International Journal of Energy Economics and Policy
Vol. 5, No. 1, 2015, pp.288-304
ISSN: 2146-4553
www.econjournals.com

The Brazilian Electricity Energy Market: The Role of Regulatory Content Intensity and Its Impact on Capital Shares Risk

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ABSTRACT: This study analyzes the risk related effect of content intensity in regulatory legislation on the shares of the companies operating in the Brazilian electricity energy market. For this analysis, the regulatory legislation, enshrined in the Federal Constitution of 1988 until 2013 and addressed to the market, was captured and selected using the Markov Regime Switching model of Regime Change. The intensity of Regulatory Content (RC) in each legislative action was quantified through the content analysis technique. The results suggest that, when classified in event families, the risk impact on shares is different and gradual. Further, the individual analyses of the different types of events, classified according to the RC intensity, show that strong and average intensity events have a higher impact on the risk factors of shares of the companies that constitute the sector. Conversely, political or institutional decisions that have low intensity of RC are not perceived as significant in the market. As research contribution, the results presented confirm that regulatory events must be differentiated by type, since they have varying influences on regulatory risk. Moreover, this study demonstrates that the RC intensity is important, and in this case, the higher its presence, the greater the impact of the potential risk on the regulated sector's shares.

Keywords: Market Model; Capital Asset Pricing Model; Laws
JEL Classifications: E3; G38; K23; M48; Q4

1. Introduction

As a developing country, Brazil increasingly stands out on the world stage by positioning itself among the major world markets, showing significant current growth (OECD, 2014). In the energy sector, Brazil shows promise in terms of growth (Guerra et al., 2014) achieved over the last decade among all member countries of the Organization for Economic Cooperation and Development (OECD). In terms of electricity generation, the country went from 51.6 Terawatt hours (TWh) in 1971 to 531,8 TWh in 2011, showing an increase of 930,77%. In this context, the consumption of electricity has increased significantly in recent decades, mainly due to the increase in the Gross Domestic Product (GDP) and population growth (OECD, 2014).

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Power consumption is an important indicator in revealing societies development stages and standards in the world (Fullerton et al., 2014). Often, most of the consumption in developed and developing countries takes place in the industrial sector (Pottmaier et al., 2013). Electricity is the backbone of many companies, and it currently represents 17% of the total global energy demand, with a forecast to reach 23% by 2050 (IEA, 2010). To meet the growing demand, the power sector requires infrastructure expansion and technological development, which can only be supported with the participation of private capital (Xiong et al., 2013; Arroyo et al., 2014; Coskun and Huseyin, 2014). For this to happen, it is necessary for the governments to make long-term commitments and for the political situation to be deemed stable and predictable (IEA, 2010; Gomes et al., 2014).

Despite the private investors interest in the infrastructure sector (Gugler et al., 2013), much more is needed to arouse their interest in buying such assets. It is necessary for the State, responsible for the regulation of this sector (Coutinho and Oliveira, 2013), to ensure profitability and amortization of the capital invested. Otherwise, not enough people will be attracted to invest (Silveira Neto and Mendonça, 2011; Coskun and Huseyin, 2014; Gomes et al., 2014). In the global capital markets (Sobel, 2002), investors seek transparent and stable rules; the design of a regulatory system has a significant impact on the levels of systematic risk (Alexander, 1996, p. 15). Besides, regulatory uncertainties ultimately increase financial costs (Fugimoto and Tahan, 2009; Gugler et al., 2013) along with the energy companies volatility in the market (Ziel et al., 2015).

Thus, the understanding of the impact of regulatory policies (Brewer and Mann, 1989) on regulated sectors is of extreme importance in framing public policy. Although this is a current and growing concern, there is still little practical knowledge of its impact on the market. Hence, such an analysis is the main contribution of this paper. In this context, the aim of this research is to describe, evaluate, and analyze the intensity of the content in the regulatory legislation addressed to the Brazilian electricity sector and provide an objective basis for measuring regulatory risk. This is intended to enable the evaluation *ex ante* of the impact of the policies and guidelines for the electricity sector as per the intensity of its Regulatory Content (RC). It will also demonstrate the different impact on the stock risks, guided by the following research question: *Does the intensity of the regulatory content have a different impact on the risk of company shares of the Brazilian Electricity Energy Sector?*

The Brazilian electricity sector has undergone several changes since the promulgation of the 1988 Constitution, "involving the sector's institutional nature, technological innovations, economic infrastructure, and significant reorientation adopted by the private investment initiative policies" (Castro Silva, 2007, p. 22). The diversity of the legislation governing the Brazilian electricity sector makes it essential to appreciate its intensity and the relationship established between the intervention and regulatory risks.

This paper is structured across five sections. After this introduction, we present the theoretical and empirical framework. The third section describes the methodological procedures. In the fourth section, the submission, review, and discussion of the results are presented. At the end of the article, the final considerations are reported.

2. Theoretical-Empirical Framework

The RC analysis and the risk impact on the private equity shares invested in the Brazilian government-regulated electricity market require a focused review of the pricing models, regulation, regulatory risk, and especially the electricity market.

2.1 Financial Asset Pricing Models

Harry Markowitz established the landmark for studies related to risk in 1952, in the Portfolio Selection study. 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 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.

The risk of an asset is characterized by the level of uncertainty of its profitability, and it can be affected by several variables. In literature, the measure devoted to risk and return of assets evaluation is based on the Financial Assets Pricing Model (Sharp, 1964; Lintner, 1965; Black, 1972). The theoretical assumption underlying the model is the Efficient Market Hypothesis. Capital Asset Pricing

Model (CAPM) is a methodology used to explain the behavior of the prices of financial assets prone to risk. The CAPM was originally developed by Sharpe (1964) and since then, has been widely studied in literature based on studies by Markowitz (1952) and Tobin (1958). Markowitz (1952) explains that the investor, when building investment portfolios, seeks to reduce risk through diversification, combining negatively correlated assets, i.e., ranging in opposite directions, and ensuring the portfolio return.

In CAPM, the only thing that is specific to a particular asset is its beta. In this case, the excess return over the market determines the asset return responsiveness.

The CAPM equation is:

$$E(R_i) = R_f + \beta_i \left[E(R_m) - R_f \right], \quad (1)$$

where, R_i is the bond rate of return, R_f is the risk free rate, β_i is the beta coefficient of the bond, and R_m is the market return. The beta term is used in CAPM to describe the average volatility of assets relative to the market as a whole. More specifically, it is estimating its covariance or co-movement with a diversified assets portfolio return. The beta coefficient calculated by CAPM is quantified by the following expression:

$$\beta_i = \frac{Cov(R_i, R_m)}{Var(R_m)}, \quad (2)$$

where, R_i and R_m have already established meanings, *Cov* represents covariance and *Var* the variance.

In CAPM, the beta to measure a bond's sensitivity to market portfolio movements reflects a standardized risk measure. In regulated sectors, the dominant element in its capital cost (Ghossoub and Reed, 2014) will always be the market's expected return, with a significantly smaller role for the free risk rate (Wright et al., 2003).

Subsequent to the formulation of the CAPM, Sharpe (1964) and Fama (1968) developed and extended the market model proposed by Markowitz (1959). The market model consists of a regression equation that seeks to explain the relationship between a particular share's movements in relation to those of the market (Black, Jensen, and Scholes, 1972; Mackinlay, 1997).

The beta coefficient differs between the CAPM and the market model. The former results from a positive analysis, and the latter from normative analysis (Markowitz, 1952). The positive analysis, that characterizes CAPM, considers a market where all investors have the same return expectation. The other assumption is regarding unrestricted access for investors at risk free rate. The normative analysis of the market model does not require such assumptions. In this sense, the market model seeks to explain the correlation of share returns relative to the market return, according to the equation:

$$R_i = a_i + \beta_i R_m + e_i, \quad (3)$$

where, $\boldsymbol{R_i}$ = Investment rate of return; $\boldsymbol{R_m}$ = Market rate of return; $\boldsymbol{a_i}$ = Line intercept, corresponding to particular factors of each company; $\boldsymbol{e_i}$ = Error term corresponding to an expected return equal to *zero.*

2.2 Regulation and Regulatory Risk

Stimulating or inhibiting investments from private companies in the public sector (Giuliano and Linder, 2013) are dependent on a government's political actions, as reflected in its strategies that can range from intrusive and dominating to a low or non-existent level of control. Government intervention in the electricity sector should set a balance between expenses on public utilities (Brewer and Mann, 1989) and the industrial policy objectives of the investors (Santos et al., 2011; Veiga et al., 2012).

The regulation comprises "[...] the set of mechanisms which ensure the development of a particular system, by means of a complex reproduction process and change" (Diebolt, 2001, p. 10). The focus of regulation is sustainability and the control exercised by a public agency on certain activities (Selznick, 1985); this is often seen as an activity seeking controlled behavior, preventing the occurrence of certain undesirable activities (Baldwin, Caverna, and Lodge, 2012).

In Brazil, the Federal Constitution promulgated on October 5, 1988 acts as the supreme law for other kinds of regulations. The "Federal Constitution contains all the elements and criteria that allow identifying the activities that embody the public service" (Grau, 2001). Siffert Filho et al., (2009) and Coskun and Huseyin (2014) point out that the electricity market, because of being a public utility service (Brewer and Mann, 1989) with natural monopoly characteristics, is subject to regulation. In this context, the issues surrounding the concept of natural monopoly challenge public

policies (Coutinho and Oliveira, 2013). If, on one hand, natural monopoly implies best production efficiency when a single company supplies to the whole market, on the other hand, in the absence of any competition, the holder may be tempted to exploit the natural monopoly power, in order to maximize profits (Depoorter, 1999). Regarding the need for economic regulation and market predictability, which fall within the regulatory risk, this is understood as "any government action to limit the freedom of choice of the economic agents" (Fiani, 1998).

The Regulatory Risk (RR) is evident in the global economy scenario (Acharya, Engle, and Diane Pierret, 2014), and although there is no widely accepted definition, its analysis becomes increasingly relevant in the discussions on regulatory reform (Ergas et al., 2001). In a given situation, RR is seen to be emanating from the implementation and enforcement of regulatory rules, both for the macro economy and the industrial sectors as a whole. At the level of specific projects, RR is determined by the rules contained in contracts with governments, laws, and in other legal instruments (Smith, 1997; Veiga et al., 2012). RR arises whenever the regulation affects the capital cost of a company (Wright et al., 2003, p. 118), thus, potentially altering the composition of costs and resulting in major losses or profits to an institution (Saddi, 2011).

RR is particularly acute when the regulator has a high range of maneuver, in terms of frequency, depth of changes, and freedom of tariff adjustments. If the regulator is able to make adjustments on a frequent basis, RR shows an increase. Conversely, when the regulator has restrictions and is able to make only minor changes at longer intervals in the base price, RR shows a decrease (Wright et al., 2003). Ergas et al. (2001) expose factors that directly affect the cost of RR. The first factor is relative to the frequency of decision points; in this case, RR arises only in the presence of irrecoverable costs and increases with the constancy of regulatory events. The second factor refers to the appreciation level of each decision point and, therefore, the regulation cannot leave discretionary items, i.e., leaving the company's decision open-ended.

2.3 The Brazilian Electricity Energy Market

"The structure of the Brazilian energy matrix defines Brazil as a world leader in the generation of electricity from renewable sources. In 2011, the share of renewable sources in electricity production reached 88.8%, thanks mainly to the large national water potential" (Gerra et al., 2014). The current composition of the national energy matrix has outstanding participation of hydropower, although the country has great potential for exploitation of other renewable energy sources such as wind, solar, and biomass (Gerra et al., 2014).

The Brazilian electricity power system (ANNEL, 2008), with its foundation in the water potential of the country, presents the basis for its development through the alternation of the participation of private capital and public capital (Siffert Filho et al., 2009; Malaguti, 2009). However, starting in the 1960s, the problems caused by the dominance of private concessionaires were the starting point for the nationalization of the sector (Buratini, 2004, p. 29). In 1962, Eletrobras was created; this open capital company, controlled by the federal government, operates in the areas of generation, transmission, and distribution of electricity. In the following period, which lasted until the early 1990s, the development of the Brazilian electricity sector was marked by a nearly absolute participation of the State (Siffert Filho et al., 2009).

Starting from the 1990s, "with the financial market crisis and the inability of the State to invest, there was a reopening of the private capital, with the adoption of a model based on free market rules" (Siffert Filho et al., 2009). In this scenario, there was a transfer of the State-controlled Brazilian electricity sector to private initiative hands (Malaguti, 2009), governed by a sector restructuring process, especially through the National Privatization Plan (PND, Plano Nacional de Desestatização). However, the free market policy adopted in the period "was inefficient and led to electricity rationing in 2001 and 2002" (Siffert Filho et al., 2009).

With the establishment of the regulatory framework in 2004, the State again assumed an important role in the long-term planning of the sector. Currently public policies and guidelines relating to the electricity market are the responsibility of the federal executive branch, through the Ministry of Mines and Energy and the National Congress, acting through Provisional Measures (MP, Medidas Provisórias) and Laws. The regulation and supervision of the federal government's policies and guidelines are controlled by the National Electric Energy Agency (ANEEL, Agência Nacional de Energia Elétrica), established in December 1996 as an independent regulatory authority for the electricity sector.

The aim of this study is not to evaluate the successes of any government, often counterbalanced by its many errors, or vice versa. It is difficult to build a critical perspective based on the historical position of the government seeking to balance the development of MP, laws, and decrees that support the market of private investors in the power sector, especially when their efficient functioning affects public interest and welfare.

3. Methodological Procedures

The following subsections describe the rational and systematic procedure developed to provide an answer to the research question. First, the regulatory law addressed to the Brazilian electricity sector will be described and, subsequently, the inquiry and research theoretical model will be discussed. The methodology used regarding the said objectives is descriptive. The procedures are classified as bibliographic and documentary. The approach is quantitative with sectional temporal cut and longitudinal evaluation.

3.1 Analyzed Regulatory Legislation

The regulatory legislation addressed to the Brazilian electricity market was captured and selected by means of Markov Regime Switching or Markov Regimes. This is a classic stochastic process in which the random variable *X* has a particular relationship of dependence in time (Morais, 2003). Markov Regimes involve multiple structures (equations) that can characterize a time series by the change of the average and/or variance of the regression residues. This allows identifying the date on which structural breaks occur and capture the regulatory events that would be associated with these breaks, as well as their industry-specific impacts.

The test of the Markov Regimes, as well as the estimates of other models, were done through CAPM, according to the following model:

$$RIEE_t = \alpha_i + \beta.RIBOV_t + e_t, \quad (4)$$

where, $RIEE_t$ represents the Electric Power Index (IEE) of the Brazilian market in time *t;* α_i is the intercept of the line corresponding to particular factors of the electricity sector; β is the beta coefficient; $RIBOV_t$ represents IBOVESPA return; e_t corresponds to an expected return equal to *zero*. This formulation allows segregating RIEE variations not shared with the global share market, which are then captured by the error term.

The dating by Markov Regimes was carried out with the help of the *PcGive Software* through *OxMetrics* version 6.01. The sample period takes the IEE as a parameter, calculated from January 01, 1995. Thus, of the 4,516 observations that make up the sample period from January 1995 to March 2013, 6 observations were excluded with variations of more than two digits, representing atypical market disturbances. One of them belonged to the time of the currency crisis of January 1999, and the other five could be traced to the first indications of the blackout crisis, with the blackout occurring in Brazil in March 1999. The estimation results of the Markov Regimes are shown in Table 1.

Table 1. Estimation of Markov Regimes

	Standard Coefficient	Error	*t*	Probability
RIBOV	0.698953	0.008405	83.2	0.000
sigma(0)	0.00869115	0.0001804	48.2	0.000
sigma(1)	0.0220369	0.001090	20.2	0.000
p_{0|0}	0.982619	0.004382	224	0.000
p_{0|1}	0.101282	0.02351	4.31	0.000

log-likelihood	14166.133		
No. of observations	4510	No. of parameters	5
AIC.T	-28322.266	AIC	-6.27988159
Average (RIEE)	0.000789565	var(RIEE)	0.000387932

Linearity LR-test Chi ^ 2 (3) = 983.96 [0.0000]
**approximated upper limit: [0.0000] **
Transition probabilities p_ {i | j} = P (Regime i in t +1 | Regime j in t)

	Regime 0, t	Regime 1, t
Regime 0,t+1	0.98262	0.10128
Regime 1,t+1	0.017381	0.89872

After the estimation of the Markov Regimes, the following results were obtained for the regression residues: (i) Regular Regime or 0 – 3,947 observations were detected with the absence of any typicality in waste; (ii) Regime 1 – A total of 563 observations noted regulatory disturbance or specificities of the electricity sector by increasing the variation.

Twenty-nine relevant periods were identified with fewer than five days of regulatory disturbance. The selection of variations of more than five days takes into account the perspective that no significant regulatory event presented an impact of only 1 or 2 days on the market. After conducting research on news sites and the websites of ANEEL and the Ministry of Mines and Energy, among others, regulatory and industry-specific events captured as Markov Regime Changes were identified.

For the evaluation of RR through its content intensity, the events captured as Markov Regimes were categorized into three groups according to their nature: (i) Provisional Measures/Laws; (ii) Other Significant RC Events; and (iii) Other Regulatory Events.

For the analysis of the intensity of the RC, the first two groups, Provisional Measures/Laws and Other Significant RC Events were analyzed separately. The third group comprises Other Regulatory Events to cover the events that do not have RC amenable to quantification; these were considered only to identify the possible presence of RR.

Thus, the original content of the components that make up the first two groups was selected and analyzed by the *Text Analysis* program, available at the website http://textalyser.net/. The terms or descriptors of greater occurrence in regulatory legislation were selected. Among the terms with the highest frequency, the use of synonyms in an approximate percentage of 15% was noted. The frequencies of the terms that presented the same meaning were carefully totaled.

3.2 Theoretical model and research question

The systematic review technique was used for this study. This includes a bibliographic review that follows a plan to answer a predefined question and uses methods outlined systematically to search, analyze, and evaluate studies of a given subject (Castro, 2010). In addition, based on the research by Sampaio and Mancini (2007), the systematic review follows a clear and objective question, with an appropriate definition for bibliographic search, adequacy of inclusion and exclusion criteria of works already done on the subject, and a critical analysis of the selected material. Within this context, to simultaneously assess the RC's intensity and make inferences regarding the risk, this study examined the following research question: *Does the RC intensity have a different impact on the risk of company shares of the Brazilian electricity energy sector?*

4. Presentation, Analysis, and Discussion of the Results

Does the RC intensity have a different impact on the risk of company shares in the Brazilian electricity energy sector?

The development and sustainability of regulatory skills are essential for both public and private companies that compete on the basis of competitive advantage (Porter, 2000), as is the case of the Brazilian electricity market. While government regulation assumes market power, it also has the potential to generate positive effects from the social point of view. Therefore, the RC in the energy sector tries to counterbalance this power of the sector's private companies without losing its associated positive aspects. The relevant question is to identify the most appropriate and effective policy instruments to achieve equilibrium of risks in investors' shares. Based on the statistical data, the following subsections analyze in detail the fundamental responses to the research question.

4.1 RC Intensity of MP/Laws

Table 2 presents the events belonging to the first event group called MP/Laws along with the period in which the regime changes occur, pertinent to these events.

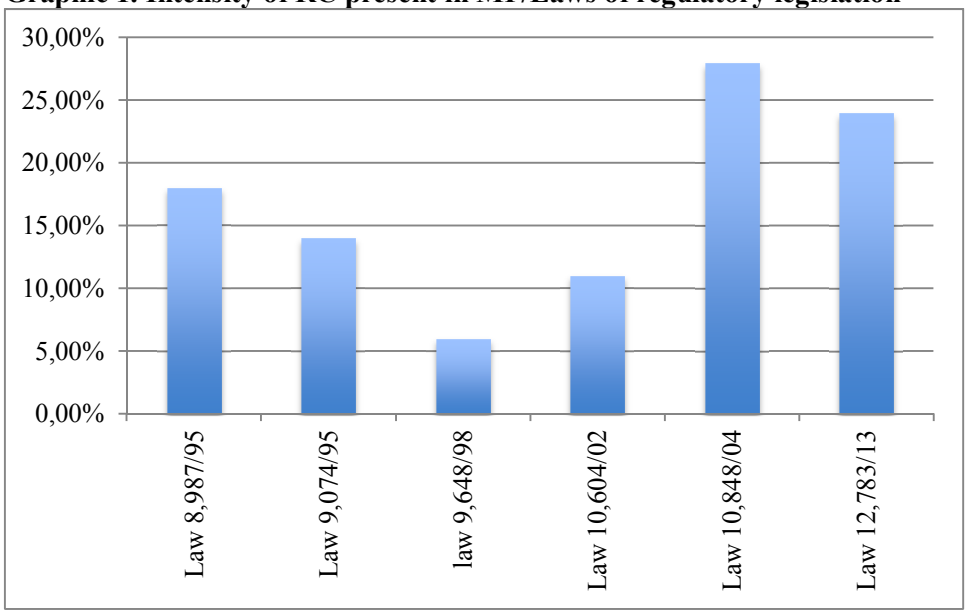
It is noted that the six laws, three of which originated from MP, were captured as Regime Changes (MR). Thus, the analysis of the individual regulatory intensity for each MP/Law seeks to highlight the laws with greater RC. Thus, it was weighted to the RC sum present in each of the parts in relation to the total RC sum. The results presented in Graphic 1 show the concentration of RC for each of the six analyzed regulatory parts.

Table 2. MP/Laws captured as Markov Regime Changes

Regime Change	Initial date	Date Final	Obs. no.	MP/Law	Description
2	01/24/1995	04/27/1995	62	Law 8,987, of 02/13/1995	Granting permission and the provision of public services.
3	06/30/1995	07/17/1995	12	Law 9,074, of 07/07/1995	Granting and extension of concessions and permissions for public services.
8	05/19/1998	05/29/1998	9	Law 9,648, of 05/27/1998	Restructuring ELETROBRAS and its subsidiaries.
18	08/07/2002	08/29/2002	17	MP 64/02 of 08/27/2002 and Law 10,604 of 12/17/2002	Subsidy to electricity consumers of the low income class.
21	11/20/2003	12/18/2003	21	MP of 12/11/2003 and Law 10,848 of 03/15/2004	EPE's creation. Electricity marketing, change of laws.
29	08/30/2012	09/13/2012	10	Announcement on 09/06/2012 of MP 579, Law 12,783 of 01/01/2013	Changes the generation of concessions, transmission, and distribution of electricity, reduction of sector charges, low rates; change of laws.

Among the laws captured as Markov Regimes, the RC with the highest intensity is found in Law 10,848/04, published in 2004, followed by Law 12,783/13, published in 2013. It is emphasized that, about twenty laws were addressed to the Brazilian electricity sector in the Federal Constitution of 1988, which for the most part, amended content of previous laws. However, only six of these laws emerge as regime changes and, therefore, indicate significant changes in the market rules.

Graphic 1. Intensity of RC present in MP/Laws of regulatory legislation



4.2 RC Intensity of Other Significant Events

The second group, called Other Significant Events, contemplates the laws addressed to the electricity sector as: Decrees, ANEEL (2014) Normative Resolutions, and other ANEEL resolutions, as shown in Table 3.

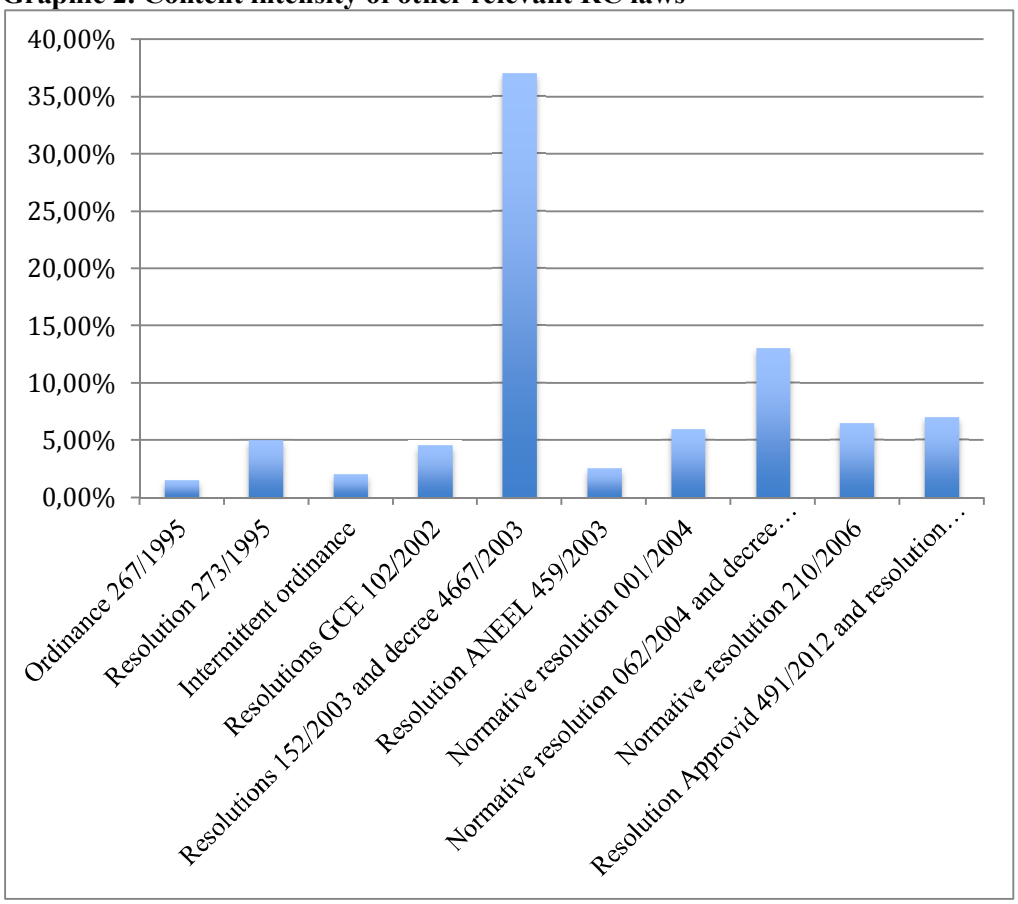
In this context, based on Table 3, ten Markov Regime Changes that were related to the relevant RC events, were identified. Of these, changes with numbers 19, 23, and 28 concern two regulatory events. The analysis of the content intensity of other regulatory laws also takes into account the frequency intensity of the terms or descriptors. Due to the nature of the content, the analysis of the other regulatory laws considers the events captured in the same Regime Change as a single part. Thus, the RC's quantification is displayed for ten sets of laws.

Table 3. Other Relevant RC Events captured as Markov Regime Changes

Regime Change	Initial date	Date Final	Obs. no.	Other Significant Events	Description
4	11/06/1995	11/16/1995	8	Ordinance n. 267, of 11/03/1995	Readjustments in electricity services supply rates.
9	08/26/1998	10/06/1998	29	RESOLUTION 273/1998 published on 08/26/1998	Authorizes ELETROBRAS to market electricity in the Wholesale Electricity Market - MAE (Mercado Atacadista de Energia Elétrica).
10	10/21/1998	10/29/1998	7	Port. Interm. 281/1998 of 10/27/1998	Authorizes ANEEL to set new values of electricity tariffs resulting from adjustment and review.
17	01/15/2002	01/21/2002	5	RES. GCE n. 102/2002 Pub. 01/18/2002	Maintains the prices of electricity charged in MAE among the agents affected by the rationing measures.
19	04/02/2003	05/12/2003	26	Aneel's Resolution 152/2003 of 04/03/2003	Changes the calculating method of the electricity distribution systems usage rates at periodic tariff review.
				Ordinance n. 4,667 of 04/04/2003	Speaks about the electricity costs and prices.
20	09/05/2003	09/11/2003	5	Res. 459/2003 of 09/05/2003	Use of resources for public good and fines applied by ANEEL.
22	01/07/2004	02/11/2004	27	Res. Norm. 001/2004 Signed Day 01/12/2004 Pub. Day 01/16/2004	Legal changes, maximum terms of the Extraordinary Tariff Reallocation permanence in the electricity supply tariffs.
23	05/06/2004	06/04/2004	22	Res. Norm. Aneel 062/2004 of 05/05/2004	Procedures for calculating the amount corresponding to the energy for participation of PROINFA.
				Ordinance 5081/2004 pub. Day: 05/14/2004	Deals with National Operator of the Electric System – NOS
25	02/08/2006	02/22/2006	11	Res. Norm. 210/2006, pub. 02/13/2006	Approves the electricity trading rules Version January/2006 instituted by Normative Resolution 109/2004.
28	06/25/2012	07/03/2012	7	Res. Norm. Aneel 491/2012 pub. 06/25/2012	Tariff Regulation Procedures – PRORET.
				Res. Hom. N. 1,316/ 2012 pub. 06/26/2012	Value of electricity Transmission System Usage Rates - TUST.

In order to estimate the regulatory power of the set of parts that make up the other regulatory laws with relevant contents, the sum of the present descriptors was weighted in each set of parts for the entire RC of the laws under review. The results are shown in Graphic 2. The results of Graphic 2 also show that the set of parts formed by Resolution 152/2003 and Decree 4667/2003 is the one with the most prominent regulatory strengths among the sets of laws under review.

Graphic 2. Content intensity of other relevant RC laws



4.3 RC Intensity Other Regulatory Events

The third group comprises thirteen structural divisions related to other regulatory disturbances, for which other events addressed to the electricity sector were identified, but with low or irrelevant RC, which are called Other Regulatory Events. These include economic and political events such as the National Privatization Plan, privatization of power companies, and international agreements that affect the sector.

4.4 Impact of the RC intensity on stock risk

To capture the impact of RC intensity on stock risk, several tests using the market model were performed (as per equation 4). The tests were performed using *Gretl Software* version 1.7.1 and *SPSS software* version 20. The first tests refer to the inclusion of a single *dummy* variable (Wonnacott and Wonnacott, 1990) for each event family: MP/Laws, Other Significant Events, and Other Regulatory Events.

4.4.1 Only one *dummy* for regime change corresponding to MP/Laws.

The *Dummy* variable of the MP/Laws family involves six Markov Regime Changes. The results are shown in Table 4. The IBOVESPA return and the MP/Laws multiplicative *dummy* explain up to 66% of the returns of the shares comprising the IEE. The risk to the electricity sector representative shares corresponds to 0.798 or 79.8% of the market risk. The *dummy* variable on the MP/Laws family is significant. In this case, the MP/Laws regulatory risk presents a 3.6% impact on the stock risks that make up the IEE

Table 4. Single *dummy*: MP/Laws family

Variable	Coefficient	Standard Error	Standardized Beta	t-statistics	p-value
Constant	0.0002011	0.00016999		1.1828	0.23696
RIBOVCORR	0.698854	0.00818369	0.798	85.3959	<0.00001
DM_MP/Laws	0.0920652	0.0238536	0.036	3.8596	0.00012
Dependent variable: RIEECOR			Coeff. of 1st order autocorrelation = -0.01427		
Dependent variable average = 0.000644049			Likelihood logarithm = 13627.6		
Dependent variable standard deviation = 0.01936			Akaike information criterion = -27249.1		
Sum of square residues = 0.571917			Schwarz's Bayesian Criterion = -27229.9		
Standard error of residues = 0.011338			Hannan-Quinn Criterion = -27242.3		
R^2 not adjusted = 0.657383			LM test for autocorrelation up to order 5 -		
R^2 adjusted = 0.657229			Null hypotheses: without autocorrelation		
Statistics-F (2, 44) = 4268.17 (p-value < 0.000)			Test statistics: LMF = 1.32494		
Durbin-Watson Statistics = 2.02845			with p-value = P(F(5.4439) > 1.32494) = 0.250304		

4.4.2 *Single dummy for Other Significant RC Events*

Dummy variable included in the regression on the Other Significant Events family comprises thirteen regulatory events captured in ten Markov Regime Changes. The results are shown in Table 5. In Table 5, the variables included in the regression explain up to 66% returns of the shares comprising the IEE. The standardized beta coefficient, representing the risks for the stocks comprising the IEE, presents a variation of 0.80 or 80% compared to the market risk. The *dummy* variable, indicative of the regulatory risk for the Other Significant Events family, is significant with an impact of 3.2% on the stock risks comprising the IEE.

Table 5. Single *dummy*: Other Significant RC Events family

Variable	*Coefficient*	*Standard Error*	Standardized Beta	*t-statistics*	*p-value*
Const.	0.000206	0.0001700		1.2147	0.22454
RIBOVCORR	0.700791	0.0081224	0.800	86.2787	<0.00001
DM_Out_Ev_Relev	0.085889	0.0252442	0.032	3.4023	0.00067
Dependent variable: RIEECOR			Coeff. of 1st order autocorrelation = -0.01617		
Dependent variable average = 0.000644049			Likelihood logarithm = 13625.9		
Dependent variable standard deviation = 0.0193657			Akaike information criterion = -27245.8		
Sum of square residues = 0.572343			Schwarz's Bayesian Criterion = -27226.6		
Standard error of residues = 0.0113422			Hannan-Quinn Criterion = -27239		
R^2 not adjusted = 0.657128			LM test for autocorrelation up to order 5 -		
R^2 adjusted = 0.656974			Null hypotheses: without autocorrelation		
Statistics-F (2.4449) = 4263.34 (p-value < 0.00001)			Test statistics: LMF = 1.50808		
Durbin-Watson Statistics = 2.03224			with p-value = P(F(5.4439) > 1.50808) = 0.183695		

4.4.3 Only one *dummy* for the Other Events family

The *Dummy* variable for Other Events involves the regulatory laws captured in the thirteen Markov Regime Changes. Other Regulatory Events selected do not overlap with Other Events; i.e., Other Events do not take place in the same period of MP/Laws and/or Other Significant Events. The results are shown in Table 6. Based on Table 6, the beta coefficient for the stocks that make up the IEE is close to the previous results. However, the regulatory risk captured from other events presents an impact of 2.2% on the stock risks, the lowest coefficient obtained for the three families under review. Overall, this result indicates that the content power or intensity present in the regulatory legislation addressed to the Brazilian electricity sector is significant, and, therefore, should be considered for risk assessment of that nature.

Table 6. Single *dummy*: Other Events family

Variable	*Coefficient*	*Standard Error*	Standardized Beta	*t-statistics*	*p-value*
Const.	0.0002094	0.00017017		1.231	0.21838
RIBOVCORR	0.70527	0.00789569	0.805	89.3234	<0.00001
DM_outros_ev	0.088126	0.035315	0.022	2.4954	0.01262
Dependent variable: RIEECOR			Coeff. of 1st order autocorrelation = -0.0156883		
Dependent variable average = 0.000644049			Likelihood logarithm = 13623.2		
Dependent variable standard deviation = 0.0193657			Akaike information criterion = -27240.5		
Sum of square residues = 0.57303			Schwarz's Bayesian Criterion = -27221.3		
Standard error of residues = 0.011349			Hannan-Quinn Criterion = -27233.7		
R^2 not adjusted = 0.656716			LM test for autocorrelation up to order 5 -		
R^2 adjusted = 0.656562			Null hypotheses: without autocorrelation		
Statistics-F (2.4449) = 4255.56 (p-value < 0.00001)			Test statistics: LMF = 1.42432		
Durbin-Watson Statistics = 2.03128			with p-value = P(F(5.4439) > 1.42432) = 0.211988		

4.5 Second sequence of tests: a *dummy* for each type of RC intensity of MP/Laws

For a second sequence of tests, events were categorized according to the content volume. Thus, events belonging to the MP/Laws family and the Other Significant Events family were classified according to the total content this legislation, as shown in Table 7.

Table 7. Events rating according to the intensity of the RCs

Laws		Intensity	Type	Regime Change
MP/Law	MP145/03 and 144/03 of 12/11/2003 and MP 579 /2013, Law 12,783 of 01/01/2013	Strong	1	21 and 29
	Law 8,987 of 1995 and Law 9,074 of 1995 and MP 64/2002 - Law 10,604 of 12/17/2002	Average	2	2, 3, and 17
	Law 9,648 of 1998	Low	3	9
Other Significant Events	Aneel. Res. 152/2003; Decree 4,667/2003	Strong	1	19
	Res. Norm. 001/2004; Res. Norm. 062/2004; Decree 5081/2004; Res. Norm. 210/2006; Res. Norm. 491/2012; Res. Hom. 1,316/ 2012	Average	2	22, 23, 25, and 28
	Ordinance 267/1995; Resolution 273/1998; Interministerial Ord. 281/1998; Interministerial Res. 102/2002; Res. 459/2003	Low	3	4, 9, 10, 17, 20

4.5.1 MP/Laws Type 1: Strong Intensity

MP/Laws Type 1 events include an MP 144/03 converted into Law 10,848 of 03/15/2004, along with the announcement of MP 579/12 converted into Law 12,783 of 01/11/2003, both of strong intensity. Results with the inclusion of the *dummy* variable, indicative of MP/Laws Type 1 events, are shown in Table 8.

The *dummy* variable, indicative of regulatory risk of strong intensity events, is statistically significant at 1% and has an impact of 3.1% on the stock risks comprising the IEE.

4.5.2 MP/Laws Type 2: Medium Intensity

MP / Laws Type 2 events comprise a *dummy* variable for Law 8,987 of 02/13/1995, Law 9,074 of 07/07/1995, and MP 64/2002 of 08/27/2002 converted to Law 10,604 of 12/17/2002, all of medium content intensity. The results are shown in Table 9.

The *Dummy* variable, indicative of regulatory risk for MP/Laws Type 2 events with medium intensity, emerges significant at 5% level. However, the impact of 2% on the stock risks comprising the IEE is lower when compared to the strong intensity impact witnessed in the MP/Laws Type 1 events.

Table 8. Results of MP/Laws Type 1 events

Variable	*Coefficient*	*Standard Error*	Standardized Beta	*t-statistics*	*p-value*
Const.	0.0001826	0.00017013		1.0734	0.28314
RIBOVCORR	0.708215	0.00770132	0.0808	91.9602	<0.00001
DM MP/Lei_Tipo1	0.492453	0.139983	0.031	3.5179	0.00044
Dependent variable: RIEECOR			Coeff. of 1st order autocorrelation = -0.0105		
Dependent variable average = 0.000644049			Likelihood logarithm = 13626.3		
Dependent variable standard deviation = 0.0193657			Akaike information criterion = -27246.6		
Sum of square residues = 0.57224			Schwarz's Bayesian Criterion = -27227.4		
Standard error of residues = 0.011341			Hannan-Quinn Criterion = -27239.8		
R^2 not adjusted = 0.657189			LM test for autocorrelation up to order 5 -		
R^2 adjusted = 0.657035			Null hypotheses: without autocorrelation		
Statistics-F (2.4449) = 4264.5 (p-value < 0.00001)			Test statistics: LMF = 1.26776		
Durbin-Watson Statistics = 2.0211			with p-value = P(F(5.4439) > 1.26776) = 0.2748		

Table 9. Results of MP /LAWS Type 2 events.

Variable	*Coefficient*	*Standard Error*	Standardized Beta	*t-statistics*	*p-value*
Const.	0.000203499	0.000170185		1.1958	0.23186
RIBOVCORR	0.703932	0.00813185	0.804	86.5647	<0.00001
DM_Lei_Tipo2	0.055145	0.0251775	0.020	2.1903	0.02856
Dependent variable: RIEECOR			Coeff. of 1st order autocorrelation = -0.0146		
Dependent variable average = 0.000644049			Likelihood logarithm = 13622.5		
Dependent variable standard deviation = 0.0193657			Akaike information criterion = -27239		
Sum of square residues = 0.573214			Schwarz's Bayesian Criterion = -27219.8		
Standard error of residues = 0.01135			Hannan-Quinn Criterion = -27232.3		
R^2 not adjusted = 0.656606			LM test for autocorrelation up to order 5 -		
R^2 adjusted = 0.656452			Null hypotheses: without autocorrelation		
Statistics-F (2.4449) = 4253.48 (p-value < 0.00001)			Test statistics: LMF = 1.36336		
Durbin-Watson Statistics = 2.029			with p-value = P(F(5.4439) > 1.36336) = 0.23485		

4.5.3 MP/Laws Type 3: Low Intensity

The results for *dummy* variable, indicative of regulatory risk of MP/Laws Type 3 of low intensity, are shown in Table 10.

Table 10. Results of MP/Laws Type 3 events

Variable	*Coefficient*	*Standard Error*	Standardized Beta	*t-statistics*	*p-value*
Const.	0.00020338	0.000170276		1.1944	0.23237
RIBOVCORR	0.709494	0.00771584	0.810	91.953	<0.00001
DM_Lei_Tipo3	0.0473964	0.123076	0.003	0.3851	0.70018
Dependent variable: RIEECOR			Coeff. of 1st order autocorrelation = -0.0140073		
Dependent variable average = 0.000644049			Likelihood logarithm = 13620.2		
Dependent variable standard deviation = 0.0193657			Akaike information criterion = -27234.4		
Sum of square residues = 0.573813			Schwarz's Bayesian Criterion = -27215.2		
Standard error of residues = 0.0113567			Hannan-Quinn Criterion = -27227.6		
R^2 not adjusted = 0.656247			LM test for autocorrelation up to order 5 -		
R^2 adjusted = 0.656093			Null hypotheses: without autocorrelation		
Statistics-F (2.4449) = 4246.72 (p-value < 0.00001)			Test statistics: LMF = 1.33786		
Durbin-Watson Statistics = 2.02792			with p-value = P(F(5.4439) > 1.33786) = 0.245016		

The indicative variable of the regulatory event MP/Laws Type 3, low intensity, represented by Law 9,648 of 05/27/1998 does not show statistical significance. One can conjecture that for the MP/Laws events, the RC intensity is relevant and has a different impact on the stock risks. Therefore, it should be considered when drafting and formulating public policies.

4.6 Third sequence of tests: a *dummy* for each Type of Other Significant Events of RCs

4.6.1 Other Significant Events Type 1: Strong Intensity

The *Dummy* variable for Other Significant Events Type 1 comprises ANEEL Resolution 152/2003 of 04/03/2003 and Decree no. 4667 of 04/04/2003, captured by the 19th Regime Change, both of strong intensity. The results are shown in Table 11.

Table 11. Other Significant Events Type 1: Strong Intensity

Variable	*Coefficient*	*Standard Error*	Standardized Beta	*t-statistics*	*p-value*
Const.	0.0001917	0.000170105		1.1273	0.25969
RIBOVCORR	0.70828	0.0077032	0.808	91.9463	<0.00001
DM_OU. EV. REL. TYPE 1	0.45297	0.137813	0.029	3.2868	0.00102
Dependent variable: RIEECOR			Coeff. of 1st order autocorrelation = -0.01664		
Dependent variable average = 0.000644049			Likelihood logarithm = 13625.5		
Dependent variable standard deviation = 0.0193657			Akaike information criterion = -27245		
Sum of square residues = 0.572442			Schwarz's Bayesian Criterion = -27225.8		
Standard error of residues = 0.0113432			Hannan-Quinn Criterion = -27238.3		
R^2 not adjusted = 0.657068			LM test for autocorrelation up to order 5 -		
R^2 adjusted = 0.656914			Null hypotheses: without autocorrelation		
Statistics-F (2.4449) = 4262.22 (p-value < 0.00001)			Test statistics: LMF = 1.25523		
Durbin-Watson Statistics = 2.03319			with p-value = P(F(5.4439) > 1.25523) = 0.2804		

The variable indicative of regulatory risk is statistically significant at 1% level. The results indicate that Other Significant Regulatory Events Type 1, strong intensity, impact the stock risks comprising the IEE by 2.9%.

4.6.2 Other Significant Events Type 2: Medium Intensity

Other Significant Events Type 2 correspond to four Regime Changes or structural breaks, as described in Table 3. The econometric tests results are shown in Table 12. The variable indicating the regulatory risk of Other Events Type 2, medium intensity, is significant at 1% level, with an impact of 3.5% on the stock risks comprising the IEE.

Table 12. Other Significant Events Type 2 of Medium Intensity:

Variable	*Coefficient*	*Standard Error*	*Standardized Beta*	*t-statistics*	*p-value*
Const.	0.000202546	0.00017		1.192	0.23349
RIBOVCORR	0.705927	0.0077459	0.806	91.135	<0.00001
DM_OU. EV. REL. TYPE 2	0.24863	0.0630103	0.035	3.946	0.00008
Dependent variable: RIEECOR			Coeff. of 1st order autocorrelation = -0.0124		
Dependent variable average = 0.000644049			Likelihood logarithm = 13626.6		
Dependent variable standard deviation = 0.0193657			Akaike information criterion = -27247.3		
Sum of square residues = 0.572154			Schwarz's Bayesian Criterion = -27228.1		
Standard error of residues = 0.0113403			Hannan-Quinn Criterion = -27240.5		
R^2 not adjusted = 0.657434			LM test for autocorrelation up to order 5 -		
R^2 adjusted = 0.65728			Null hypotheses: without autocorrelation		
Statistics-F (2.4449) = 4265.48 (p-value < 0.00001)			Test statistics: LMF = 1.17563		
Durbin-Watson Statistics = 2.02489			with p-value = P(F(5.4439) > 1.17563) = 0.3184		

4.6.3 Other Significant Events Type 3: Low Intensity

The *Dummy* variable for Other Significant Events Type 3 includes five structural breaks. The first structural break refers to Ordinance 267/1995. The second and third structural breaks refer to the Resolution 273/1998 of 26/08/1998 and the Ministerial Decree 281/1998, respectively. The fourth and fifth structural breaks refer to the Energy Crisis Management Resolution - GCE 102/2002 and the ANEEL Resolution 459/2003, respectively. The results are shown in Table 13.

Table 13. Other Significant Events Type 3 of low intensity

Variable	*Coefficient*	*Standard Error*	*Standardized Beta*	*t-statistics*	*p-value*
Const.	0.000205183	0.000170229		1.205	0.22814
RIBOVCORR	0.708551	0.00772868	0.809	91.678	<0.00001
DM_OU. EV. REL. TYPE 3	0.144628	0.0875074	0.015	1.653	0.09845
Dependent variable: RIEECOR			Coeff. of 1st order autocorrelation = -0.0144		
Dependent variable average = 0.000644049			Likelihood logarithm = 13621.6		
Dependent variable standard deviation = 0.0193657			Akaike information criterion = -27237.3		
Sum of square residues = 0.573441			Schwarz's Bayesian Criterion = -27218.1		
Standard error of residues = 0.0113531			Hannan-Quinn Criterion = -27230.5		
R^2 not adjusted = 0.65647			LM test for autocorrelation up to order 5 -		
R^2 adjusted = 0.656315			Null hypotheses: without autocorrelation		
Statistics-F (2.4449) = 4250.91 (p-value < 0.00001)			Test statistics: LMF = 1.348		
Durbin-Watson Statistics = 2.02879			with p-value = P(F(5.4439) > 1.348) = 0.24093		

The standardized beta coefficient displays a variation of just 10% level compared to the market risk. The dummy variable, indicative of the regulatory risk for the Other Significant Events family Type 3 of low regulator intensity, shows a 1.5% impact on the stock risks comprising the sector index. These results support the idea that low regulatory intensity content events do not significantly affect the stock risks in the Brazilian electricity sector.

5. Conclusion

The objective of this study was to verify if the intensity of the content in regulatory legislation affects the Brazilian electricity market. The study also aimed to provide an objective basis for measuring regulatory risk, enabling the evaluation *ex ante* of the impact of policies and guidelines on the electricity sector according to the intensity of its RC, and also demonstrate the different impact on the stock risks: In this context, the following search question was analyzed: *Does the intensity of the regulatory content have a different impact on the risk of company shares of the Brazilian electricity energy sector?*

By analyzing the intensity of the content in the regulatory legislation addressed to the Brazilian electricity market, this article aimed to provide an objective basis for measuring regulatory risk, enabling the evaluation *ex ante* of the impact of policies and guidelines for the electricity sector, according to the intensity of their contents.

The first sequence of tests showed that when classified in event families, the impact is different and gradual. The impact on the stock risks of regulatory measures set by MP/Laws is 3.6%. The Other Significant Events family, which generally has a lower intensity of RC when compared to the MP/Laws family, presented an impact of 3.2%. The Other Events family, whose RC is extremely low, presented an impact of 2.2%. These results lead to the conclusion that the RC intensity or the power present in the regulatory law addressed to the Brazilian electricity market is significant, and, therefore, should be considered the first analysis to estimate such risk.

However, the individual analyses of different types of events, rated according to the RC intensity, also show a different impact on the stock risks. Strong and medium intensity events have a greater impact on the stock risks comprising the Brazilian electricity sector. Conversely, institutional or policy decisions addressed to the electricity sector presenting low intensity RC are not perceived as significant in the market.

As a research contribution, the results presented here confirm that the regulatory events must be differentiated by type, since they have different effects on regulatory risk. In this context, the fact that the regulatory laws of low content intensity do not emerge as significant does not indicate that such effects do not exist, given that they may be eclipsed by other market or regulatory disruptions. Moreover, search results show that the RC intensity is important, and in this case, the higher the intensity of the RC, the greater the impact of the potential risk on the shares of companies in the regulated sectors. For future research, we suggest the analysis of the effect of regulatory events in other energy segments such as oil and gas.

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