IJEEP

INTERNATIONAL JOURNAL OF ENERGY ECONOMICS AND POLICY

EJ EconJournals ISSN: 2146-4553

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2015, 5(2), 612-623.

EJ EconJournals

Evolution of Risks for Energy Companies from the Energy Efficiency Perspective: The Brazilian Case

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ABSTRACT

This study aims to evaluate whether energy savings from energy efficiency programs in Brazil affected the risks taken by energy companies during the period 2000-2013, based on the following research question: can we assume that energy conservation programs affect return risks to electrical energy companies? The results obtained through risk assessment models, exponentially weighted moving averages, and the capital asset pricing model indicated that during periods of crisis, both volatility and required returns were higher, but during less difficult periods, risks taken were significantly reduced. Further, as research contribution, this research suggests the elimination the affirmative hypothesis that a possible increase in energy efficiency affects the risks taken by electrical energy companies.

Keywords: Capital Asset Pricing Model, PROCEL, Energy Conservation Programs
JEL Classifications: E30, G38, K23, M48, Q4

1. INTRODUCTION

After the oil crisis in the 1970s, and given the excessive reliance on this non-renewable energy source (Dixon et al., 2010; Geller et al., 2006; Lee and Zhong, 2015), which in 2005 still accounted for around 40% of both the Brazilian and world energy needs, its risk of depletion has been constant. Investments have been made in alternative energy sources and energy conservation, as well as efficiency, which is one of the main concerns involving electrical energy (Pinto Jr et al., 2007; Guerra et al., 2014; Taffarel et al., 2015).

According to Pinto Jr et al. (2007) and Taylor et al., (2008), hydroelectricity accounted for 6% of the world energy matrix and around 13% in Brazil in 2005. According to a report published by the Ministry of Mines and Energy (MME, 2007) in collaboration with the Brazilian Energy Research Company titled “2030 National Energy Matrix” (2007), hydroelectricity accounts for 19% of the world’s electrical energy, 75% of the installed power in Brazil, and supplies 93% of the total electrical energy required by the National Interconnected Energy System. The same report shows that only 30% of the national hydropower potential is explored, indicating a growth potential for this sector (Guerra et al., 2014).

The demand for energy, according to Castro et al. (2013), is closely related to trends in the level of economic activity, technological paradigms (Emodi et al., 2015), and economic structure. This relationship is not constant, and is essentially characterized by scarce energy resources and the efficient use of energy, as described in Phylipsen et al’s., 1997 study.

According to the National Energy Efficiency Plan (PNEE) published in 2011, one of Brazil’s main initiatives towards energy conservation was the creation of a National Electrical

Energy Conservation Program - PROCEL (Geller et al., 2000; Can et al., 2014) in 1985. This program's main objective was to publish and distribute materials on the efficient use of electrical energy, conduct specialized training, impose technical regulations, create laboratories and labeling programs, among others. From 2000 onwards, Law 9.991 determined the mandatory investments of electrical energy distributors in energy efficiency programs, who generated investments of around R$2 billion (MME, 2011).

Therefore, electrical energy companies are affected in two-ways: they are required to allocate resources from their own profits towards energy efficiency programs (Hobbs et al., 1994; Scott et al., 2008; Kama and Kapalan, 2013) and face reduced demand due to greater efficiency. It seems contradictory that energy companies encourage a reduction in demand for electricity. Therefore, can we assume that energy conservation programs affect return risks to electrical energy companies? The main contribution of this study is to analyze whether energy efficiency programs affect the risks of energy companies and attempt to define a possible fragility of the system. The PROCEL program is addressed here as the legislation used in such program implementation.

2. THEORETICAL-EMPIRICAL FRAMEWORK

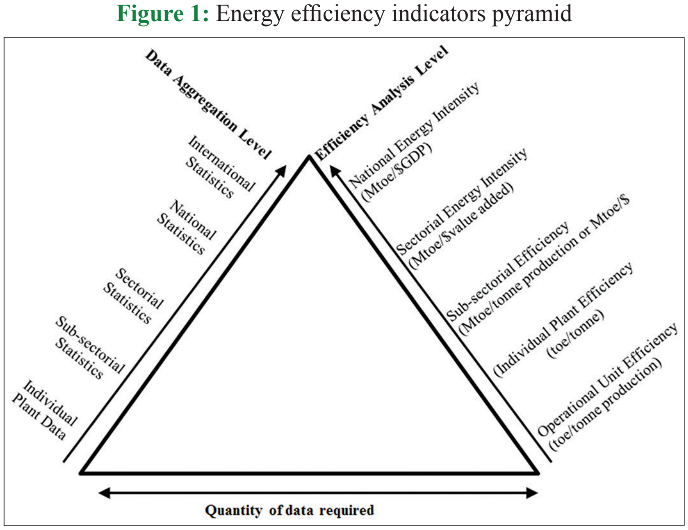
This study is based on two apparently distinct research areas: (1) research and application in energy efficiency, and (2) financial risk calculation methods.

2.1. Energy Efficiency

Figure 1 represents the energy efficiency indicators (Vikhorev et al., 2013), and demonstrates that efficiency may occur from the bottom of the pyramid (equipment efficiency) to the top (efficiency of the economy as a whole).

Tanaka (2011) stresses on the relationship between energy efficiency policies and industry, trade associations, the government,

Figure 1: Energy efficiency indicators pyramid



Source: Phylipsen et al., (1997) and Vikhorev et al. (2013)

and the economy as a whole. In his 2011 model, he classifies energy efficiency measures as prescriptive measures, economic measures, supportive measures, and direct investments (Arroyo et al., 2014). This energy efficiency model corresponds with the energy efficiency pyramid, as its policies or measures may be applied to equipment or the economy as a whole.

According to Lucon and Goldemberg (2009), in the developed Organization for Economic Co-operation and Development countries, energy efficiency accounted for 58% of the total profits in 2005. This is largely due to the legislation forcing manufacturers to produce more efficient equipment. In Brazil, the most popular energy efficiency program is PROCEL. According to institutional information, the program was created in 1985 by the Ministries of Mines and Energy and Industry and Commerce. In the following 25 years after its creation, the following subdivisions responsible for energy efficiency were incorporated: Procel Info (information); Procel Edifica (Buildings); Procel Selo (equipment); Procel Indústria (industry); Procel Sanear (environmental sanitation); Procel EPP (public buildings); Procel GEM (municipalities); Procel Educação (education); and Procel Reluz (public lighting). According to PROCEL results (2013) published by Eletrobrás, using 2012 as the base year, these subdivisions saved 9097 GWh by implementing energy efficiency measures, which accounts for 2.03% of the total consumption of electrical energy in Brazil (Eletrobrás, 2013).

This study does not focus on discussing all the activities of PROCEL, but focuses on its main objective, i.e., reducing energy consumption via efficiency measures. The efficiency program here is identified by the regulations (Leme et al., 2014) created to support it. Table 1 classifies the regulations by date.

2.2. Risk Assessment Models

The risk is the probability of receiving a return on investment other than the expected amount (Fama and French, 2007). Risk does not include negative results, in other words, returns that are less than the expected amount alone, but also includes positive results, being returns that are more than the expected amount. Investors are expected to maintain a balance between risks and returns (Hung et al., 2003). Risk is represented by the variances of expected returns (Damodaran, 2010; Ghysels et al., 2014).

According to Alexander (2005), the two-variance models used to represent risk (volatility) are: equally weighted moving average - EQMA (Morgan, 1996) and exponentially weighted moving average - EWMA (De Santis et al., 2003). The first model assigns the same weight, considering present and past observations, while the second assigns greater weight to recent observations, considering the exponential decay. Variances of these models may be represented as follows:

$$\begin{aligned} &\text{EQMA} \qquad \hat{\sigma}^2 = \sum_{i=1}^{n} r_{t-i}^2 / n \\ &\text{EWMA} \quad \hat{\sigma}^2 = (1-\lambda) r_{t-1}^2 + \lambda \hat{\sigma}_{t-1} \end{aligned} \tag{1}$$

According to Bueno (2010), such techniques may be applied if the series do not present trends or seasonality (Costantini and

Table 1: National regulations related to energy efficiency

Date	Regulations and associated projects	EE
December 30, 1985	Directive 1.877 – National Electrical Energy Conservation Program (PROCEL)	EE
January 9, 1987	Decree 93.901 – Electrical energy rationing criteria	RZ
October 26, 1990	Decree 99.656 – Internal Commission for Energy Conservation (CICE)	EE
November 23, 1993	Decree 34.979 – State Program for Energy Conservation in Buildings	EE
December 8, 1993	Decree 0-002 – Creates the National Award of Energy Conservation and Rational Use	CS
December 8, 1993	Decree 0-006 – Creates the Green Seal of Energy Efficiency	EE
January 11, 1994	Decree 1.040 – Conservation project funding by financial agents	CS
November 12, 1997	Directive 466 – Provides general conditions of electrical energy supply	O
August 13, 1998	Directive 001 – Creates a workgroup to study energy efficiency	EE
December 2, 1999	ANEEL Resolution 334 – Projects aiming to improve load factor	EE
January 6, 2000	Decree 3.330 - Goal of energy consumption reduction in public bodies	RC
July 24, 2000	Law 9.991 – Establishes mandatory resource allocation to R&D and energy efficiency	EE
November 14, 2000	Decree 19.147 – Electrical energy consumption reduction in public buildings	RC
November 29, 2000	ANEEL Resolution 456 – Establishes electrical energy supply conditions	O
January 1, 2001	Law 3.486 – Installation of solar energy and gas heating equipment in Varginha	EQ
January 26, 2001	Decree 45.643 – Procedures for high-performance lamp acquisition	EQ
March 7, 2001	Directive 46 – Creates the Energy Conservation Goal Supervision Committee	CS
April 18, 2001	Decree 3.789 – Offer and Consumption Rationalization Management Commission	RZ
April 26, 2001	Decree 3.806 – Addresses emergency measures for energy rationalization	RZ
May 4, 2001	Decree 45.765 – State Program for Energy Use Reduction and Rationalization	RZ
May 15, 2001	Provisional Measure 2.147 – Electrical Energy Crisis Management Chamber (GCE)	CM
May 22, 2001	CGCE Resolution 004 – Special regimes of billing, usage limits, and supply	TR
May 25, 2001	Directive 174 – Creates the internal commission for energy consumption reduction	RC
July 16, 2001	Decree 3.867 – Defines where the energy efficiency R&D resources will be deposited	EE
September 17, 2001	ANEEL394 Resolution – Criteria for projects that fight against waste	DS
October 17, 2001	Law 10.295 – National Policy of Energy Conservation and Rational Use	CS
December 19, 2001	Decree 4.059 – Minimum levels of efficiency for equipment	EQ
December 19, 2001	Law 10.334 – Regulates incandescent bulb manufacture and marketing	EQ
February 25, 2002	Decree 4.145 – Regulates emergency consumption goal	MC
March 15, 2002	Directive 113 – Establishes a consumption goal for public bodies	MC
April 29, 2002	Law 10.438 – Expansion of emergency electrical energy offer	O
July 26, 2002	Decree 21.806 – Book of charges for energy efficiency in public buildings	EE
September 3, 2002	ANEEL Resolution 492 – Criteria for resource allocation to energy efficiency	EE
December 11, 2002	Decree 4.508 – Minimum levels of energy efficiency of electric engines	EQ
March 18, 2004	CC-23 Resolution – Creates a technical group to study and propose best practices	EM
January 1, 2005	Law Project 518 – Municipal policy of incentives for using alternative sources	EM
March 30, 2005	Law 4.507 – Installation of solar heaters in Birigui	EQ
September 29, 2005	CC-64 Resolution – Technical group of the Public Management Quality Committee	EM
November 28, 2005	ANEEL Resolution 176 – Criteria for resource allocation to energy efficiency	EE
December 8, 2005	Inter-ministerial Directive 553 – Performance of electric 3-phase induction engines	EQ
January 1, 2006	Law Project 1.045 – Piping facilitating the adoption of solar heating system	EQ
March 28, 2006	ANEEL Resolution 215 – Changes in the efficiency program manual	EE
June 12, 2006	Inter-ministerial Directive 132 – Regulation for compact fluorescent lamps	EQ
October 24, 2006	ANEEL Normative Resolution 233 – Calculation of resources foreseen in Law 9.991	EE
July 1, 2007	Law 14.459 – Installation of solar water heating system	EQ
January 21, 2008	Municipal Decree 49.148 – Solar heating system in the municipality of São Paulo	EQ

Source: http://www.procelinfo.com.br and the National Energy Efficiency Plan (2011). EE: Energy efficiency, RZ: Rationalization, CS: Conservation, O: Offer, RC: Reduced consumption, EQ: Equipment, CM: Crisis management, TR: Tariff (billing), EM: Energy management

Martini, 2010), indicating the presence of self-correction and stationarity (Box et al., 1994). The augmented Dickey-Fuller test[1] is typically used to verify a series. Silva et al. (2010) concluded that EWMA was the model that adapted better, considering the estimation of value at risk, and was based on a theoretical portfolio of stock price indexes from Argentina, Brazil, and Mexico.

Fama and French (2004; 2007) present the capital asset pricing model (CAPM) as one of the widely used models in the estimation of capital cost and return assessment of portfolios. The original model was proposed by Sharpe (1964), Lintner (1965) and Black et al., 1972, and was based on the efficient portfolio theory of Markowitz (1959). Markowitz (1952) emphasizes that risk in the financial area is measured by the variance of returns or the deviation from the average. Sharpe (1964) points out that asset prices have a close relationship with risk, measured by the beta

1 According to Gujarati and Porter (2011), the Dickey-Fuller test uses statistics (tau) τ to observe whether the series is a random walk (with and without displacement or a temporal trend), considering the white noise of error values. Given a simple random walk $Y_t = \rho Y_{t-1} + u_i$ transforming $Y_t - Y_{t-1} = (\rho-1)Y_{t-1} + u_i$, with $\delta = (\rho-1)$, testing null hypothesis H0: $\delta = 0$ is the same as testing $H0$: $\rho = 1$. For cases in which errors are correlated, the values with deviations from the dependent variable are summed up. Currently, it is known as the augmented Dickey-Fuller test, represented in a complete equation with displacement and temporal trend as $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t$.

coefficient, and that investment decisions are constructed from two variables: (i) the mathematical expectation of returns, and (ii) the standard deviation from the probability distribution.

In Brazil, this classic model was introduced by Alcântara (1981) and was viewed as a popular model in the European and American financial markets, which was subsequently used by select institutions in the Brazilian market. This study was selected as the base for raising questions regarding the objectives of this article, namely, the challenges involved in measuring risk and returns based on the selection of every possible event, and its implications in terms of risk and return. CAPM is based on certain essential concepts: (i) efficiency of the capital market – The stock prices reflect all available information, which is the same as the fair price; (ii) based on the utility theory, investors are opposed to risks, and make their rational combinations based on a logic of a map of indifferences that take risk and return into account; (iii) existence of an efficient portfolio that is superior in terms of risk and return, which is represented by a market index; and (iv) risk-free assets. According to Alcântara (1981), this model can be represented as follows:

$$R_j - R_F = \alpha_j + \beta_{jM}(R_M - R_F) + r_j \quad (2)$$

Where, R_F is a risk-free asset; $R_j - R_F$ is the stock excess return; $R_M - R_F$ is the market excess return; α_j is the additional stock return when the market excess return is zero; β_{Jm} is the sensitivity of stock return excess in relation to the market return excess; and r_j represents the uncertain portion of the extra market component of the stock return excess. According to Alcântara (1981), when the model terms are reorganized, we obtain the following:

$$R_j - R_F = \left\{\begin{array}{c}\beta_{jM}\left(R_M - R_F\right)\\ \text{return component}\\ \text{due to market}\end{array}\right. + \left\{\begin{array}{c}\alpha_j + r_j\\ \text{return component due to}\\ \text{extra-market factors}\end{array}\right. \quad (3)$$

Therefore, α_j represents the expected return excess portion that is not related to the market, while r_j represents deviations from the expected return that do not depend on the market. Extra-market risk (diversifiable or non-systematic risk) may be measured through the dispersion of return excess owing to extra-market factors. Essentially, they are deviations in linear regression. Based on the idea that a non-systematic risk can be diversified, the model places more emphasis on the systematic risk component, represented:

by β_{jM} or $Cov(R_M, R_j) / \sigma^2 R_M$, covariance between stock and market divided by market profits, and such a model may be represented as follows:

$$E_{R_j} = R_F + \beta_j(E_{R_M} - R_F) \text{ reorganized as } E_{R_j} - R_F = \beta_j(E_{R_M} - R_F) \quad (4)$$

It should be noted that components α_j, r_j were not included in the equation above because they are part of the diversifiable risk. This equation can be interpreted as follows: the expected return of a stock depends on the risk-free return rate adopted and marked excess return weighted by the behavior of such stock in relation to the market behavior, which is measured by beta (Alcântara, 1981). This model receives strong empiric criticism by Fama and French (2004; 2007), who propose a model of three factors as an alternative. This study does not intend to discuss the model. However, Saito and Bueno (2007) consider it valid, while others do not.

Several studies in the extant literature aim to test the proposals of the original CAPM. Castro Junior and Yoshinaga (2010) propose an extension based on co-skewness and co-kurtosis, using a panel data technique; Araújo et al., (2006) test the GDP as a proxy for market portfolios; Tambosi Filho et al. (2006) work with conditional models, with beta that varies along time. According to these authors, beta variation studies are not very common, probably because the conclusions of the studies conducted by Fama and MacBeth (1973), Black et al., (1972), suggest that beta is static, and indicating that the systematic risk would not change with time.

According to ANEEL's technical note 49/2013-SER, the CAPM and Weighted Average Cost of Capital (Modigliani and Miller, 1958; 1963) models are used to establish the capital costs of providing electrical energy transmission services.

> *The cost of equity capital is the return rate that investors require to invest their capital in a company associated with a certain activity. ANEEL has adopted the CAPM to calculate the cost of equity capital (sheet 6 of Technical Note 49/2013).*

Although CAPM is the capital cost method used in beta calculations, even considering local bet as the ideal, the report uses mean beta from electrical sector companies in the United States, which have a levered beta of 0.7009 and unlevered beta of 0.27. According to the report, beta from the United States was used owing to the following: (a) data quality and quantity regarding energy transmission; (b) immature capital markets; (c) insufficiently extensive time series; (d) high volatility of stock; and (e) low liquidity in many cases.

3. METHODOLOGICAL PROCEDURES

The proposed methodology has to be aligned with the availability of information and tools. The regulations and projects related to energy efficiency (energy saving) will be used as a secondary information source, as a proxy of energy efficiency measures, as well as to extract prices of historic series of stocks from the Economatica database (http://economatica.com). EQMA/EWMA and CAPM were presented as risk/return assessment techniques. A central question that needs to be addressed at this stage is how to support the methodology? To answer this, two citations are presented below:

> *The challenges in measuring risks and returns may be understood if we imagined an analyst trying to outline every possible event (a stock price, for instance) and estimate its probability of occurring and the effect of every price on the investment alternatives* (Alcântara, 1981. p. 56). *If general economic trends are stable, industry characteristics remain relatively unchanged, and there is a continuous management of companies, beta measurement will be relatively stable when calculated for different periods. If these conditions of stability do not exist, the beta value will also vary* (Alcântara, 1981. p. 62).

By analyzing whether the Brazilian energy conservation program impacted the risks/returns of electrical energy companies, every regulation/program presented in Table 1 can be considered as an event, the following problem refers to, according to the citation above, estimating the probability of every event on the stock of every electrical energy company, and that may be tautological, as considering 2001, for instance, with many events occurring close to each other, how to identify which event is affecting the analyzed variable? Table 1 shows that most events take place in 2000-2001, which is a period of crisis, as analyzed mainly by Goldenberg and Prado (2003).

According to Damodaran (2010), in addition to the market risks that affect all companies and the risks taken by a specific company, as literature gap, we find risks that affect an entire sector. Therefore, this study essentially establishes that energy efficiency events affect the entire electrical sector. Therefore, the objective is to analyze the risk/return stability of the electrical sector during the period of intense energy efficiency measures to the present day.

3.1. Data Collection and Sampling

During the analyzed period, starting 2000, energy efficiency programs were intensified, as indicated in Table 1. Stock prices were extracted from the Economatica database, with sectorial classification as potential samples. An investigation of the energy sector generated 85 potential stocks for analysis, and of these, ten stocks with valid weekly data were found in the period from early 2000 to 2013. To assign other sectors as controls, the same technique was applied to all sectors of Economatica, using the sectors with four or more stocks negotiated with valid data, as indicated in Table 2.

Data of weekly saving accounts were also collected from the database as a proxy of the risk-free rate and IBOVESPA as a proxy of the market portfolio. Raw data were collected over a total of 729 weeks for every series, from January 7, 2000 to December 20, 2013.

Table 2: Sample - Stocks by sector

Sector	Stocks
Energy	Celesc PN, Cemig ON, Cesp ON, Coelce PNA, Copel ON, Eletrobras ON, Emae PN, Light S/A ON, Tractebel ON, Tran Paulist PN
Metallurgy	Ferbasa PN, Forja Taurus PN2, Gerdau PN, Gerdau Met PN, Sid Nacional ON, Usiminas PNA
Telecommunications	Embratel Part PN, Oi PN, Telebras ON, Telef Brasil ON, Tim Part S/A ON
Finance/Insurance	Amazonia ON, Bradesco ON, Brasil ON, ItauUnibanco PN

Source: Economatica[2]

3.2. Analysis Metrics and Model Variables

Given the proposed problem, a metric system that naturally emerges is the application of a panel analysis, or a data combination in temporal series with cross sections. Panel data can be used to capture a possible heterogeneity, either between groups or in time (Arroyo et al., 2014; Tagi, 2005; Gujarati and Porter, 2010; Hill et al., 2010; Nauleau, 2014; Wooldridge, 2010).

Essentially, three methods are available to analyze panel data: the pooled model, the fixed effects model, and the random effects model (REM), represented in the matrix forms below:

$$\begin{array}{lll} 1 \quad \text{Pooled Data} & \equiv & y_{it} = \alpha + \beta X'_{it} + \mu_{it} \\ 2 \quad \text{Fixed Effects} & \equiv & y_{it} = \alpha_i + \beta X'_{it} + \mu_{it} \\ 3 \quad \text{Random Effects} & \equiv & y_{it} = \beta X'_{it} + (\varepsilon_i + \mu_{it}) \end{array} \quad (5)$$

Where y_{it} is the vector of independent variable of i^{th} individual in t time units; X'_{it} is the matrix of dependent variables of i^{th} individual in t time units; α, β are the vectors of coefficients; and $\varepsilon_i + \mu_{it}$ are the vectors of errors, respectively.

As introduced by Tagi, 2005; Gujarati and Porter, 2010; Wooldridge, 2010; Croissant and Millo, 2008; Katchova, 2013, model 1 (pooled data) consists of constant coefficients, where α and β present no variation between individuals or in time. In model 1, it is assumed that individuality is represented by μ_{it}. In model 2 (fixed effects), it is assumed that heterogeneity between individuals is represented by intercept α_i; in this model, variables not observed as represented by α_i are correlated with μ_{it}. In model 3 (random effects), heterogeneity between individuals is represented by error ($\varepsilon_i + \mu_{it}$), ε_i is randomly distributed, i.e., it is not correlated with regressors. If ε_i is correlated with repressors, the fixed effects model is the most appropriate.

There are at least five ways to estimate the models above based on (Croissant and Millo, 2008; Katchova, 2013ab):
1. Pooling (uses both variation between and within groups)
2. Between (uses variation between groups)
3. Within (uses variation within groups)
4. Random (uses the weighted mean between variations within and between groups)
5. First difference (uses the first difference).

The model that better fulfills the needs of the proposed problem is model 2 (fixed effects), as this model may be estimated according to Gujarati and Porter (2010), through dummy variables, for both individuals and in time (one-way or two-way)[3]. As its purpose is to analyze how the sectorial risk behaved along time, 10 companies along 728 weeks, representing 14 years, a version of the one-way fixed effects model for time can be adapted as follows:

2 Even with the procedure referred above, the following missing data were identified in the sample: Coelce PNA [24/08/2001] – Emae PN [16/11/2012; 12/07/2013; 09/08/2013; 01/11/2013] – Amazonia ON [13/12/2002; 31/01/2003; 07/02/2003; 22/04/2005; 17/06/2005; 27/01/2006; 24/02/2006] – Ferbasa PN [15/02/2002] – Embratel Part PN [09/09/2011; 14/10/2011; 06/01/2012; 29/06/2012; 21/09/2012; 21/12/2012; 15/02/2013; 22/02/2013; 05/04/2013; 31/05/2013; 28/06/2013] – Telebras ON [04/05/2012; 11/05/2012; 18/05/2012; 12/07/2013; 06/09/2013; 13/09/2013; 20/09/2013], representing {31/(25*729)}*100 = 0.17% of total. The technique used to correct the problem was the assignment of closest value, according to Hair et al. (2009), where missing data are replaced with real values using the closest case. In this specific case, the stock price from the previous week was used.

3 The problem of a two-way model with dummy variables recognized by both Gujarati and Porter (2010) and Baltagi (2005) is the large number of variables the model has to handle, which makes the analysis of a small sample not viable.

$$Y_{10-14} = \alpha_{14} + \beta_{14} X_{10-14} + DT_{1\to13} + DTX_{1\to13} + \mu_{it} \qquad (6)$$

Where, $Y_{10-14} = E_{R_j} - R_F$ is the expected return from 10 stocks in 14 years;

$\beta_{14} X_{10-14} = \beta_j (E_{R_M} - R_F)$ represents beta from 10 stocks in 14 years;

$DT_{1\to13} + DTX_{1\to13}$ represents 26 dummy variables of intercept and time interaction.

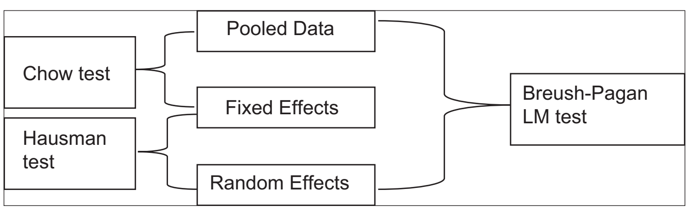
Although this model is equivalent to the estimator within groups (within), as introduced by Gujarati and Porter (2010), this study also presents other estimators with their respective statistical tests, for comparison purposes, as illustrated in Figure 2. A similar approach was adopted by Resende (2014).

4. DATA PRESENTATION AND ANALYSIS

4.1. Evolution of Risk

To begin explaining the problem, two questions are asked: how has the market risk represented by IBOVESPA volatility progressed during the analyzed period? How has the energy sector risk progressed by considering the stocks in Table 2? Figure 3 represents the evolution of market risk (volatility) represented by the IBOVESPA index.

Figure 2: Tests in data panel models



Source: Developed by the authors

Figure 3 indicates that at least two conclusions can be made: (i) the level of volatility is lower at the end of the period, and (ii) there are two periods of higher volatility as represented by the circles in the Figure 3. The former refers to reduced volatility at the end of the period, i.e., a lower risk. The latter refers to exogenous shocks, which at first, does not establish an exact cause-effect relation, given the multiple events between 2000 and 2002. In the case of the subprime crisis, the cause-effect relationship is more evident owing to a higher volatility. Figure 4 shows the return volatility by considering the stocks presented in Table 2.

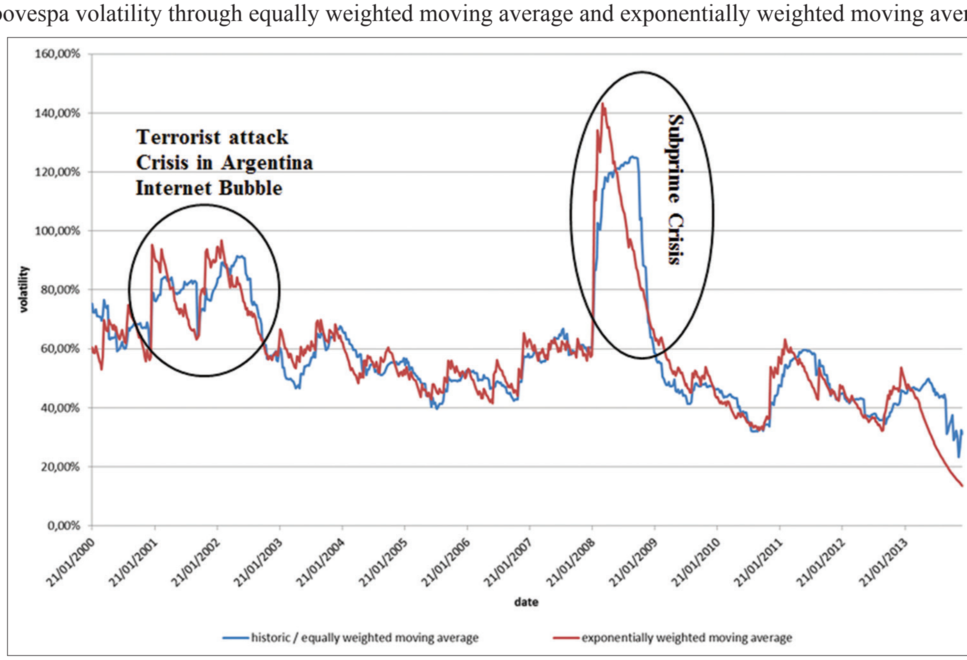
Figure 4 shows return volatility for collective stocks presented in Table 2. Based on Damodaran (2010) study involving the sector risk component and market risk, one question that naturally emerges is: when analyzing Figure 4, what are the factors that can be attributed to sector risk and market risk?

Considering that the total risk is the sum of sector risk and market risk, the differences in Figures 3 and 4 can be attributed to the sector risk. The square in Figure 4 shows that between 2000 and 2004, the energy sector volatility represented by the sample stocks is greater than the market volatility. According to Table 1, this period had the creation of more than 50% of regulations related to energy efficiency. According to Gomes and Vieira (2009), owing to a lack of investment, a crisis period occurred in 2001, leading to rationing.

Goldenberg and Prado (2003) believe that the peak energy crisis was a result of reforms that occurred in the Fernando Henrique Cardoso government, with respect to de-verticalization,

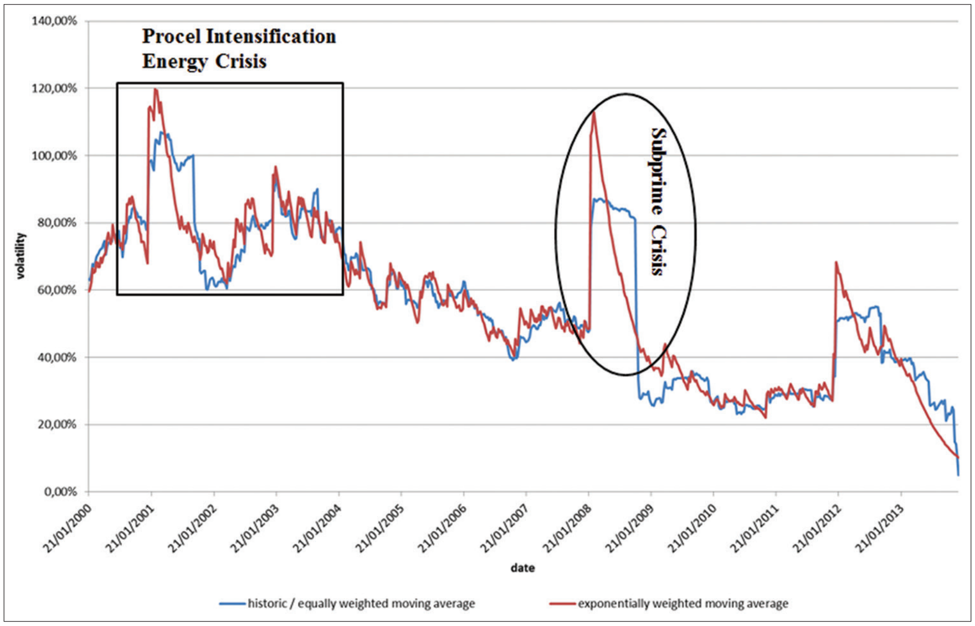
4 It is possible to implement these methods, because the series of Figures 3 and 4 did not present unit root at the level of 99% reliability, when using GRETL software. The tests were conducted under the following hypotheses: (a) Without constant; (b) With constant; (c) With constant and TREND.

Figure 3: Ibovespa volatility through equally weighted moving average and exponentially weighted moving average[4] methods



Source: Research data

Figure 4: Energy sector volatility through EQMQ and exponentially weighted moving average methods



Source: Research data

privatization, and increased competition. According to Goldenberg and Prado (2003), there were differences between market interests and social interests, considering that Eletrobrás coordination was not in place anymore, and there was the absence of clearly developed regulation, resulting in reduced investment low levels of reservoirs in 2001, which resulted in the consequent instability of the sector (which experienced blackouts and rationing).

According to a report from the Brazilian Federal Accountability Office (TCU, 2009), after the blackout, R$ 32.2 billion was invested in 2003, of which 60% came from tariff increases and the remaining from the National Treasury. Post investment, stock volatility significantly reduced, thereby worsening the subprime crisis and the 2012 crisis.

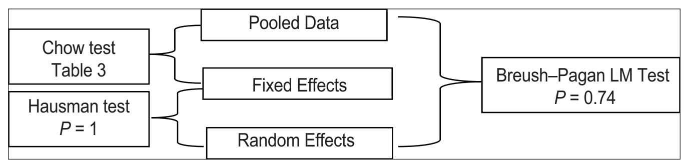
4.2. Expected Return and Risk

The expected return measured via CAPM also indicates the risk, considering that to invest in an asset of greater volatility (variance), the investor requires a higher return rate, as presented in Alcântara's (1981) study. Equation 6 from data panel model was used to estimate the beta value in Box 1, with the saving rate as a proxy for risk-free assets.

Data from Box 1 were estimated using four different estimation techniques: least squares dummy variables (LSDV); ordinary least squares in first difference; REM; and ordinary least squares with pooled data. The estimations were entered into the GRETL econometric software and in an R plm pack, and both systems provided the same results.

As beta represents systematic risk, the four estimation techniques showed that the energy sector risk is lower than the market risk,

Figure 5: Results from statistical tests



Source: Developed by the authors

Table 3: Chow test for data structure

Stock	*P* value	*F*-statistics
Celesc PN	0.036**	3.35
Cemig ON	0.021**	3.87
Cesp ON	0.214	1.54
Coelce PNA	0.725	0.32
Copel ON	0.051*	2.99
Eletrobras ON	0.002***	6.07
Emae PN	0.011**	4.57
Light S/A	0.004***	5.48
Tractebel ON	0.331	1.11
Tran Paulist PN	0.001***	6.90

Source: Developed by the authors based on research data. *Significant at 10% **Significant at 5%; ***Significant at 1%

with high statistical significance. One interpretation of beta values obtained is that for every R$ 100 return required by the market, the energy sector requires around R$ 86 if using the fixed effects estimation (LSDV) is used and R$ 82 if REM is used. The results from statistical tests with these models are presented in Table 3 and Figure 5.

Table 3 presents the Chow test for beta structure division, i.e., series division in two, if the test is significant, evidence provided to state betas may differ along the time; according to the Table 3, 7 out of 10 stocks presented significant values in the Chow test. Figure 5 summarizes the results of statistical tests as follows: both the Chow test and the Hausman test provide greater evidence for fixed effects, and the Breusch–Pagan LM test shows the supremacy of the pooled data model when compared to the random effects model. In summary, the tests indicate that the fixed effects model (LSDV) may be a proper estimation model.

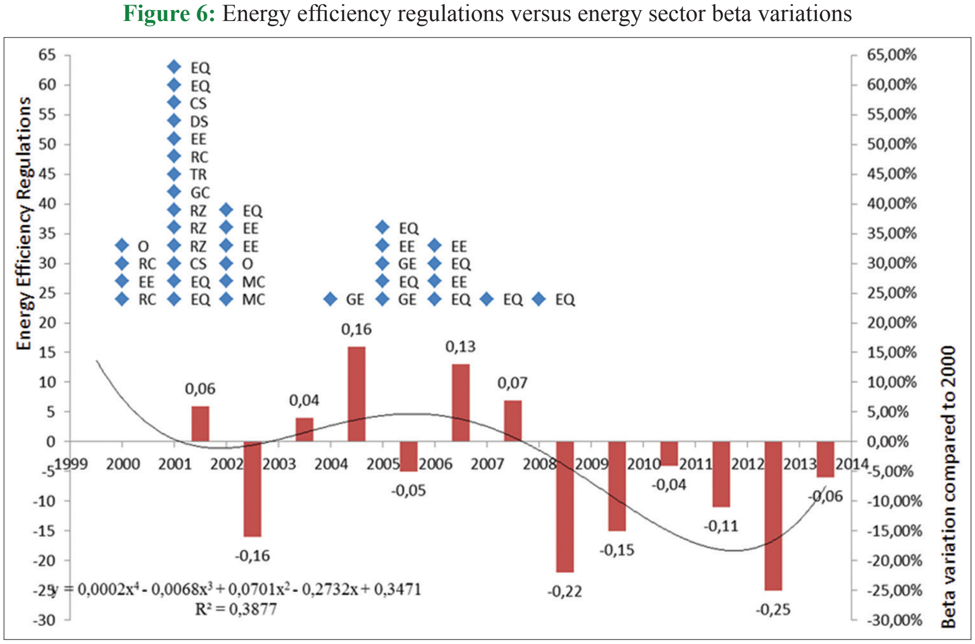
Based on these considerations for a control factor, beta values were estimated for three other sectors: metallurgy (0.826); finance/insurance (0.855); and telecommunications (1.033). Only the telecommunications sector presented a slightly higher risk then the market risk, as indicated in Box 2.

Box 1: Beta value calculated through different data panel estimators

Models	LSDV		OLSFD		REM		OLSPD	
Constant	0.004*	(1.84)	0.001	(0.531)	0.001	(1.13)	0.001	(1.26)
Beta	0.867***	(23.09)	0.854***	(20.15)	0.822***	(81.07)	0.823***	(81.06)
DT1	−0.001	(−0.20)	−0.034	(−1.29)	-	-	-	-
DT2	−0.009**	(−2.54)	−0.044	(−1.19)	-	-	-	-
DT3	−0.006	(−1.62)	−0.083*	(−1.85)	-	-	-	-
DT4	−0.006*	(−1.81)	−0.089*	(−1.72)	-	-	-	-
DT5	−0.004	(−1.19)	−0.104*	(−1.79)	-	-	-	-
DT6	−0.003	(−1.03)	−0.127**	(−2.01)	-	-	-	-
DT7	−0.005	(−1.53)	−0.135**	(−1.96)	-	-	-	-
DT8	−0.003	(−0.85)	−0.190**	(−2.57)	-	-	-	-
DT9	−0.004	(−1.25)	−0.228***	(−2.91)	-	-	-	-
DT10	−0.004	(−1.28)	−0.226***	(−2.74)	-	-	-	-
DT11	0.001	(0.20)	−0.204**	(−2.36)	-	-	-	-
DT12	−0.008**	(−2.54)	−0.270***	(−2.99)	-	-	-	-
DT13	−0.003	(−0.80)	−0.316***	(−3.37)	-	-	-	-
DT1B	0.058	(1.23)	0.075	(1.47)	-	-	-	-
DT2B	−0.166***	(−3.14)	−0.149***	(−2.84)	-	-	-	-
DT3B	0.040	(0.81)	0.036	(0.64)	-	-	-	-
DT4B	0.161***	(2.78)	0.099	(1.63)	-	-	-	-
DT5B	−0.046	(−0.82)	−0.015	(−0.25)	–	-	-	-
DT6B	0.130	(2.47)	0.096*	(1.66)	-	-	-	-
DT7B	0.070	(1.17)	0.073	(1.10)	-	-	-	-
DT8B	−0.223***	(−4.60)	−0.19***	(−3.66)	-	-	-	-
DT9B	−0.159***	(−3.00)	−0.127**	(−2.28)	-	-	-	-
DT10B	−0.037	(−0.63)	−0.024	(−0.40)	-	-	-	-
DT11B	−0.107**	(−2.04)	−0.133**	(−2.38)	-	-	-	-
DT12B	−0.249***	(−3.99)	−0.302***	(−4.35)	-	-	-	-
DT13B	−0.055	(−0.71)	−0.046	(−0.56)	-	-	-	-
R^2 adjusted	0.48		0.47		0.47		0.47	
P value	0.000		0.000		0.000		0.000	
DW	2.18		3.07		-		2.17	

Source: Research data. LSDV: Least squares dummy variables, REM: Random effects model, *Significant at 10% **Significant at 5%; ***Significant at 1%

Figure 6: Energy efficiency regulations versus energy sector beta variations



Source: Research data

Box 2: Beta values for the data panel LSDV estimator for different sectors

LSDV	Metallurgy		Finance/insurance		Telecommunications	
Constant	−0.001	(−0.50)	0.003	(1.05)	0.000	0.001
Beta	0.826***	(19.82)	0.855***	(18.23)	1.033***	(10.29)
DT1	0.007*	(1.92)	0.002	(0.43)	−0.002	(−0.25)
DT2	0.015***	(3.92)	−0.004	(−0.87)	−0.007	(−0.74)
DT3	0.006*	(1.66)	−0.003	(−0.79)	0.002	(0.23)
DT4	0.007*	(1.74)	0.000	(0.003)	−0.000	(−0.04)
DT5	−0.002	(−0.45)	−0.002	(−0.36)	−0.003	(−0.33)
DT6	0.004	(1.13)	−0.001	(−0.13)	0.001	(0.12)
DT7	0.008**	(2.01)	−0.002	(−0.42)	0.003	(0.28)
DT8	0.003	(0.68)	−0.004	(−0.83)	0.001	(0.19)
DT9	0.003	(0.78)	−0.003	(−0.58)	−0.000	(−0.05)
DT10	−0.001	(−0.22)	−0.003	(−0.65)	0.000	(0.00)
DT11	−0.004	(−1.16)	−0.002	(−0.51)	0.008	(0.94)
DT12	0.005	(1.34)	−0.002	(−0.48)	−0.003	(−0.36)
DT13	0.004	(0.98)	−0.000	(−0.10)	−0.004	(−0.43)
DTIB	0.085	(1.62)	0.063	(1.05)	−0.090	(−0.70)
DT2B	−0.041	(−0.75)	0.095	(1.53)	−0.158	(−1.20)
DT3B	0.092*	(1.69)	0.101	(1.64)	−0.052	(−0.39)
DT4B	0.1488**	(2.30)	0.034	(0.47)	−0.020	(−0.13)
DT5B	0.224***	(3.58)	0.045	(0.63)	−0.135	(−0.89)
DT6B	0.171***	(2.93)	0.173***	(2.64)	−0.006	(0.05)
DT7B	0.143**	(2.15)	0.262***	(3.50)	−0.038	(−0.23)
DT8B	0.278***	(5.16)	0.205***	(3.38)	−0.358***	(−2.76)
DT9IB	0.138**	(2.34)	0.061	(0.92)	−0.275*	(−1.94)
DT10B	0.292***	(4.46)	0.132	(1.79)	−0.262*	(−1.66)
DT11B	0.211***	(3.63)	0.096	(1.46)	−0.159	(−1.13)
DT12B	0.258***	(3.74)	0.125	(1.61)	−0.204	(−1.23)
DT13B	−0.087	(−1.00)	−0.025	(−0.26)	−0.321	(−1.54)
R^2 adjusted	0.63		0.67		0.23	
P value	0.000		0.000		0.000	
DW	2.12		2.18		2.55	

Source: Research data. LSDV: Least squares dummy variables. *Significant at 10% **Significant at 5%; ***Significant at 1%

The study question addresses risk variation, and whether such variations were influenced by energy efficiency programs. Boxes 1 and 2 tested risk variation via annual dummy variables. Box 1 shows a significant change in beta value in 7 of the total 13 compared[5]. Figure 6 depicts beta changes via a bar chart and energy efficiency events (regulations) in the inflection point chart.

Figure 6 shows that with more intense energy efficiency regulations, a trend was observed towards greater beta values when compared to the year 2000, and when the main energy efficiency program events stopped, the beta value was lower than that in the year 2000. Is it possible to state that the energy efficiency programs actually affected the risk taken by energy companies? In an attempt to answer this question, Figure 7 shows the differences in beta values for the metallurgy, finance/insurance, and telecommunications sectors, and, according to Box 2, the metallurgy sector presents the best statistical significances.

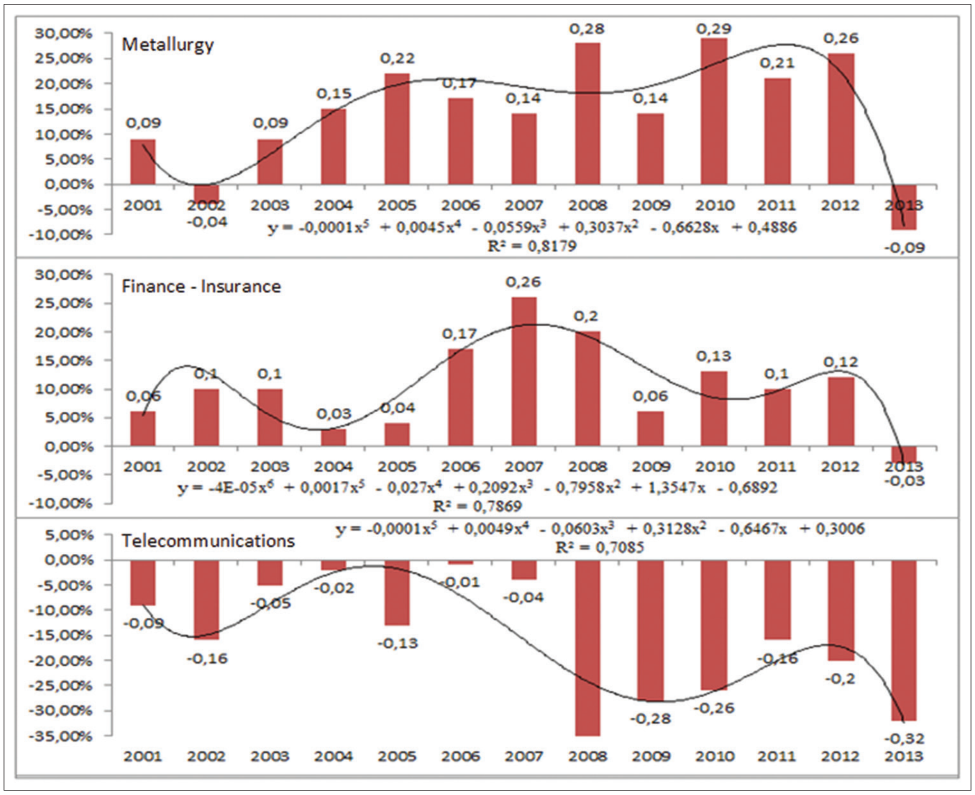
Figures 6 and 7 show that when compared to baseline year of 2000, non-energy sectors represented in Figure 7 show higher or lower beta values, while Figure 6 shows higher beta values until 2008 and lower beta values in the following years. Standard deviations and R^2 of beta change polynomial adjustment are: energy (0.131-0.39); metallurgy (0.115-0.82); finance/insurance (0.077-0.79); and telecommunications (0.118-0.71). The energy sector presented greater beta change variability represented by both variance and greater adjustment difficulty.

Figures 4, 6, and 7 are critical in studying the study question. According to the PNEE reports (2011), PROCEL invested around R$ 2 billion in energy efficiency programs. According to data from the TCU report, to mitigate the blackout crisis, almost R$ 40 billion was invested in 2003 alone. The evidence suggests that if the energy efficiency program had any impact on the risk taken by energy companies, the bar chart in Figure 6 would have to show a positive trend during or after the implementation of regulations; but both Figures 4 and 6 indicate risk as a reducing trend. It is difficult to establish a cause-effect relationship, but the period with the highest risk coincides with that of crisis, which is probably a serious cause-effect relationship: the crisis increased the risk of energy companies, requiring a more stable regulatory environment (Table 1), and after the implementation of such more stable regulatory environment, risks were reduced.

The first chart in Figure 7 shows a singular contradiction: while higher investments, increased tariffs and proper regulations favor reduced risks of energy companies. The scenario was different in the metallurgy sector when compared to the baseline year of 2000, where the risk was always high. The year 2013 was an exception, which may be explained by the strong participation of energy in the sector cost.

5 This result confirms that the Chow test is significant even if the sample is divided into 14 equal portions, unlike that in Table 3.

Figure 7: Beta variations for control sectors



Source: Research data

5. CONCLUSIONS

The objective this study was to analyze whether energy efficiency programs affect the risks of energy companies and attempt to define a possible fragility of the system, based on the following research question: can we assume that energy conservation programs affect return risks to electrical energy companies?

Based on research findings, the evidence from Figures 4 and 6 indicates reduced risks of the energy sector, then, the energy efficiency programs did not present such dimension to affect the risk of companies. Energy efficiency and energy conservation are more popular during periods of moments of energy crisis. As electrical energy is a non-replaceable resource for many devices and machines, during periods of crisis and increased risk, government intervention was required to reduce such risks. This is a scenario where 93% of energy consumed by the National Interconnected Energy System are produced by hydroelectric power plants. In an alternative scenario with a more distributed electrical matrix, for instance: solar, wind, and biofuel energy, the results presented in Figures 4 and 6 would probably be different. This context, there are two limitations to be noted: (i) the sample in Table 2 does not represent all the companies in a sector, but the most negotiated stocks; and (ii) the analysis of energy efficiency effects on the risks taken by energy companies was an indirect analysis, as a variable not directly observed.

As a research contribution, the results obtained through risk assessment models, exponentially weighted moving averages, and the CAPM indicated that during periods of crisis, both volatility and required returns were higher, but during less difficult periods, risks taken were significantly reduced. Beside, eliminated the affirmative hypothesis that a possible increase in energy efficiency affects the risks taken by electrical energy companies. For future research, we suggest the analysis of the effect of regulatory events and programs affect return risks in other energy segments such as oil and gas companies.

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