt of 70% of its assets. One may note that during the debt service payment period, the relation of leverage changes, which requires a reevaluation of the structure of capital each period. As a proxy, an average leverage of 35% for the entire period was used.

In defining the cost of equity, the cost of debt, the leverage and the fiscal benefits on the debt capital, one reaches the minimum value of remuneration of the project that satisfies stakeholders. Table 11 shows the nominal Weighted Average Cost of Capital at 11.54% and the real Weighted Average Cost of Capital of 5.45%.

Table 11 – Weighted Average Cost of Capital (WACC)

	Nominal	**Real**
Ke (CAPM)	13.67%	6.73%
Kd	11.48%	4.67%
Leverage (Kd)	35%	
Ke	65%	
WACC	**11.54%**	**5.45%**
IPCA – 2011 (IPEA data)		*6.50%*

Now we have to define the basic assumptions for the free cash flow. These assumptions will help us calculate the rate of return and define our target price.

Table 12 – Basics Assumptions - Free Cash Flow.

Basics Assumptions	
Investment	1,500,000

Revenue[4]	186,912
Variable Costs	16,400
Revenue Taxes	13.25%
PIS/COFINS	9.25%
P&D + TFSEE	1.50%
RGR	2.50%
Profit Tax	34.00%

Based on these premises, a free cash flow was projected to meet the goal of the previously calculated IRR. The IRR for this free cash flow is equal to WACC (5.45%).

Table 13 – Free Cash Flow to Project

Cash Flow[5]	2012	2013	2014	2015	2016	...	2042
Input	**225,000**	**750,000**	**525,000**	**155,760**	**186,912**		**113,652**
Equity	225,000	750,000	525,000	0	0		82,500
Revenue	0	0	0	155,760	186,912		31,152
Output	**(225,000)**	**(750,000)**	**(525,000)**	**(63,454)**	**(76,145)**		**(12,691)**
Investment	(225,000)	(750,000)	(525,000)	0	0		0
Variable Costs	0	0	0	(13,667)	(16,400)		(2,733)
Revenue Tax	0	0	0	(20,638)	(24,766)		(4,128)
Profit Tax	0	0	0	(29,149)	(34,979)		(5,830)
Final Cash 1	0	0	0	92,306	110,767		100,961
Investment Flow	(225,000)	(750,000)	(525,000)				
Operational Flow				92,306	110,767		100,961
Final Free Cash Flow	**(225,000)**	**(750,000)**	**(525,000)**	**92,306**	**110,767**		**100,961**
IRR @ 5.45%							

Concluding the first phase, where the value of remuneration defined does not contemplate the associated risks of the project, it is necessary to attribute new spreads to the Weighted Average Cost of Capital to translate not only the remuneration required by the shareholder but also the quantifiable risks of the project. However, it is necessary to evaluate the probability of occurrence for each risk associated with the project. As mentioned before, the Monte Carlo simulation brings a spectrum of results associated to each chosen variable.

To carry out the simulation, the following premises were defined: (i) the events analyzed do not have any correlation; (ii) the results follow a normal distribution of an

[4] This revenue balances the value of the project IRR with the shareholder WACC.
[5] Note that this method can be applied in every financial model that used the free cash flow method since the didactic proposal used was a simple model.

average µ and a standard deviation S². The quantity of random data produced for the Monte Carlo simulation was 10,000 observations.

To test whether the quantity of data was sufficient, the convergence of the average of the observations was tested as shown in Figure 1 below:

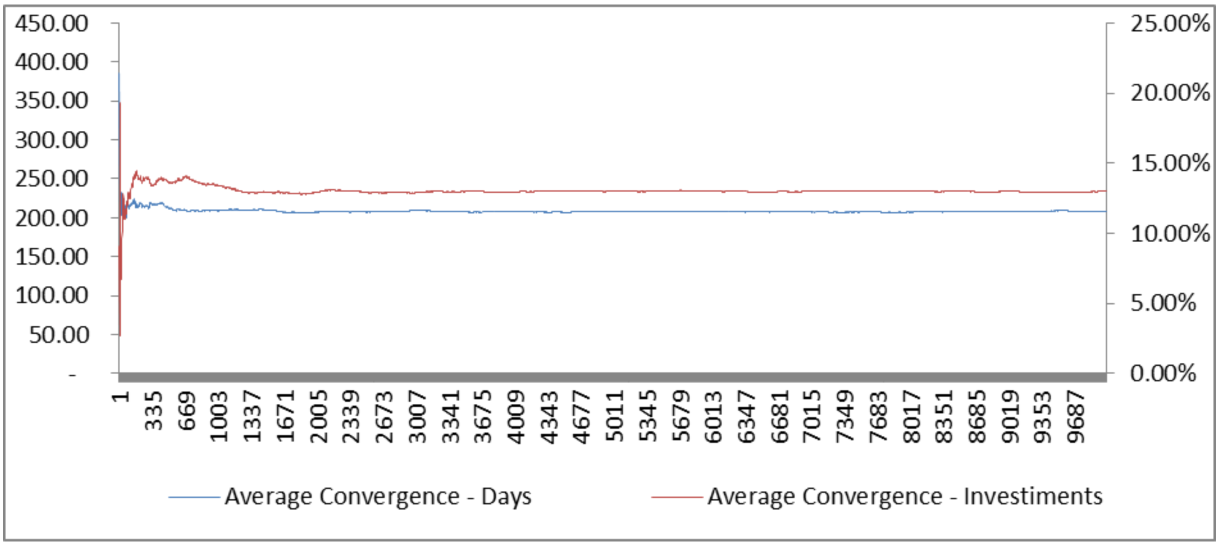

Figure 3 – Convergence of the Average (Days and Variation of Investment)

As seen above, the projections converge with less than 10,000 observations, i.e., the number of random variables is adequate.

To evaluate the impact on the variation of each risk chosen, hypothetical data from 10 electric energy transmission ventures in Brazil were used.

Such ventures are Special Purpose companies (SPVs), with fictitious data, under construction or already in operation and serve as proxies for projections of the desired impacts regarding time to enter commercial operation and changes in planned investment.

The first step is to aggregate all necessary information, after which, the average and the standard deviation are calculated, assuming that future observations will behave as a normal curve ($N(u,s^2)$).

Afterward, the Monte Carlos Simulation is applied to generate random numbers, and with this, converge the evaluation into the universe desired.

Table 14 – Variation of the Date to Enter into Operation

Name	Initial Date	Final Date	Variation (days)
SPC 1	08/01/05	08/25/05	24
SPC 2	06/01/09	09/19/09	110
SPC 3	04/01/12	04/26/12	25
SPC 4	01/01/08	05/31/08	151
SPC 5	01/01/12	07/01/12	181

SPC 6	10/01/10	05/31/12	608
SPC 7	10/01/11	05/31/12	243
SPC 8	10/01/11	07/01/12	274
SPC 9	07/01/11	11/19/11	141
SPC 10	06/28/10	04/30/11	306
		Total	**2,063**
		Average	**206**
		Standard Deviation	**170**

Table 15 – Variation % in Investment

Name	Initial Investment R$ millions	Actual Investment R$ millions	Variation (%)
SPC 1	116.3	116.6	0.26%
SPC 2	205.3	256.1	24.73%
SPC 3	1,406.2	1,449.4	3.07%
SPC 4	503.6	530.0	5.23%
SPC 5	1,936.0	2.014.9	4.08%
SPC 6	412.2	489.7	18.81%
SPC 7	1,250.1	1,793.6	43.47%
SPC 8	238.3	262.6	10.21%
SPC 9	240.0	255.4	6.42%
SPC 10	87.4	99.8	14.24%
Total	***7,682***	***8,584***	
		Average	12.54%
		Standard Deviation	11.50%

Tables 16 & 17 demonstrate the probability of occurrence between each interval defined for the case study applied.

Table 16 – Probability of Delay in Entering into Operation

Sample	10,000		
Observations < 0	1,125	11.25%	
Observations > 0	8,875	88.75%	
<30	1,475	14.75%	14.75%
<60	1,904	19.04%	4.29%
<90	2,439	24.39%	5.35%
<120	3,027	30.27%	5.88%
<180	4,352	43.52%	13.25%
<360	8,084	80.74%	37.32%
<720	9,982	99.82%	18.98%

Table 17 – Probability of Alteration of Investment

Universe	10.000		
Observations <0%	1,632	16.32%	
Observation > 0%	8,368	83.68%	
0%	1,632	16.32%	16.32%
10%	4,113	41.13%	24.81%
25%	8,227	82.27%	41.14%
50%	9,975	99.75%	17.48%
75%	10,000	100.00%	0.25%
90%	10,000	100.00%	0.00%
100%	10,000	100.00%	0.00%

With the probability of occurrence, it is possible to measure, for each interval, the impact on the project's Internal Rate of Return and, with this, create a risk matrix for the items covered.

The next step is to consider the data referenced to benchmark the variation of the Internal Rate of Return when compared with the Weighted Average Cost of Capital calculated.

As previously defined, the following risk variables were analyzed didactically: the change of date of entering into operation and alterations in the value of investment. In Tables 14 through 17, the number of ventures that serve as reference for analysis was identified, as well as the generation of random numbers for the composition of the risk associated to each interval indicated.

In Table 18 and Table 19, the values of the sample series were normalized to make it possible to produce Figures 4 & 5, which show, didactically, the probabilities obtained according to the interval chosen.

For example, if one sought a confidence interval of 97.725% (2 σ) one needs only to assume the entire project has a potential risk of delay of 547 days (Table 18) or have an increase in investment of approximately 39% (Table 19).

Table 18 – Distribution of f (days)

	Dist f(x)	*Dist (z)*	**Dist Simulation f(x)**	***Simulation F(x)***
3º Deviation	- 304	-3.0	0.10%	0.10%
	- 270	-2.8	0.13%	0.23%
	- 236	-2.6	0.24%	0.47%
	- 202	-2.4	0.28%	0.75%
	- 168	-2.2	0.63%	1.38%
2º Deviation	- 134	-2.0	0.73%	2.11%
	- 100	-1.8	1.44%	3.55%
	- 66	-1.6	1.75%	5.30%
	- 32	-1.4	2.61%	7.91%

	2	-1.2	3.66%	11.57%
1º Deviation	36	-1.0	4.01%	15.58%
	70	-0.8	5.14%	20.72%
	104	-0.6	6.28%	27.00%
	138	-0.4	7.19%	34.19%
	172	-0.2	7.48%	41.67%
Average	206	**0.0**	8.15%	49.82%
	240	0.2	7.86%	57.68%
	274	0.4	7.49%	65.17%
	308	0.6	6.95%	72.12%
	342	0.8	6.17%	78.29%
1º Deviation	376	1.0	4.84%	83.13%
	410	1.2	4.68%	87.81%
	445	1.4	3.66%	91.47%
	479	1.6	2.88%	94.35%
	513	1.8	1.90%	96.25%
2º Deviation	547	2.0	1.40%	97.65%
	581	2.2	0.92%	98.57%
	615	2.4	0.57%	99.14%
	649	2.6	0.34%	99.48%
	683	2.8	0.22%	99.70%
3º Deviation	717	3.0	0.12%	99.82%

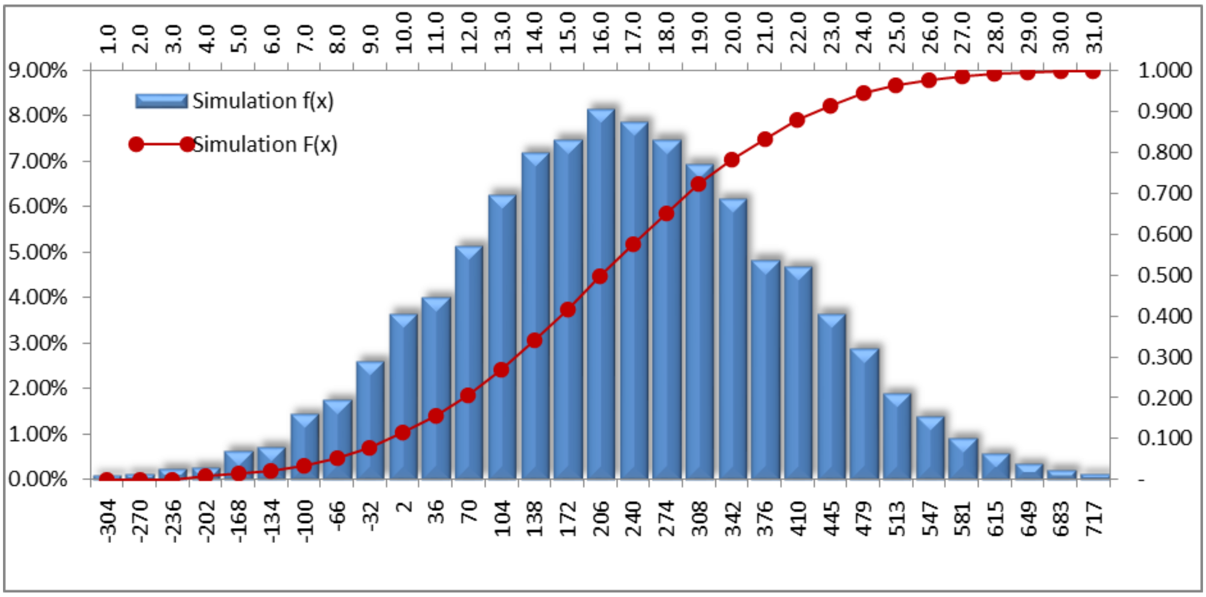

Figure 4 – Normal Distribution for Variation of Days.

Table 19 – Distribution of f (Δ investment)

	Dist f(x)	*Dist (z)*	**Dist. Simulation f(x)**	*Simulation F(x)*
3rd Deviation	-26%	*-3.0*	0.14%	0.14%
	-24%	*-2.8*	0.08%	0.22%
	-21%	*-2.6*	0.19%	0.41%

	-18%	*-2.4*	0.36%	0.77%
	-16%	*-2.2*	0.51%	1.28%
2nd Deviation	-13%	*-2.0*	0.88%	2.16%
	-11%	*-1.8*	1.36%	3.52%
	-8%	*-1.6*	2.15%	5.67%
	-5%	*-1.4*	2.84%	8.51%
	-3%	*-1.2*	3.28%	11.79%
1st Deviation	0%	*-1.0*	4.35%	16.14%
	3%	*-0.8*	5.08%	21.22%
	5%	*-0.6*	6.14%	27.36%
	8%	*-0.4*	6.93%	34.29%
	10%	*-0.2*	8.16%	42.45%
Average	13%	***0.0***	7.62%	50.07%
	16%	*0.2*	7.55%	57.62%
	18%	*0.4*	7.69%	65.31%
	21%	*0.6*	7.04%	72.35%
	24%	*0.8*	6.61%	78.96%
1st Deviation	26%	*1.0*	5.54%	84.50%
	29%	*1.2*	4.26%	88.76%
	31%	*1.4*	3.42%	92.18%
	34%	*1.6*	2.45%	94.63%
	37%	*1.8*	1.90%	96.53%
2nd Deviation	39%	*2.0*	1.30%	97.83%
	42%	*2.2*	0.65%	98.48%
	45%	*2.4*	0.63%	99.11%
	47%	*2.6*	0.37%	99.48%
	50%	*2.8*	0.26%	99.74%
3rd Deviation	52%	*3.0*	0.10%	99.84%

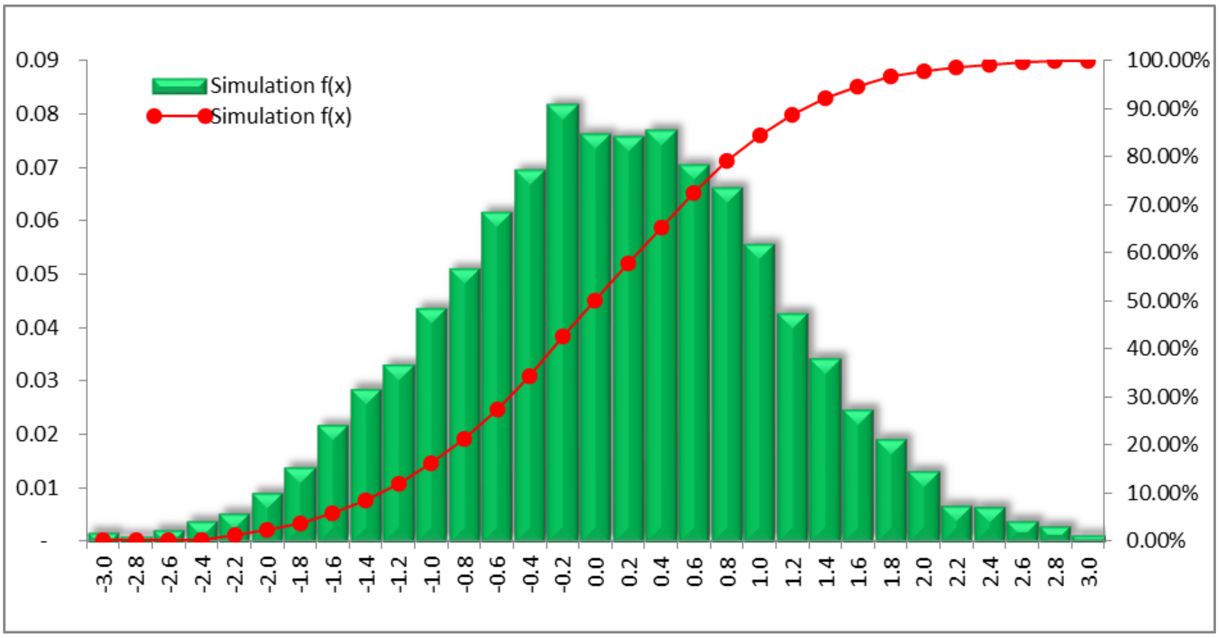

Figure 5 – Normal Distribution for Variation of Investment.

Table 20 presents a list of possible delays in construction with diverse associated probabilities, based on observing the 10 ventures of reference (Table 14 and 15). As an example, to mitigate approximately 100% of the risk of delay of construction, it would be necessary to add 0.93% to the minimum desired return.

Table 20 – Calculation for Increase in the WACC for Each Alternative of Variation of Date

Probability of occurrence of more than X days of delay			IRR Verified	Increase in WACC
	Accumulated Probability	Probability		
30 Days	14.75%	14.75%	5.41%	0.04%
60 Days	19.04%	4.29%	5.38%	0.08%
90 Days	24.39%	5.35%	5.34%	0.11%
120 Days	30.27%	5.88%	5.30%	0.15%
180 Days	43.52%	13.25%	5.23%	0.22%
360 Days	80.84%	37.32%	4.95%	0.50%
720 Days	99.82%	18.98%	4.52%	0.93%
		Average	5.10%	
For a confidence interval of 99.7%, Increase IRR by:				0.93%
Average of Increase for the IRR:				0.35%

In Table 21, the variation was in the investment item, which was much more sensitive than the delay of construction variable. To eliminate 100% of the risk, it would be necessary to add to the minimum desired return approximately 3.21% of the 5.45% of the Weighted Average Cost of Capital.

Table 21 – Calculation for Increase in WACC for Each Alternative of Variation % of Investment

Probability of Occurrence of more than X % of Increase in Investment			IRR Verified	Increase in WACC
	Accumulated Probability	Probability		
0%	16.32%	16.32%	5.45%	0.00%
10%	41.13%	24.81%	4.64%	0.82%
25%	82.27%	41.14%	3.61%	1.85%
50%	99.75%	17.48%	2.25%	3.21%
75%	100.00%	0.25%	1.19%	4.27%
90%	100.00%	0.00%	0.65%	4.80%
100%	100.00%	0.00%	0.33%	5.12%
		Average	3.95%	
For a confidence interval of 100%, Increase IRR by:				3.21%
Average of Increase for the IRR:				1.50%

To complete the analysis, it is also possible to combine both risk matrices (time and investment) and build a tridimensional matrix with which it would be possible to evaluate for each interval the percentage of corresponding risk and how much the increase in minimum desired return would be.

In Table 20, the maximum value of increase to mitigate 99.9% of the risks would increase the Weighted Average Cost of Capital of 5.45% to 9.85%, which could make the entrepreneur less competitive if such number were used for setting price in transmission auctions. However, the entrepreneur can use an average value that would offer protection in approximately 50% of the cases aggregating 2.20% of the Weighted Average Cost of Capital.

Table 22 – Tridimensional Risk Matrix (Time and Investment)

580

	P(Invest. increase)		16.32%	24.81%	41.14%	17.48%	0.25%	0.00%	0.00%
P(Days)		Invest. (Var)	0	10%	25%	50%	75%	90%	100%
				0.82%	1.85%	3.21%	4.27%	4.80%	5.12%
	Days	WACC	5.45%	**6.31%**	**7.40%**	**8.83%**	9.95%	10.52%	10.86%
14.75%	30	0.04%	**5.49%**	**6.36%**	**7.44%**	**8.88%**	10.00%	10.56%	10.90%
4.29%	60	0.08%	**5.53%**	**6.39%**	**7.48%**	**8.92%**	10.04%	10.60%	10.94%
5.35%	90	0.11%	**5.57%**	**6.43%**	**7.52%**	**8.96%**	10.08%	10.64%	10.98%
5.88%	120	0.15%	**5.61%**	**6.47%**	**7.56%**	**9.00%**	10.12%	10.68%	11.02%
13.25%	180	0.22%	**5.69%**	**6.55%**	**7.64%**	**9.07%**	10.19%	10.76%	11.10%
37.32%	360	0.50%	**5.98%**	**6.85%**	**7.94%**	**9.38%**	10.50%	11.07%	11.41%
18.98%	720	0.93%	**6.44%**	**7.30%**	**8.40%**	**9.85%**	10.98%	11.55%	11.89%

The applicability of the analysis proposed can mitigate or provide top management arguments for negotiation in a possible transfer of risk to third parties.

For auction price setting, the method offers security and analytical capacity to maximize returns and the probability of success.

9) CONCLUSION

The objective of this study was to address subjects that affect decision-making and participation of companies in ventures of electric energy transmission in Brazil. Structuring Project Finance traverses all the processes inherent in construction and performance of the ventures, making good risk management necessary. Given this, elaborating risk matrices to map and quantify all project-related risks, whether transferrable or not, was proposed.

As for mapping and quantification, matrices were separated into: Qualitative Risk Matrices and Quantitative Risk Matrices. The first merely evaluates the risks from the view of responsibilities, and the second from that of measuring some of the risks that impact shareholder return.

To reach the desired results, this study addressed aspects of evaluating the expected return for ventures of electric energy transmission within the Eletrobras System and aggregated statistical components to the analysis.

The Weighted Average Cost of Capital was used to calculate the average of the rates required by Eletrobras shareholders and creditors to invest in the company. In this study, such a result was considered the minimum rate of attractiveness of the company's projects.

In the composition of the Weighted Average Cost Capital, it was necessary to include the cost of equity. This has been acknowledged in the theoretical benchmarking of the study. The method used to calculate the cost of a company's own capital was developed in 1964 by William Sharpe at al. in his, *Capital Asset Pricing Model* (CAPM). To conclude the analysis of CAPM, it was necessary to compile and evaluate the average returns of Eletrobras shares and the average returns of the market (IBOVESPA), from which the average market return and correlation of Eletrobras shares with the market (β) were obtained. For the risk-free premium, the Treasure Note type B – NTN-B was used as a reference for reasons explained above.

As for the cost of debt, benchmark costs relative to the financing granted by BNDES for electric energy transmission projects in Brazil were used as well as the maximum estimated leverage.

This information was sufficient to calculate the Weighted Average Cost of Capital of the Eletrobras System for example. The average expected return for the system, considering all the variables indicated above, was 5.45% per annum in 2012[6].

After calculating the minimum shareholder return, the risks of the projects were quantified. As discussed earlier, this evaluation was limited to measuring risks of delay in construction of the ventures and changes in the volume invested.

As the available sample was limited, data was generated with statistical tools. The Monte Carlo method, which consists of generating successive random *n* samples in terms of cost and time, was used. These samples were tested against a statistical model.

The results presented confirm the alteration of the date of entering into commercial operation and the alteration of the volume of investment, both risk factors, require decision makers to assume or distribute the risks depending on the their amplitude.

Through the tridimensional risk matrix, it was verified that the composition of the associated probabilities allows for more control over the decision alternatives thereby

[6] Note that the WACC is constantly changing due to the volatility of the shares to which it is tied.

offering more security in carrying out the project, in which the range of profitability in terms of the associated probabilities runs between 5.45% and 9.85% (Table 22).

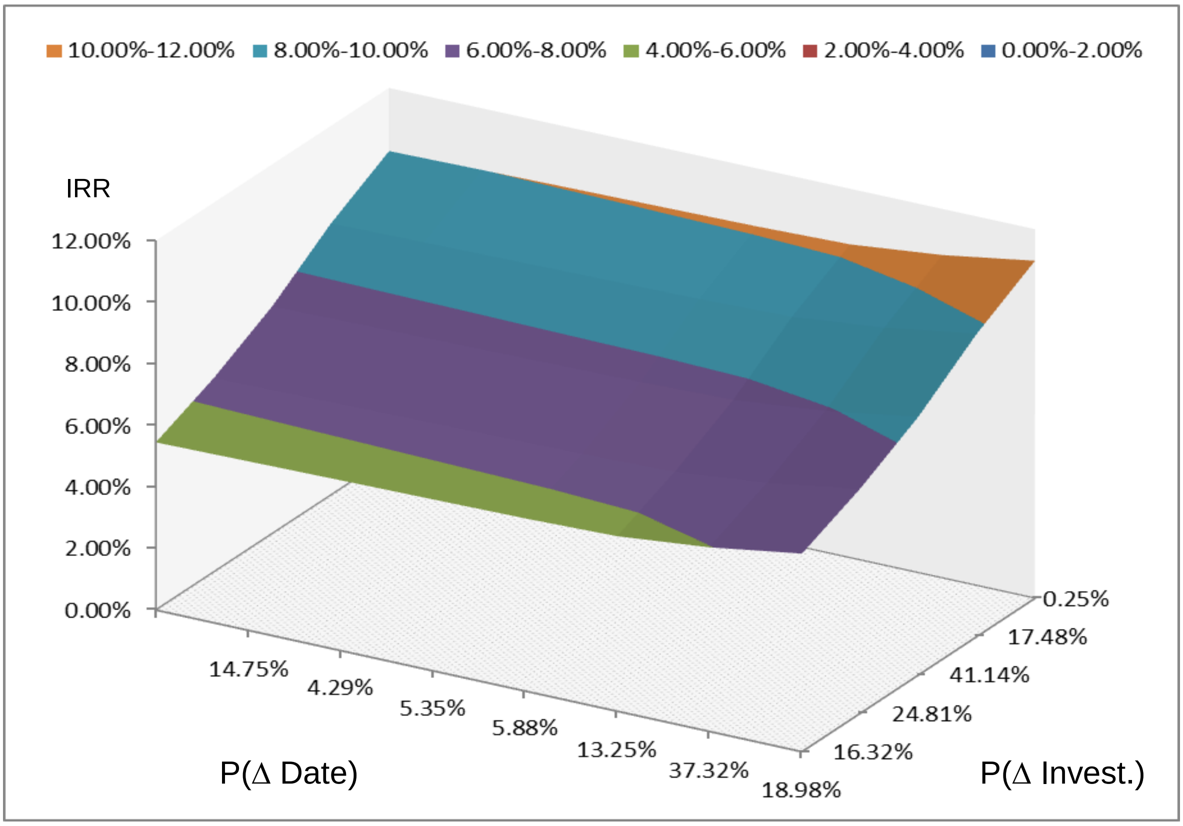

Figure 6 – Tridimensional Matrix Chart.

Figure 6 shows how the probability of occurrence for each variation in IRR, investment and date influences a shareholder's decisions. We can see that the largest areas are blue and purple. This means that between 6% and 10% (IRR axis) lies the biggest probability of variation in investment and date.

Therefore the shareholder should increase his or her minimum IRR, instead of starting with 5.45% as the initial WACC shows.

If the project sponsors want to be more conservative, they choose the rate on the border between blue and brown, in other words, almost 10% for the minimum return due to the risk.

Therefore, it can be concluded that evaluating projects that incorporate the impacts of the probabilities of the associated risks maximizes their adequate performance, maintaining the minimum profit desired. However, if such incorporation of risk were made irresponsibly, 'theoretically' viable projects could be transformed into unattractive ones thereby diminishing the possibilities of incorporating the results on the part of the evaluating entity and, consequently, diminishing its competitiveness.

It is on this point that future studies could focus. Decision-making should be accompanied by structural measures if the aggregation of risk negatively interferes in achieving new projects.

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ANNEX I - Sample of Construction Period Risk Matrix for Electric Generation Facility

Risk	Part Allocated Risk	Mitigation	Effect ON Lender	Effect ON Developer
Cost overrun that is within contractor's control	contractor	construction contract is for a fixed price	creditworthiness of contractor to finish project	construction price reflects risk assumed by contractor
Cost overrun not within contractor's control - Insured event	insurance company	insurance proceeds	none if proceeds are sufficient	none if proceeds are sufficient
Cost overrun not within contractor's control - uninsured force majeure event	developer	stand-by equity commitment is drawn upon	none	equity returns deferred until completion occurs
Cost overrun not within contractor's control - change of law	developer power purchaser	stand-by finance facility drawn until tariff adjustment is made	stand-by debt facility and unavailable for other contingencies	increase financing costs offset by increased tariff, but timing of adjustment may reduce equity returns
Cost overrun not within contractor's control - subsurface site conditions	developer	Stand-by finance facility drawn	stand-by debt facility reduced and unavailable for other contingencies	increased financing costs; equity returns reduced.
Completion delay that is within contractor's control	Contractor	fixed completion date in construction contract; daily liquidated damages to cover debt service, fixed operating cost and fuel supply contract late delivery payments	creditworthiness of contractor to finish project	construction price reflects risk assumed by contractor
completion delay that is not within contractor's control insured event	insurance company	insurance company	none if proceeds are sufficient	none if proceeds are sufficient
completion delay not within contractor's control - uninsured force majeure event	power purchaser and central government	if cost is less than $ 5MM, Stand-by finance facility drawn until tariff adjustment is made; if more than $5MM, government pays developer fee, retires debt and assumes project	stand-by debt facility reduced and unavailable for other contingencies; government credit risk	increase financing costs offset by increased tariff, but timing of adjustment may reduce equity returns; if over $5MM, equity return lost
completion delay not within contractor's control - change of law	power purchaser central government	if cost is less than $ 5MM, Stand-by finance facility drawn until tariff adjustment is made; if more than $5MM, government pays developer fee, retires debt and assumes project	stand-by debt facility reduced and unavailable for other contingencies; government credit risk	increase financing costs offset by increased tariff, but timing of adjustment may reduce equity returns
cost overrun not within contractor's control - subsurface site conditions	developer	stand-by finance facility drawn	stand-by debt facility reduced and unavailable for other contingencies	increase financing costs; equity return reduced
Failure of contractor to satisfy performance guarantees at	contractor	performance guarantees in construction contract; liquidated	creditworthiness of contractor to pay	creditworthiness of contractor to pay may affect equity return

completion due to contractor fault		damages for reduced performance payable by contractor		
Increase interest during construction period	power purchaser	stand-by finance facility drawn until tariff adjustment is made	stand-by debt facility recoded and unavailable for other contingencies	increase financing costs offset by increased tariff, but timing of adjustment may reduce equity returns
unfavorable exchange rates during construction period	power purchaser	stand-by finance facility drawn until tariff adjustment is made	stand-by debt facility recoded and unavailable for other contingencies	increase financing costs offset by increased tariff, but timing of adjustment may reduce equity returns
country risk - expropriation, nationalization, interference	Central government	government pays debt and guaranteed equity return to developer	government creditworthiness	government creditworthiness

(HOFFMAN, 2007)