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Abstract:

This paper shows that a change in systematic risk of a regulated sector affects the regulatory environment by changing also the systematic risk of other sectors not directly affected by the intervention. We consider the Provisional Act. no. 579/2012 (PA 579) aimed at reducing power fees for Brazilian consumers. However, it has led to other consequences, including uncertainties about the rules for renewals of existing concessions. The analysis of systematic risk uses time-varying betas from 140 companies listed on the Brazilian Stock Market between January 2008 and September 2016. Based on both synthetic control and Dif-in-Dif methodologies, we conclude that the PA 579 increased the systemic risk not only of the sector it regulates, but also of other regulated sector in Brazil, suggesting a contagion effect on the country's regulatory environment

Keywords: Finance; Provisional Act; Contagion effect; Regulation; Regulatory impact.

JEL Codes: G11; G14; G18

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ABSTRACT

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1. INTRODUCTION

This paper shows that public policy can impact not only the systematic risk of the sector it regulates, but also that of other regulated sectors in the economy. We reach this conclusion by studying a Brazilian data set considering the effects of the Provisional Act. no. 579/2012 (PA 579). This act was aimed at reducing the power fees for Brazilian consumers, however, it also increased the uncertainties regarding the renegotiation of existing government concessions, which was perceived as an increase in sector risk.

This paper is related to the literature dedicated to the study of political and regulatory influences of the regulated company’s risk (Robinson and Taylor, 1998; Binder and Norton, 1999; Buckland and Fraser, 2001; Pescetto, 2008; Taffarel, Silva, and Clemente, 2013; Buckland and Beecher, 2015; Bond and Goldstein, 2015). The paper explores the PA 579 like previous studies (Assunção, Takamatsu, and Bressan, 2015; Ogg and Taffarel; 2014; Sampaio et al., 2016), however it focuses on the systematic risk and explores the contagion effect on other regulated sectors.

There are several questions on the effect of economic regulation and the impact of regulators' decisions on the concerned sectors. Among the main effects discussed in the literature, the variation in a regulated company’s risk has been highlighted.

Regulatory changes tend to affect company asset prices, since they directly impact cash flow expectations. Moreover, depending on the regulatory change and how it is communicated to the market (Bond and Goldstein, 2015), other effects may be found, for example, the increase in the sector's regulatory risk (Taffarel, Silva, and Clemente, 2013). According to Taffarel, Silva, and Clemente (2013), companies in the public utility services domain may be a good investment option, combining predictability of gains, protection against inflation, and growth. However, such companies are subject to strong regulatory restrictions, similar to the Brazilian electric energy sector. Binder and Norton (1999) show that the systematic risk of a firm is inversely related to profits, and thus regulation can affect the systematic risk by altering: (i) the covariance of the returns on equity of the regulated firm with the market; (ii) firm or industry specific factors and (iii) the buffering effects of regulation. Buckland and Fraser (2001) demonstrates that utilities' risk is time-variant and establishes significant political and regulatory influences in the systematic risk.

Provisional Act. no. 579, of September 11, 2012, , had the goal of reducing the cost electric energy for the Brazilian consumer. Yet, asymmetry in the communication during the regulatory transition has caused negative effects on the stakeholders' perception, impacting investor confidence due to the uncertainties regarding the new rules of concession renewal in the sector (Sampaio et al., 2016).

Several studies evaluated the impact of PA 579 in the Brazilian electrical sector. Assunção, Takamatsu, and Bressan (2015) concluded that the market reacted to the PA 579 negatively, presenting significant abnormal returns in the two-days window after its edition. Ogg and Taffarel (2014) evaluated the impact of the PA 579 on idiosyncratic risk and the returns of the electric energy companies, and their results indicated that the PA 579 immediately affected company share prices. Sampaio et al. (2016), using the differences-in-differences and synthetic control methods, have found that after the PA 579 was made public, electric company prices were reduced by 37.5% in relation to those of companies in the control group.

This study aims to measure the impact of PA 579, not only on the systemic risk parameters of electrical sector companies, but also on other regulated sectors in the Brazilian economy. In this context, it expands the discussion on the effect of economic regulation and the impact of the regulators' decisions on the sectors they regulate. Specifically, it analyzes the impact of the PA 579 on the systemic risk of the electrical sector companies. Additionally, it verifies the effect of the PA 579 on the systemic risk of other regulated sectors and the existence of a possible contagion effect on the Brazilian regulatory environment. The novelty of the study is the finding that a regulatory measure is not restricted to the sector that it regulates but may also impact other regulate sectors. This impact must be measured to help decision-makers evaluate the extent of their decisions on the economy.

To isolate the effect of the PA 579 on the systemic risk of the electrical sector companies and other regulated sectors, the synthetic control method was applied, enabling the construction of the counterfactual by combining the characteristics of other, untreated units (controls). A counterfactual close to the ideal minimizes the influence of other variables in the identification of the causal relationship being investigated (Abadie, Alexis, and Jens, 2010).

The results indicate that the increase in systemic risk observed in the treated units (regulated sectors) did not occur at random. The negative impact arising from the regulatory intervention is evident on the systemic risk of the electrical sector, as well as those of the other regulated sectors, suggesting a contagion effect. Furthermore, regarding the contracts under the concession regime established between Public sector and private partners between 2013 and 2018, it is estimated that the increase in systemic risk may have cost more than R$ 14 billion (U$ 3.5 billion) to Brazilian taxpayers, casting doubts on whether the effect of the PA was positive.

This paper is divided into seven sections, including this introduction. Section 2 presents the theoretical references adopted. Section 3 presents the database used. Section 4 provides the measurement methodology employed. Section 5 analyzes the results found. Section 6 specifies the economic impact of the measure. Section 7 concludes.

2. LITERATURE REVIEW

2.1 THE BRAZILIAN ELECTRIC SECTOR AND PA 579/2012

On September 11, 2012, before the reduction in the country's overall growth and a decrease in the growth of the industrial sector, the Federal Government issued Provisional Act no. 579, whose main aim was to reduce the energy costs for consumers, as stated in its Explanatory Memorandum:

> […] the proposal of the issuing of a Provisional Act that changes devices of the existing legislation with the aim of enabling the reduction of the cost of electrical energy for the Brazilian consumer, thus seeking to promote fee modality and the guarantee of electrical energy, as well as make the productive sector even more competitive, contributing to the increase in the levels of employment and income in Brazil (Provisional Act no. 579, 2012).

In general, the new rules changed the agreements on the renewal of the concessions of generation and transmission of energy. The measure limited the concession holders' gain margins and presented a new price structure (Sampaio et al., 2016). According to the authors, the main aim of the PA 579 was not only to make the national industrial sector more competitive, but also to gather greater popular support through the reduction in the electrical energy fees.

Costellini and Hollanda (2014) claim that from 2012 onward, a significant amount of concession contracts would expire; therefore, that was the right moment for changing the rules based on the new concession regimes.

The government stated that the concessions granted before 1995 were mostly amortized and depreciated. Thus, these benefits should be transferred to consumers as soon as possible through a new fee calculated by the National Electrical Energy Agency (ANEEL), as provided by *the price cap* regulation. The proportion of the fee corresponding to generation costs would be reduced, since the fee proportion related to the coverage of these companies' depreciation and capital remuneration would not be charged anymore. The new fee would have only to cover the operation and maintenance costs (O&M) of the system and the remuneration due to new investments.

Under these rules, generator companies that still had a renewal right would forfeit it, and they would have to either accept the conditions proposed by the government or reject them. In the latter case, they would go through a new bidding. If a concessionaire wanted to continue to explore the concession until the bidding, it could do so; otherwise, the Union would explore the concession until the end of the process.

To the concessionaires that accepted the conditions, the Union would have the power to extend the due concessions of generation, transmission, and distribution only once, for a maximum deadline of 30 years in the hydropower plant cases, and for up to 20 years in thermal power plants cases.

The compensation for the goods still not depreciated or amortized would follow the New Replacement Value methodology for both renewals and bidding. This methodology consists of the calculation of the investment necessary to build a plant according to its present value:

> This methodology refers to the calculation of the value of an asset (in this case, the reversible asset bound to a concession due) if it were built at current prices, based on the quantities of materials, electromechanical equipment, and services, which integrate the Technical Assistance Projects at ANEEL (Ministry of Mining and Energy, 2012 p. 2).

Regarding the new energy trade rules, the energy generation concessionaires abiding by the PA 579 would have their energy contracts broken and would be rehired by the distributors in the Free Hiring Environment, through quotas proportional to the weight of each concessionaire in the Interlinked National System (INS). Since these rehirings would take place at a lower price, reflecting the concessions renewal, this would allow consumers to benefit from the reduction in their costs for purchasing the energy provided by the distributors (Costellini and Hollanda, 2014).

Transmission companies' revenues would also be reduced, with only O&M costs being covered. Moreover, the government stated that all the transmission concessions granted until 2000 had already been fully depreciated and amortized, so the transmission companies would not be compensated from the granting power, as planned.

In this context, as highlighted by Sampaio et al. (2016), the obligation to express interest before learning about the new conditions of renewal and the new refund payment rules have generated concern among the main investors in the sector. Assunção et al. (2015) show that on the days following the announcement of the new rules, the prices of the electrical sector company shares listed in the Brazilian Stock Market exhibited considerable losses.

Thus, the absence of clearer information has caused uncertainties in the electrical sector regarding the application of the energy policy and the use of the sector as an instrument to achieve political objectives. In addition to the direct consequences, PA 579 may have created some indirect impacts. The impact on the environment of regulated contracting and the postponement of execution of new electric power generation projects. (Sampaio et al., 2016).

2.2 COST OF EQUITY AND SYSTEMIC RISK

This section presents the theoretical concepts supporting the systemic risk premises used in this study. According to Damodaran (2012), the weighted average cost of capital (WACC) reflects a company's financing decision, considering the financing costs between equity and third parties, as per Equation 1:

$$WACC = \left(\frac{E}{D + E}\right) \times K_e + \left(\frac{D}{D + E}\right) \times K_d \times (1 - T) \qquad (1)$$

where E is the total volume of equity, D is the total third-party capital volume, K_d is the third-party capital cost, K_e is the cost of equity, and T is the income tax rate.

Among the various models for measuring the cost of equity, *the Capital Asset Pricing Model* (CAPM) is the one most accepted in the global market (Graham and Harvey, 2001). It is also the model recommended by ANEEL when the regular reviews of concessions in the Brazilian electrical sector take place.

The equation for K_e shows that the return of an asset may be determined from a free rate of risk: from beta *(β),* which measures the variation in the asset returns in relation to the return on the market portfolio, that is, its systematic risk; and, from the market risk award, measured by the difference between the market return and the risk-free rate (Equation 2):

$$K_e = R_f + \beta\left[E(R_m) - R_f\right] \tag{2}$$

where R_f is the interest rate of the risk-free asset; β is the beta coefficient, which measures the sensitivity of the asset value in relation to the market portfolio value; *E(Rm)* is the expected return on the market portfolio; and, $[E(R_m) - R_f]$ is the prize for the risk of the market portfolio.

As shown in CAPM, in terms of systemic risk, of all the model parameters, only beta reflects a specific feature of the asset. Although the other components reflect economic scenarios in general terms, the risk-free rate (R_f) reflects the return obtained from the risk-free asset, and the prize of the market risk is the same for all assets at a certain time. The beta coefficient reflects the specific risk of the asset analyzed in relation to that of the market portfolio. It is the model parameter capable of explaining the difference in the feedback level required for several assets at the same instance in time. Thus, when measuring the impact of an event in terms of systemic risk, the analysis of the achievements on the asset, beta, is the most appropriate.

To achieve this, the conditional CAPM model was adopted to estimate the systemic risk (beta) of the companies throughout the period under analysis. CAPM determines the price of the assets, by assuming that optimal investment decisions are made when the market is in balance. As in the non-conditional static CAPM, the model uses the premise that investors share identical expectations for the time-varying assets, but that the latter are related to the information of the previous instance in time.

To evaluate systemic risk, the moving beta was estimated in a 252-working days window. More specifically, its value was obtained using the following equation:

$$\beta_{i,t} = \frac{\sum_{h=t-252}^{t}(R_{i,h} - \bar{R}_{i,t})(R_{m,h} - \bar{R}_{m,t})}{\sum_{h=t-252}^{t}\left(R_{m,h} - \bar{R}_{m,t}\right)^2} \tag{3}$$

where $R_{m,t}$ is the market return on day t, calculated and provided by the Nefin website[1], and $\bar{R}i.t$ is the average return of the last 252 days in relation to day t.

Moreover, the results obtained for the unlevered beta are also analyzed. The unlevered beta is given by

$$\beta_{i.t}^{des} = \frac{\beta_{i.t}}{1 + (1 - T) \times \left(\frac{Capital\ structure}{1 - Capital\ structure}\right)} \tag{4}$$

where T = 0.34 and

$$Capital\ structure = \frac{Debt}{Debt + Market\ Value} \tag{5}$$

Conditional CAPM aims to associate the asset return with the risk-free fee and the market risk prize, and associate beta with the information available to the investors at each instance in time. Consequently, these parameters will change as a result of the change in investors' expectations. Finally, conditional CAPM accurately represents asset pricing, since it enables temporal variations of the risk prize and beta.

3. DATA

In this study, daily and quarterly financial share data from January 1, 2005, to April 29, 2018, obtained from Economatica®, were used. The shares were selected according to the following method: (a) belonging to the Nefin share portfolio at some point; (b) being in the period analyzed and having enough data history to estimate the dependent variable (252 for the rolling CAPM beta); (c) not being a financial sector company.

The database used comprises 99 shares, with 3295 trading days each. To evaluate the effect of PA 579 on the systemic risk of the electrical sector and other regulated sectors, these 99 shares listed on the database were classified into 3 groups:

- **Impacted:** electric-sector regulated companies, thus directly affected by PA 579 – 14 shares [2];

[1] Brazilian Center for Research in Financial Economics of the University of São Paulo (NEFIN) website – Núcleo de Pesquisas em Economia Financeira da Universidade de São Paulo http://nefin.com.br

[2] Directly impacted shares: CESP6, CMIG4, COCE5, CPFE3, CPLE6, ELET6, ELPL4, ENBR3, EQTL3, GETI4, LIGT3, TAEE11, TRPL4, and EGIE3.

- **Contagion:** regulated companies not in the electrical sector, thus potentially affected by PA 579, but not directly – 12 shares [3]; and,
- **Others:** Unregulated companies – 73 shares.

As a classification criterion, companies are considered to be regulated when they somehow have their service prices regulated by a regulatory agency: for electrical energy, sanitation, gas, aviation, telephony, healthcare, or highways. This definition method follows the same procedure applied by Barcelos and De-Losso (2010).

Finally, the companies of the treated groups (Impacted and Contagion) were organized as portfolios, in which the participation of each company was proportional to its market value.

4. METHODOLOGY

As described by Sampaio et al. (2016), finding evidence for causality generally involves using the temporal series methodology. However, such an approach for evaluating the impact of regulatory interventions may present some limitations (Taffarel, 2015, Barcelos and De-Losso, 2010).

Sampaio et al. (2016) claim that the main obstacle in the use of temporal series is that the changes in the behavior of the systemic risk of the national electrical sector companies and other regulated companies may be biased by other macroeconomic variables.

The authors also highlight that another limitation of that method is that sectors have specific characteristics, and that using another sector as the counterfactual is not the most appropriate approach. A simple comparison between the trajectories of the share betas of the electrical and other regulated sectors and those in the unregulated sectors may not reflect the effect of the intervention, but only the differences in pre-intervention characteristics, which affect the subsequent economic behavior.

As a strategy for isolating the impact of PA 579 on the systemic risk of the electrical sector and other regulated sectors, the synthetic control method was adopted.

The relevant model uses a data-driven estimation to calculate a weighted mean of the control groups that may serve as the counterfactual for the treated group in the post-treatment period. The process of creating the synthetic control consists of using the pre-treatment period to estimate weights for which the synthetic unit (a weighted mean of the controls) follows the same trajectory as the treated group. After that, these weights are used to construct the counterfactual in the post-treatment periods.

[3] Indirectly impacted shares: CCRO3, STBP11, CGAS5, CSMG3, ECOR3, OIBR4, SAPR4, SBSP3, TELB4, TIMP3, TPIS3, and VIVT4.

More specifically, considering a balanced panel with $J + 1$ units indexed by j and observed in $t = 1, \ldots, T$ periods, estimating the treatment effect of a policy change that affected only one unit ($j = 1$) from the period $T_0 + 1 \leq T$ to the T period, the potential results are given by:

$$\begin{cases} y_{jt}^{C} = \delta_t + \lambda_t \mu_j + \epsilon_{jt} \\ \\ y_{jt}^{T} = \alpha_{jt} + y_{jt}^{C} \end{cases} \tag{6}$$

where δ_t is an unknown common factor with a constant factor loading across the units, λ_t is a vector of common factors ($1 \times F$), μ_i is a vector ($F \times 1$) of unobservable factor loadings, and the error terms of ϵ_{it} are unobservable transient shocks. Only $y_{jt} = d_{jt} y_{jt}^{T} + (1 - d_{it}) y_{jt}^{C}$ was observed, in which $d_{jt} = 1$ if the unit is treated at the time t.

The synthetic control method consists of estimating the weights $\widehat{w}_j = \{\widehat{w}_1^j\}_{j \neq 1}$ based on the information provided by the pre-treatment periods and then building the interest estimator $\hat{\alpha}_{jt} = y_{1t} - \sum_{j \neq 1} \widehat{w}_1^j \, y_{jt}$ for $t > T_0$. Abadie et al. (2010) suggest a minimization problem to estimate such weights, which considers the pre-intervention observations. The authors define a set of K economic predictors, in which X_1 is a vector $(K \times 1)$ that contains the predictors for the treated unit and X_0 is a matrix ($K \times J$) of economic predictors for the control units. The synthetic control weights are estimated by the minimization of $\|X_1 - X_0 \, \boldsymbol{w}\|_V$ subject to $\sum_{j=2}^{J+1} w_1^j = 1$ e $w_1^j \geq 0$, where V is a positive semidefinite matrix $(K \times K)$. They discuss different possibilities for the choice of the V matrix, including an iterative process in which V is chosen so that the solution for the optimization problem $\|X_1 - X_0 \, \boldsymbol{w}\|_V$ minimizes the prediction error of the pre-intervention period. In other words, denoting the pre-intervention results by a vector Y_1^P $(T_0 \times 1)$ for the treated unit and denoting the pre-intervention results for the control units by **matrix** $\boldsymbol{Y}_0^P$ ($T_0 \times J$), the chosen weights of the synthetic control in this case, would be given by $\hat{\boldsymbol{w}}(V^*)$, where V^* minimizes $||Y_1^P - Y_0^P \hat{\boldsymbol{w}}(V)||$.

As argued by Ferman, Pinto, and Possebom (2018), a limitation of the synthetic control method is that the theory behind it does not provide any indication on how to choose the economic predictors for matrixes X_1 and X_0. As a result, a wide range of specification choices were found in applications of this method.

In this paper, the most common specification was adopted, which consists of using all the values from the pre-intervention results to estimate the weights[4]. This practice is in line with

[4] Ferman et al. (2018) discuss the adequacy of the results for the choice of variables adopted to define the weights determining the control group. On the other hand, the study also demonstrates that choosing predictor variables

the results of Kaul, Klöbner, Pfeifer, and Schieler (2018), which shows that the addition of more control variables is irrelevant when the historical values of the dependent variable will be considered in the pre-treatment period to estimate the weights of interest.

In this case, the weights for constructing the synthetic unit are given by the following minimization problem:

$$\{\widehat{w}_1^j\}_{j\neq 1} = argmin_{w \in W} \frac{1}{T_0}\sum_{t=1}^{T_o}\left[y_{1t} - \sum_{j\neq 1} w_1^j y_{jt}\right]^2 \tag{7}$$

where

$$W = \left\{\{ w\}_{1j\neq 1}^{j} \in \mathbb{R}^J \middle| w_1^j \geq 0 \; e \; \textstyle\sum_{j\neq 1} w_1^j = 1\right\} \tag{8}$$

Synthetic control was recently proposed in a series of seminal articles by Abadie and Gardeazabal (2003), Abadie et al. (2010), and Abadie, Diamond, and Hainmueller (2015) as an alternative method for estimating the effects of the treatment in comparative case studies. Moreover, as shown by Ferman and Pinto (2016), the synthetic control estimator features better properties than the differences-in-differences estimator, in terms of bias and variance.

In the case in question, there are two treated groups, whose impacts are measured separately. The first, Impacted, refers to the portfolio of the companies directly affected by the measure, namely, the electrical sector companies. The second group analyzed, Contagion, involves the portfolio of the regulated companies, which, owing to the shock characteristics, were potentially and indirectly affected. All the remaining companies are used as controls; based on these, portfolios are created, in which the dynamics of the analyzed risk parameter are as similar as possible to the dynamics of that risk parameter in the Impacted and Contagion groups in the pre-treatment period.

To assess the significance of the obtained results, it is possible to use a placebo test, as proposed by Abadie et al. (2010). For this test, the same synthetic control procedures are repeated for each of the control units, and it is verified whether the effects found for the treated states are “significantly” greater than those found for the placebos.

To do so, first, Error ($E_{j,t}$) is defined as:

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is asymptotically irrelevant when the number of pre-treatment periods tends to infinity, and the values of the dependent variable in the pre-treatment period are used as predictors.

$$E_{j,t} := \left(y_{1t} - \sum_{j \neq 1} \widehat{w}_1^j \, y_{jt} \right) \tag{9}$$

Subsequently, the following value mean is calculated for the pre- and post-treatment periods.

$$MSE_{j,pre} := \frac{\sum_{t=1}^{T_0} \left(E_{j,t}\right)^2}{T_0} \tag{10}$$

$$MSE_{j,post} := \frac{\sum_{t=T_0+1}^{T} \left(E_{j,t}\right)^2}{T - T_0} \tag{11}$$

Then, the ratio of these metrics is calculated, and the post/pre-treatment MSE ratio (MSER) is defined for each unit:

$$MSER_j := \frac{MSE_{j,post}}{MSE_{j,pre}} \tag{12}$$

Finally, it is verified in which metric's percentile the group is found in relation to the control units, considering the effect "significant" if the treated unit presents a value in the 5% of the most extreme percentiles. When assessing this ratio, the fact that some placebos may not produce good adjustments in the pre-treatment period is controlled for.

As observed by Abadie et al. (2010), this is not a formal statistical test; however, its result is still informative about whether the estimated effect of the intervention is large relative to the distribution of the estimated effects for units not exposed to the intervention. Abadie et al. (2010) recognize that the randomization inference premises are very restrictive for the synthetic control method, since treatment is generally not assigned at random. In the absence of random allocation, the p-value is interpreted as the probability of obtaining an estimated value for the test statistics at least as large as that obtained for the units assigned to the treatment or intervention at random.

It must be indicated that, as shown by Ferman et al. (2018), under conditions in which the pre-treatment period tends to infinity and the observations in the pre-treatment period are used for the estimation of the optimum weights ($\widehat{w}_1^j$), the proposed placebo test asymptotically leads to the same conclusions, regardless of the inclusion of other predictor variables.

The dependent variable used in the study is the CAPM beta, used as a systemic risk metric of the asset. For each instant analyzed, the parameter is calculated based on information of the previous 252 trading days. Moreover, since the study's interest is the temporal dynamics of the variable, and not its level, all companies have their Betas transformed to the mean beta scale observed for the treated units *(β_1):*

$$y_{j,t} = \beta^*_{j,t} = \left(\frac{\beta_{j,t}}{\frac{1}{T_0}\sum_{t=1}^{T_0}\beta_{j,t}}\right) \times \frac{1}{T_0}\sum_{t=1}^{T_0}\beta_{1,t} = \beta_{j,t} \times \left(\frac{\sum_{t=1}^{T_0}\beta_{1,t}}{\sum_{t=1}^{T_0}\beta_{j,t}}\right) \quad (13).$$

Similarly, the errors *($E_{j,t}$)* of each unit for each time period have their measuring units treated to allow for the most appropriate graphical representations. The applied transformation follows the recommendation by Ferman and Pinto (2017), and it consists of rescaling the post-intervention and pre-intervention errors of the control units using the pre-intervention MSE. More specifically, for placebo i, the prediction error is divided by the square root of its pre-intervention MSE, and it is multiplied by the square root of the pre-intervention MSE of the treated unit, thus resulting in:

$$E^*_{j,t} = E_{j,t} \times \sqrt{\frac{MSE_{1,pre}}{MSE_{j,pre}}} \quad (14)$$

It must be stressed that these transformations only alter the variables' scale without impacting the significance tests.

5 RESULTS

5.1. SYNTHETIC CONTROL

In this section, the main results obtained from the analysis of the effect of PA 579 on the directly affected companies, named the Impacted group, and the potentially and indirectly affected companies, named the Contagion group, are presented. The systemic risk variation effects (betas) are analyzed, and the results shown below are based on the synthetic control methodology, as discussed in Section 5.

To determine the control and treated groups, the following procedure was applied:

a) Two portfolios were made. One of them featured the electrical sector companies and the other one the remaining regulated companies; they were named Impact and

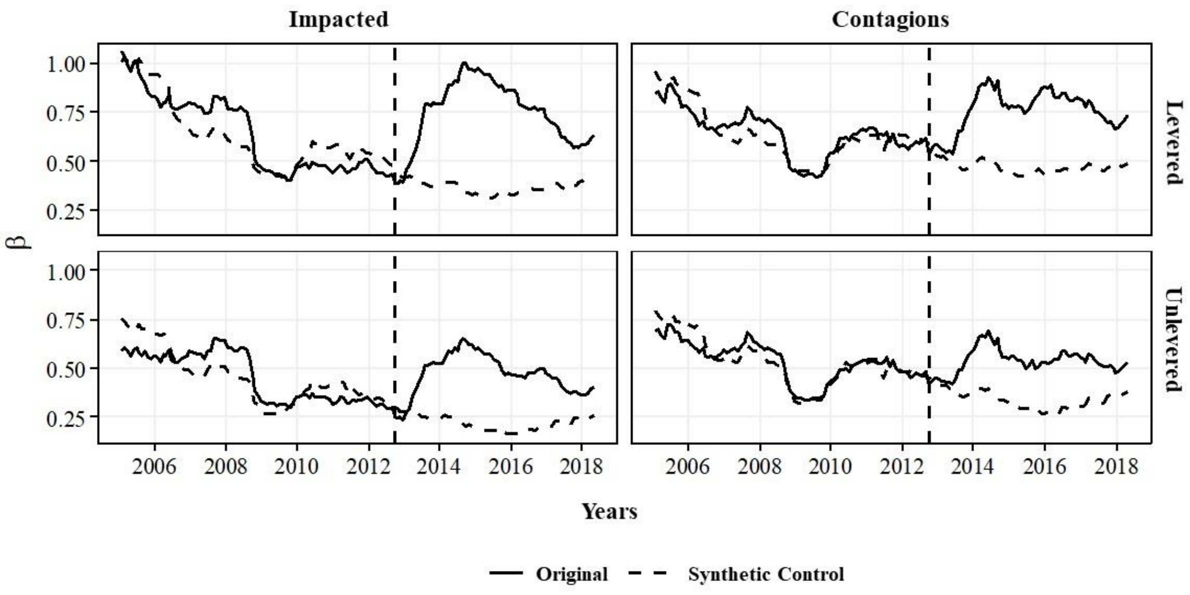
Contagion group, respectively; in both portfolios, the shares have equity proportional to their respective market values;

b) The other shares were analyzed individually and make the control group defined in this study as the Others group;
c) For each portfolio and analyzed company, the one-year rolling window beta (252 days) was calculated throughout the entire data history;
d) The trajectories of the Impact and Contagion portfolios were analyzed throughout the data history and around the application of PA 579 (September 2012), and compared to the trajectory observed for the elaborate synthetic control;
e) Finally, a placebo test was carried out to identify the significance of the obtained results.

Figure 1 below shows the differences between the rolling window betas of one-year for the Impacted and Contagion group, each accompanied by its respective synthetic control. The top graphs present the results for the levered beta and the bottom graphs the results for the unlevered betas. The results for the Impact group are shown on the left and those for the Contagion Group on the right.

Figure 1 – Treated units versus synthetic controls (β)

This figure presents the historical trajectories of the treated units' betas between 2005 and 2018, accompanied by their respective synthetic controls. The top graphs present the results for the levered beta and the bottom graphs those for the unlevered betas. The results for the Impacted and the Contagion group are shown in the left and right panel, respectively. Solid lines represent the one-year rolling window beta history for the portfolios analyzed, and the dotted lines the history of the respective synthetic controls. The dashed vertical line indicates the time when PA 579 was applied.



Source: Authors' calculations based on the data in this study.

It can be seen that, for both groups, in the period prior to PA 579, it is possible to note a clear downward trend for the betas of the portfolios. For the Impacted group, it was determined that the beta value was close to 1 at the beginning of 2005 and reached values below 0.5 in 2012, before the change imposed on the electrical sector. The same may be stated about the Contagion group, composed of the other regulated companies; its beta, which was close to 0.8 in 2005, reached a value very close to 0.5 in 2012.

It is also possible to note the groups' very similar reaction after the application of PA 579 in September 2012. For both groups, there was a downward trend in the betas, which develop a rising trend and achieve their maximum value by 2015. For the Impacted group, the rising trend ends, the beta exhibits a new downward trend after its maximum point. However, for the Contagion group, the beta remains stable, close to its new plateau.

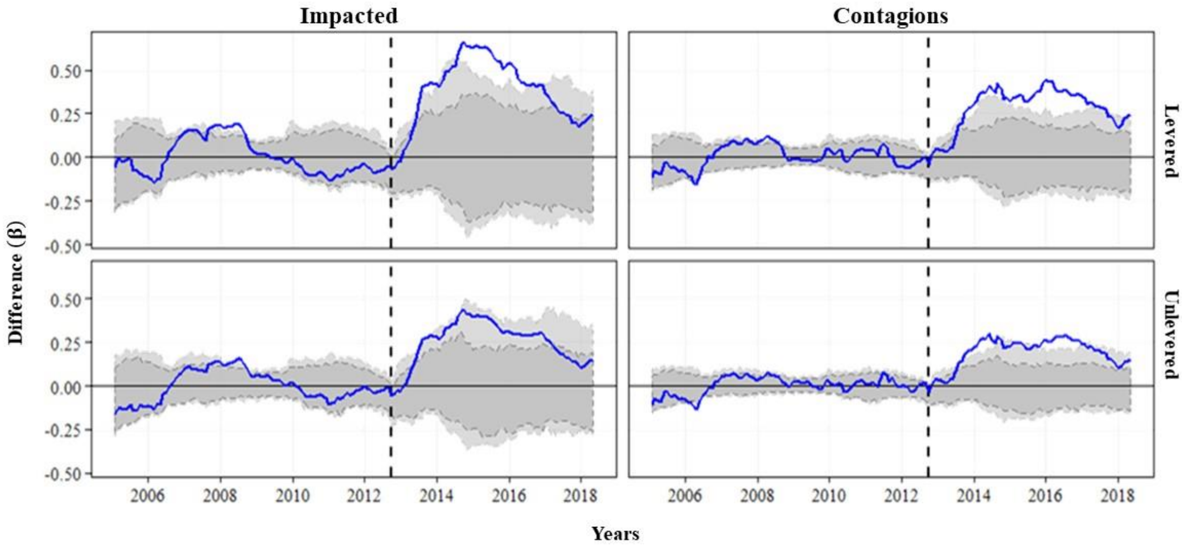
When we analyzed the estimated synthetic controls, we noted a strong adherence between their beta history and the original portfolio betas in the pre-treatment period. This behavior indicates that the estimated synthetic controls represent the treated groups analyzed very well. Moreover, after the event under study, there was a clear mismatch between the original series and their respective synthetic controls. Although the synthetic control series maintain the downward trend observed before September 2012, the original series exhibit a strong increasing trend immediately after the event.

For the Impacted group, this effect reached maximum value in October 2014, when the difference between the group's beta and that of its synthetic control reached a value of 0.69 for the levered beta and of 0.45 for the unlevered beta. For the Contagion group, in this period, the effect was estimated at 0.43 for the levered beta and 0.25 for the unlevered beta. However, in this group, the maximum effect was in March 2016, when it reached 0.41 for the levered beta and 0.29 for the unlevered beta.

The effect of removing the variation of the rolling window betas in all four scenarios highlighted the impact in the event of an increase in the systemic risk of the regulated sectors, whether they were directly or indirectly affected by PA 579.

Figure 2 – Placebo test analysis of the control: 90% and 95% significance intervals

This figure presents the historical trajectory of the difference between the beta observed for each group and the beta of the respective synthetic control. The solid line represents this difference for the treated groups and the dark gray area represents the 5th and 95th percentile limits for the placebo units. The light gray area represents the 2.5th and 97.5th percentile limits for the placebo units. The top graphs present the results for the levered beta, and the bottom graphs present those for the unlevered betas. The results for the Impact and Contagion group are shown in the left and right panel, respectively.



Source: Authors' calculations based on the data in this study.

In terms of significance, the results are presented in Figure 2. This figure summarizes the placebo test conducted for the Impact and Contagion groups, for both the levered and unlevered betas.

In Figure 2, the historical trajectory of the difference between the beta observed for each group and the beta of the respective synthetic control is illustrated. The solid line represents this difference for the treated groups; the dark gray area represents the 5th and 95th percentile limits for the placebo units. The light gray area represents the 2.5th and 97.5th percentile limits for the placebo units.

The test confirms that the adjustment in the pre-treatment period is adequate, since the differences between the observed betas and the synthetic control betas remain predominantly within the confidence interval. Moreover, it is possible to conclude that the results are significant[5] in all four perspectives analyzed. Finally, it is also possible to see a decrease in the effect in the more recent periods, even when the effect is shown to be nonsignificant.

[5] It must be pointed out that despite the fact that the placebo test is not strictly a statistical significance test, this term is used throughout the study, and it also occurs conventionally in studies adopting this methodology. The placebo test informs us in what percentile the estimated effect lies relative to the estimated effects of the untreated, and supposedly unaffected, companies.

The results of the placebo test are also summarized in Table 1, which shows the post/pre-treatment MSE ratio (MSER) ratio and also the 95th and 97.5th percentiles for the control group companies.

Table 1 – post/pre-treatment MSE ratio (MSER)

This table shows the ratio of the post- and pre-treatment MSE ratio for the Impacted and Contagion group and also the 95th and 97.5th percentiles for the control group companies. The values in brackets refer to the "p-values" calculated as ||1 – observed percentile||.

Type of beta	Groups			
	Impacted	Contagion	Others	
			95th Percentile	97.5th Percentile
Levered	2.83 *(p-value = 0.017)*	3.17 *(p-value = 0.012)*	2.02 *(p-value = 0.05)*	2.47 *(p-value = 0.025)*
Unlevered	2.20 *(p-value = 0.012)*	2.82 *(p-value = 0.003)*	2.04 *(p-value = 0.05)*	2.08 *(p-value = 0.025)*

Source: Authors' calculations based on the data in this study.

The results presented indicate significance of the effects of PA 579 on the electrical sector companies, as well as on other regulated companies.

Given these results, it is evident that after the intervention, the systemic risk of the electrical sectors and the other regulated sectors in the Brazilian economy was negatively impacted due to the interventions in and legal uncertainty of the contracts, indicating the existence of a contagion effect on the regulated sectors of the Brazilian economy.

5.2. ROBUSTNESS

In this section, the results obtained after the application of alternative methodologies, variations in the definition of the systemic risk variable (beta), and different weightings in the portfolios, are analyzed.

First, the sensitivity of the results was analyzed according to different definitions of the dependent variable (beta). The results obtained were analyzed using portfolios composed of all the shares equally weighted (that is, no longer proportional to their respective market values). After that, the results obtained were also analyzed with the rolling window betas estimated using two-year windows (502 days).

Both analyses are summarized in Table 2, which is organized in the same way as Table 1 of the previous section. The results refer to the placebo tests obtained after the application of the adjustments to estimating beta.

Table 2 – post/pre-treatment MSE ratio (MSER) robustness

The table shows the post-/pre-treatment MSE ratio for the Impacted and Contagion groups, as well as the values found in percentiles 95 and 97.5 among the control group companies. The values in brackets refer to *the "p-values"* calculated as ||1 – *observed percentile*||. Panel A, with results for a 252-day beta and portfolios with an equally weighted participation. Panel B, with results for 504-day betas and portfolio portfolios with a weighted participation per market value.

Type of beta	Groups			
	Impacted	Contagion	Others	
			95th Percentile	**97.5th Percentile**
Panel A: 252-day beta – equally weighted portfolio				
Levered	2,99 (*p-value = 0,015)*	1,73 (*p-value = 0,080)*	2.02 (*p-value = 0.05)*	2.47 (*p-value = 0.025)*
Unlevered	2.20 (*p-value = 0.011)*	1.56 (*p-value = 0.100)*	2.04 (*p-value = 0.05)*	2.08 (*p-value = 0.025)*
Panel B: 504-day beta – portfolio shares weighted per market values				
Levered	4.17 (*p-value = 0.60)*	5.15 (*p-value = 0.030)*	4.69 (*p-value = 0.05)*	5.31 (*p-value = 0.025)*
Unlevered	2.82 (*p-value = 0.040)*	4.66 (*p-value = 0.006)*	2.70 (*p-value = 0.05)*	3.47 (*p-value = 0.025)*

Source: Authors' calculations based on the data in this study

There were no differences in the results with regard to significance, and all results remained significant.

After that, the robustness of the results was analyzed when the different methodology was applied to the original proposal. The synthetic control methodology is the most appropriate to the situation in question, especially because it is able to capture the temporal variation component of the situation more adequately and it has better properties than the differences-in-differences estimator in terms of bias and variance, as shown by Ferman and Pinto (2016). Nevertheless, the chosen method is not the only option for the analysis of the situation. The traditional differences-in-differences methodology is also an option; therefore, we also present its results below.

To apply the differences-in-differences methodology, the observations from September 2012 (the last month before the application of PA 579) and September 2013 (one year after the event) were selected. The latter date was defined as the period after treatment, and two treated groups were established: (a) Impacted, comprising all electrical sector companies; and (b) Contagion, composed of the other regulated companies. The control group comprised the remaining companies.

It must be noted that, unlike the synthetic control method, in which the companies of each treated group are organized in portfolios and each group is analyzed separately, in this approach, the companies are not organized in portfolios, but analyzed individually; furthermore, the effects of the Impacted and Contagion groups are analyzed using the same approach.

Moreover, for a better comparison between the treated and control groups, the companies in the treated and control groups were paired. The aim of the pairing was to identify, among the control companies, the control companies most similar to the treated ones. The variables used for the pairings were: capital structure, assets, ratio of *Earnings Before Interests and Taxes* (EBIT) and assets, market value, ratio of negotiated value and market value, ratio of market value and accounting value *(market-to-book)*, levered beta, and unlevered beta. The pairing results are summarized in Table 3.

Finally, the regression results are presented in Table 4 below. The regression was conducted on both the complete and paired samples. Furthermore, the samples were also analyzed after the inclusion of the control variables.

Table 3 – Control variables and pairs

The table shows the means of the variables used for pairings between observations. The columns refer to the companies grouped as follows: control, Impacted group, Contagion group, and control after pairing, respectively.

Variables	**Group**			
	Complete Control	**Impacted**	**Contagion**	**Paired**
Capital structure	0,31	0,37	0,26	0,31
Assets (millions)	31,21	25,45	19,36	33,94
EBIT/assets	0,05	0,09	0,07	0,05
Market value (millions)	21,39	9,78	13,54	22,47
Negotiated value/market value	0,15	0.19	0.11	0,15
Market-to-book	2,71	1,78	2,91	2,78
Beta	0,55	0,37	0,49	0,57
Unlevered beta	0,38	0,24	0,38	0,39

Source: Authors' calculations based on the data in this study

The effect of the treatment on the estimated coefficient for the interaction between the treated group and post-treatment period was observed, that is, for *PA579 × Impacted* for the Impacted group and *PA579 × Contagion* for the other regulated companies. Thus, it was possible to observe the statistical significance of the effect of the PA 579on the two groups in all the perspectives analyzed. In terms of levered beta, the results are close to 0.54 for the Impacted group and close to 0.30 for the Contagion group. For the unlevered betas, the values are close to 0.38 and 0.20 for the Impacted and Contagion group, respectively.

Again, all the results analyzed indicated significant effects of the measure regarding its impact on the systemic risk; the effect is not only limited to electrical sector companies, but it also extends to the other regulated companies.

Table 4 – Results of differences-in-differences

The table presents the results of the differences-in-differences regression. In the first column are the variables used, whereas in the following columns, their respective estimated coefficients. The Levered column refers to the levered beta results. The Unlevered column refers to the unlevered beta results. The Complete column presents the results based on the entire sample. The Paired column refers to the results based on the paired sample. The Fixed Effects column refers to the results obtained after the inclusion of the companies' fixed effects.

Variables	Levered					Unlevered				
	Complete		Paired		Fixed effects	Complete		Paired		Fixed effects
PA579	-0.067** (0.034)	-0.068** (0.031)	-0.076** (0.034)	-0.077** (0.031)	-0.096*** (0.022)	-0.037 (0.025)	-0.039 (0.024)	-0.039 (0.026)	-0.042* (0.024)	-0.064*** (0.017)
Impacted	-0.074 (0.060)	-0.103* (0.055)	-0.082 (0.060)	-0.109* (0.056)	-0.396*** (0.135)	-0.082* (0.045)	-0.089** (0.043)	-0.085* (0.045)	-0.090** (0.043)	-0.409*** (0.103)
Contagion	-0.100 (0.064)	-0.074 (0.058)	-0.108* (0.064)	-0.080 (0.059)	-0.136 (0.136)	-0.084* (0.048)	-0.071 (0.046)	-0.086* (0.048)	-0.074 (0.046)	-0.151 (0.103)
PA579 × Impacted	0.542*** (0.084)	0.538*** (0.077)	0.551*** (0.085)	0.547*** (0.078)	0.477*** (0.055)	0.385*** (0.063)	0.385*** (0.060)	0.387*** (0.064)	0.387*** (0.061)	0.318*** (0.041)
PA579 × Contagion	0.310*** (0.090)	0.282*** (0.082)	0.319*** (0.091)	0.290*** (0.083)	0.213*** (0.058)	0.219*** (0.068)	0.207*** (0.064)	0.221*** (0.068)	0.210*** (0.065)	0.136*** (0.044)
Constant	0.0005 (0.031)	-0.023 (0.033)	0.007 (0.031)	0.007 (0.037)	0.652*** (0.094)	0.013 (0.023)	0.012 (0.028)	0.018* (0.023)	0.021 (0.030)	0.631*** (0.072)
Controls^{a}	-	Yes	-	Yes	-	-	Yes	-	Yes	-
Notes	198	198	104	104	198	198	198	104	104	198
R^2	0.808	0.844	0.811	0.847	0.959	0.778	0.806	0.773	0.801	0.952
Adjusted R^2	0.802	0.835	0.805	0.837	0.916	0.771	0.794	0.766	0.788	0.901

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; ^{a} Controls: 252-day lagged beta, capital structure, total assets, EBIT/assets, market value, mean negotiated value (USD)/market value (USD).
Source: Authors' calculations based on the data in this study

6. ECONOMIC IMPACT

This section does not aim to specify the economic impact of the PA 579 on the Brazilian economy; rather, it aims to scale the magnitude of change that the measure may have achieved in the national regulatory environment, specifically, in the hiring of public and private agents.

Between 2013 and 2018, 140 concession contracts were established between Public Power (municipalities, states, and the Union) and private partners[6,7]. The contracts provided investments in the order of R$ 61.4 billion in the private sector, which would be remunerated throughout the contracts.

As discussed in the methodology section, systemic risk is one of the components used to measure the WACC, a measure used by both Public Power and private companies to estimate whether the profitability of a project is adequate. Thus, considering the increase in the systemic risk, and consequently, in the WACC of the regulated companies in Brazil after PA 579[8], it can be concluded that, as a consequence of the PA, the minimum profitability required by the private partners to operate these concessions was raised.

6 Data obtained from Radar PPP consulting, available at: <https://www.radarppp.com/planos/>.
7 Until June 2018.
8 In the period in question, there were no concessions for electrical sector companies, so this section focuses on the other regulated companies, that is, companies in the Contagion group.

For the regulated companies, the variation in WACC resulting from the PA 579 is estimated by the difference between $WACC^{Contagion}$ and $WACC^{Control}$, as follows:

$$WACC^{Contagion} = \left(\frac{E}{D + E}\right) \times K_e^{Contagion} + \left(\frac{D}{D + E}\right) \times K_d \times (1 - T) \quad (15)$$

$$WACC^{Control} = \left(\frac{E}{D + E}\right) \times K_e^{Control} + \left(\frac{D}{D + E}\right) \times K_d \times (1 - T) \quad (16)$$

Thus,

$$\Delta \text{WACC} = WACC^{Contagion} - WACC^{Control} = \left(\frac{E}{D + E}\right) \times (K_e^{Contagion} - K_e^{Control}) \quad (17)$$

By assessing the increase in the WACC of the regulated companies, it is possible to measure the increase in the cost of capital required by private agents after PA 579, and then quantify the PA 579cost to the consumers and other taxpayers in the other regulated sectors, their which were not directly affected by the measure. Table 5 presents these results.

Table 5 – Quantification of impact: Results

The table presents the results on the increase in the estimated WACC and its impact on the annual load cost for investments in new concessions between 2013 and 2018. To measure K_e, it is considered the unlevered beta of the contagion group and of its respective control group. The annual risk premium ($E(R_m) - R_f$) is estimated at 6%.

Year	$\left(\frac{E}{D+E}\right)$	Control K_e	Contagion K_e	ΔWACC	Investment (R$ millions)	Δ Annual load cost (R$ millions)	22.5 × Δ Annual load cost (R$ millions)
2013	0.68	11.95	12.94	0.67	13.836.0	92.7	2,085.1
2014	0.64	14.34	16.54	1.41	19.178.0	271.2	6,102.0
2015	0.57	16.82	19.02	1.24	6.323.0	78.5	1,766.3
2016	0.58	15.95	18.21	1.30	1.752.0	22.9	514.1
2017	0.62	11.50	13.08	0.97	17.129.0	166.6	3,749.0
2018	0.63	9.58	10.60	0.64	3.185.0	20.3	457.4
Total					**61,403.0**	**652.2**	**14,673.8**

Source: Authors' calculations based on the data in this study

As it can be seen, the increase in the regulated sector companies' WACC produces a higher investment load cost. The annual value of this increase was R$ 652.2 million. In Brazilian concessions, the contract remuneration rate is conventionally fixed at the beginning of the concession. Hence, it can be presumed that this will be the annual increase in the cost throughout the entire concession period. Considering the average concession length is 22.5 years, it is possible to estimate that the impact of PA 579 on the other regulated sectors, their consumers, and other taxpayers not directly affected by the measure, is R$ 14.67 billion, equivalent to 23.90% of the planned investments [9].

[9] It must be stressed that the assessment of this impact differs from that of the effects of the likely non-investments, since the increase in WACC may turn some smaller profitability projects into something unattractive to the private sector.

7. CONCLUSION

The main aim of PA 579 was to enable fees reduction for the electric energy consumers in Brazil. However, this measure led to several consequences in the electrical sector, such as uncertainties regarding the rules for renewing existing concessions.

The obligation to express interest before learning about the new renewal conditions and the new refund payment rules has concerned the main investors in the sector. Thus, the absence of clearer information has caused uncertainties in the electrical sector regarding the application of the energy policy and the use of the sector as an instrument for achieving political objectives. In addition to the direct consequences, PA 579 led to an indirect impact on the regulated hiring environment.

It was found that the government attempted to reduce the fees to the consumer in an abrupt way. This caused problems to the Electrical sector companies and impacted all the regulated sectors of the Brazilian economy, disseminating the increase in regulatory risk.

Through the synthetic control and Dif-in-Dif methodologies and a 140-share sample spanning from January 2008 to September 2016, this study showed that PA 579 increased the systemic risk of the electrical sector and of the other regulated sectors in the economy, highlighting the contagion effect on the Brazilian regulatory environment. Furthermore, regarding the contracts under the concession regime established between the Public sector and private partners between 2013 and 2018, it is estimated that the increase in systemic risk may have cost more than R$ 14.67 billion (U$ 3.5 billion) to Brazilian consumers/taxpayers, casting doubts on the whether the effect of PA 579 was positive.

Future studies may consider elaborating on the regulatory risk contagion mechanisms among the regulated sectors, as well as on the discussion of variables not considered in this study, which may explain the effect of the increase in the systemic risk of the regulated sectors in the analyzed period.

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