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The Effect of 2021 Brazil's "Proposal for Free Market Expansion of the Electricity Sector" on Short-Term Stock Prices and Volatility

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We examine the effect of the "Proposal for Free Market Expansion of the Electricity Sector" disclosure on Brazil's short-term stock market prices and volatility. We employ the Difference-in-Differences and the Doubly Robust Difference-in-Differences methodologies to analyze the proposal's disclosure effect on daily returns and volatility of electricity sector companies listed on the Brazilian stock exchange. Results show a negative effect of the policy on stocks' average daily returns and volatility.

I. Introduction

Currently, energy markets are key to the sustainable development of nations. Nations are promoting changes to make their energy matrices less dependent on single energy sources and suppliers. The free energy market is available to all residential and industrial consumers in Japan, South Korea, France, and the United Kingdom. In Brazil, 70% of the electricity sold fits into the Regulated Contracting Environment, a model in which captive consumers pay a single bill to the local energy distributor, including the costs of consumed electricity, fees, and charges. The electricity tariff is determined by government regulation, with annual readjustments. Only a fraction of consumers (above 1,500kW consumed electricity) can directly negotiate prices on the free market, exempting them from buying electricity from a local distributor. Senator Cássio Cunha Lima of the Brazilian Social Democracy Party (PSDB) has submitted Proposal No. 414/21, aimed at modernizing the electricity sector and expanding access to the free market for all of Brazil, including residential consumers. The project allows consumers to buy electricity from suppliers and sources (hydraulic, wind, solar, and others), with tariffs differentiated by quantity, time, and prepayment. The project also removes consumers' obligation to buy electricity to meet 100% of their load, considering self-production.

Fama et al. (1969) define an efficient market as one in which rational and profit-maximizing investors actively compete, each trying to predict the future value of shares and where information is available to all participants. Therefore, regulatory changes tend to alter companies' operating outcomes and provoke new pricing of shares. Changes in market prices can occur in the short, medium, and long term. Several studies verify the impact of the disclosure of new regulatory information on the financial market (Binder, 1985; Dnes & Seaton, 1999; He et al., 2020; Hoang et al., 2020; Kunert et al., 2017; Ramiah et al., 2015; Su & Fleisher, 1998; Zhao et al., 2018). However, few studies address the impact of government regulation in electricity markets. He et al. (2020) and Zhao et al. (2018) analyze the impact of environmental regulations on Chinese companies' shares in the energy sector. Both studies demonstrate an adverse market reaction to stronger regulations due to fear of rising costs. To the best of our knowledge, we are the first to examine the effects of the "*Proposal for Free Market Expansion of the Electricity Sector*" (Proposal No. 414/2021) on the Brazilian stock market.

We analyze the proposal's disclosure effect on daily returns and volatility of electricity sector's companies listed on the Brazilian stock exchange (B3). We consider four operating segments in the estimations: whole electricity sector, generation sector, transmission sector, and distribution sector. The data has a panel structure and spans January 14th to March 10th, 2021. The Brazilian Congress disclosed Proposal No. 414/2021 occurred on February 10th (the intervention date). Companies in the electricity sector are considered in the treated group, while all other companies listed on the B3 are considered the control group. We employ the Difference-in-Differences (DD) methodology and the Doubly Robust Difference-in-Differences (DRIPW) estimator proposed by Sant'Anna and Zhao (2020).

The DD results show negative effects of the policy on stocks' average daily returns and daily volatility across market segments, with significant impacts only on daily returns for the generation and transmission segments and on daily volatility for generation companies. The DRIPW estimator, on the other hand, reports significant negative effects of the policy on daily returns and volatilities for all market

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segments (except for daily volatility for generation companies). Effects are heterogeneous across subsectors but indicate that investors forecast company profit reductions due to future market openings. This expectation shift is consistent with the legislation's intent to expand competition in the electricity market.

II. Data

The sample consists of thirty-seven companies belonging to the electricity sector and listed on the Brazilian stock exchange (treatment group). The companies operate in the generation, transmission, and distribution of electricity. Companies can be "pure companies", operating exclusively in just one market segment, while others are "integrated companies", operating in two or more segments. Twenty-six companies are in the generation segment, twenty-two operate in transmission, and twenty-three distribute electricity. We also consider firms outside the electricity sector and listed on the stock market, totaling 103 companies (control group). The dataset spans January 14th to March 10th (business days), 2021, with a panel structure. We collected daily stock prices using the Excel software and the "*stockhistory*" command. We obtained daily and monthly traded volume data from the Brazilian stock exchange website.[1] We collected data on market risk factors from the Center for Research in Financial Economics (NEFIN, FEA-USP) website.[2]

We define the outcome variable "daily return" as the natural logarithm of daily differences in stock prices at market closure (day-to-day performance). We obtain the outcome variable "daily return volatility" by estimating the squared residuals of daily returns following the exponential general autoregressive conditional heteroskedastic model (EGARCH(1,1)). We formulate the market risk covariates following NEFIN methodology: (i) "HML" (High Minus Low); (ii) "IML" (Illiquid Minus Liquid Factor); (iii) "Market Factor;" (iv) "Risk-Free Rate;" (v) "SMB" (Small Minus Big Factor); and (vi) "WML" (Winners Minus Losers Factor). We also employ stock monthly traded volumes and monthly stock number of trades as covariates. Table 1 presents the descriptive statistics for the variables.

III. Method

We employ the Difference-in-Differences (DD) methodology to analyze the proposal's disclosure effect on the stock market. The central hypothesis of the DD methodology is the presence of parallel trends for the outcome variable between the treated (electricity segment companies) and control (non-electricity companies) groups. The following equation describes the Average Treatment Effect on the Treated (ATT):

$$\begin{aligned}\beta_{ATT} = \ & \{E[Y_i|T_i=1,X_{it},d_t=1]-E[Y_i|T_i=1,X_i,d_t=0]\} \\ & -\{E[Y_i|T_i=0,X_{it},d_t=1]-E[Y_i|T_i=0,X_i,d_t=0]\}\end{aligned} \quad (1)$$

Further, we employ the Doubly Robust Difference-in-Differences (DRIPW) estimator proposed by Sant'Anna and Zhao (2020). The DRIPW estimator combines outcome regression and inverse probability weighting (IPW), resulting in a doubly robust estimator for identifying the ATT. This procedure allows the resulting estimator to correctly identify the ATT even if one of the models is misspecified.

The econometric equation has the following form:

$$\begin{aligned}Y_{it} = \ & \beta_0+\beta_1*T_i+\beta_2*d_t+\beta_3\,(T_i*d_t) \\ & +\lambda*X_{it}+\theta_t+\pi_i+\varepsilon_{it}\end{aligned} \quad (2)$$

where Y_{it} represents the outcome variables "daily return" or "daily return volatility" for firm i stock prices. Variable T_i is a dummy variable identifying the company segment (whole electricity sector, generation, transmission, or distribution). Variable d_t identifies the period after the intervention (February 10th to March 10th). The interaction between T_i and d_t captures the causal effect of the proposal disclosure on the outcome variable. The vector X_i represents the market covariates. Vector θ_t represents covariates for month-fixed effects. Variable π_i represents firm fixed effects. Parameter β_3 captures the treatment effect, and λ is the vector of parameters associated with the covariates and ε_{it} represents the error term.

IV. Results

Tables 2 and 3 present the results, considering the DD and DRIPW estimators. In both tables, we consider four different samples per market segment: the whole electricity sector, generation, transmission, and distribution. We divide the results into two panels, considering the outcome variables "daily return" (Panel A) or "daily return volatility" (Panel B).

Concerning Table 2, we present two estimations for each market segment: with and without market covariates. The DD results show negative treatment effects on stocks' average returns and volatility across samples, although with significant impacts only on returns (Panel A) for the generation and transmission segments (regressions 3 to 6), and on volatility (Panel B) for the generation sample (regressions 3 and 4). Therefore, for the DD methodology, the disclosure of Proposal No. 414/2021 significantly affects the electricity generation segment, provoking reductions in average stocks' daily returns (circa 0.3%) and daily return volatilities. We find similar reductions in daily returns for the transmission sample.

Concerning Table 3, the DRIPW estimator reports significant negative effects of the policy on daily returns and volatilities for all segments (except for average daily volatility in the generation subsample). Estimated treatment effects for daily returns (Panel A) are heterogeneous across samples, varying between -0.0032 (generation) and -0.0119

1 https://www.b3.com.br/en_us/

2 https://nefin.com.br/data/risk_factors.html

Table 1. Descriptive Statistics

Variable	Mean	S.D.	Min	Max
Outcome Variables				
Daily return	-0.0021	0.0288	-0.2423	0.7528
Daily return volatility	0.0008	0.0093	0.0000	0.5690
Stock Segments				
Electricity sector	0.3592	0.4798	0.0000	1.0000
Generation	0.2524	0.4345	0.0000	1.0000
Transmission	0.2136	0.4099	0.0000	1.0000
Distribution	0.2233	0.4165	0.0000	1.0000
Non-electricity sector	0.6408	0.4798	0.0000	1.0000
Covariates				
HML[1]	-0.0005	0.0077	-0.0132	0.0159
IML[2]	-0.0001	0.0050	-0.0095	0.0119
Market Factor[3]	-0.0024	0.0161	-0.0434	0.0232
Risk-Free Rate[4]	0.0001	0.0000	0.0001	0.0001
SMB[5]	-0.0011	0.0065	-0.0187	0.0117
WML[6]	0.0027	0.0111	-0.0223	0.0289
Monthly trades	5.78e+05	8.36e+05	0.0000	6.63e+06
Monthly trading volume	6.41e+09	1.27e+10	0.0000	8.68e+10

Notes: [1]Return of a portfolio long on stocks with a high book-to-market ratio ("High") and short on stocks with a low book-to-market ratio ("Low"). [2]Return of a portfolio long on stocks with high illiquidity ("Illiquid") and short on stocks with low illiquidity ("Liquid"). [3]Difference between the value-weighted daily return of the market portfolio and the risk-free daily rate. [4]Daily risk-free rate calculated from the 30-day DI swap. [5]Return of a portfolio long on stocks with a low market capitalization ("Small") and short on stocks with a high market capitalization ("Big"). [6]Return of a portfolio long on stocks with high past returns ("Winners") and short on firms with low past returns ("Losers"). Month and firm binary variables were omitted due to space considerations.

Table 2. Difference-in-Differences Results (DD)

	Electricity Sector		Generation		Transmission		Distribution	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Daily return ($\ln P_t/P_{t-1}$)								
Treat. Effect	-0.0020 (0.0017)	-0.0016 (0.0015)	-0.0032* (0.0019)	-0.0029* (0.0016)	-0.0035* (0.0019)	-0.0032† (0.0017)	-0.0028 (0.0019)	-0.0026 (0.0017)
Market Cov.	NO	YES	NO	YES	NO	YES	NO	YES
N	3,914	3,914	3,496	3,496	3,344	3,344	3,382	3,382
Panel B. Daily return volatility (u^2)								
Treat. Effect	-0.0008 (0.0005)	-0.0004 (0.0003)	-0.0008† (0.0004)	-0.0006† (0.0003)	-0.0005 (0.0004)	-0.0003 (0.0003)	-0.0005 (0.0004)	-0.0002 (0.0003)
Market Cov.	NO	YES	NO	YES	NO	YES	NO	YES
N	3,914	3,914	3,496	3,496	3,344	3,344	3,382	3,382

Notes: * denotes significance at 10% and † significance at 5%. Values in parentheses are bootstrap standard deviations. Other coefficients are omitted due to space considerations. All regressions include time (month) and firm fixed effects. Regressions (3) to (8) consider different subsamples.

(distribution). The estimated treatment effects for return volatilities are also heterogeneous, although with smaller magnitudes (between -0.0001 and -0.0004). Therefore, when considering the DRIPW estimator proposed by Sant'Anna and Zhao (2020), the disclosure of Proposal No. 414/2021 significantly affected all electricity market segments, provoking reductions in average stocks' daily returns (between circa 0.3% and 1.2%) and daily return volatilities (between circa 0.01% and 0.04%). Albeit small, the reduced volatility indicates less dispersion of returns, meaning that agents can predict stock prices more precisely.

Results are heterogeneous across subsamples. Nevertheless, they indicate that investors forecast reductions in companies' profits due to the future market opening resulting in lesser market value. This result is consistent with the proposal's main goal to expand access to the free market

Table 3. Double Robust Difference-in-Differences Results (DRIPW)

	Electricity Sector	Generation	Transmission	Distribution
	(1)	(2)	(3)	(4)
Panel A. Daily return (ln P_t/P_{t-1})				
Treat. Effect	-0.0072‡ (0.0016)	-0.0032* (0.0018)	-0.0055‡ (0.0018)	-0.0119‡ (0.0016)
N	3,914	3,496	3,344	3,382
Panel B. Daily return volatility (u^2)				
Treat. Effect	-0.0002‡ (0.0006)	-0.0001 (0.0001)	-0.0004‡ (0.0001)	-0.0001* (0.0001)
N	3,914	3,496	3,344	3,382

Notes: * denotes significance at 10% and ‡ significance at 1%. Values in parentheses are bootstrap standard deviations.

to residential consumers, allowing them to buy electricity from different suppliers and to negotiate prices.

V. Conclusion

We examined the effect of the "Proposal for Free Market Expansion of the Electricity Sector" disclosure on Brazil's short-term stock market prices and the volatility of companies in the electricity sector. We employed the Difference-in-Differences and the Doubly Robust Difference-in-Differences methodologies. Results are heterogeneous across market segments but show negative effects of the policy on stocks' average daily returns and daily volatilities, indicating that investors forecast reductions in companies' profits and values due to the future market opening. This expectation shift is consistent with the legislation's intent to expand competition in the electricity market. We provide the first evidence of the market impact of the proposed change in regulation. We recommend further analysis to verify the impact of the proposal's approval on medium and long-term stock price returns, volatilities, and market competitiveness.

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