Household Electricity Default in Brazil: Evidence from Billing Data[*]

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Abstract

This paper aims to examine the key factors influencing default rates among residential electricity consumers in Brazil. To achieve this, we use a unique dataset comprising monthly electricity bills, and we combine it with several administrative data sources. By leveraging the policy designs adopted by the regulator, we employ a causal inference approach to identify the effects of tariff changes and enforcement actions implemented by electricity distributors on default rates. Our findings indicate that an increase in electricity tariffs raises the likelihood of default. Furthermore, the results reveal that power cuts represent the primary tool for combating default, and allowing such cuts can reduce the default duration by up to 9%. These findings contribute to the understanding of the factors influencing household default behavior and their implications for ensuring electricity affordability.

Keywords: electricity tariff, electricity bill default, power cuts

JEL Codes: L94, L51, G50

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1 Introduction

The default rate is a critical factor that can have a significant impact on the financial management of electricity distributors. When consumers fail to pay their bills, it can lead to financial losses for the companies, potentially necessitating increased electricity tariffs for all consumers within the concession area. Non-payment can be influenced by both conjunctural economic shocks to consumers and intrinsic factors within the electricity sector. In order to address the default rate, utilities have the option to implement punitive measures, such as disconnecting the electricity supply.

In Brazil, there was an upward trend in electricity default rates over the last decades. However, in March 2020, at the onset of the Covid-19 pandemic, the Brazilian Electricity Regulatory Agency (ANEEL) suspended the permission to power cuts due to non-payment as a measure to mitigate the adverse effects of the pandemic on families' income. This factor, combined with the severe economic crisis caused by the pandemic, led to a significant increase in the default rate. The default rate reached its peak in the early months of the pandemic but rapidly declined afterward. However, the default during those few months increased the stock of accumulated delays.

This study aims to analyze the factors that contribute to default among electricity consumers and evaluate the impact of punitive policies on default rates. To achieve this, we employ a unique monthly panel dataset comprising a sample of consumers from two utility concession territories in Brazil spanning the period from 2016 to 2022. The dataset provides comprehensive information on billing and collection, which we enhance with administrative data obtained from the Ministry of Labor and Employment (MET) and the Brazilian National Electric Energy Agency (ANEEL). Utilizing the panel data, we calculate the duration of default for each consumer on a monthly basis. Subsequently, we employ policy designs to identify the causal effect of electricity prices and punitive measures on consumer non-payment.

First, we aim to understand whether electricity price causes default. To quantify the effect of a tariff variation on default, we use quasi-experimental strategies to identify the causal effect between tariffs and default. The results suggest that an increase in tariffs raises default. However, for low-income consumers, we do not find evidence that an increase in the social tariff, which is lower, increases short-term default.

Next, we study the relationship between punitive actions by distributors and default. For this purpose, we estimate a linear model considering various layers of fixed effects and observable consumer characteristics. The results show that warning and power cut both decrease default, but the result is less conclusive for negative listing.

However, it is clear that there is no causality from the punitive actions to default, since default is what trigger the actions. In order to obtain causality, or the effect of actions on the default measures, we exploit the suspension of power cuts during the Covid-19 pandemic. Using this event as an exogenous variation on the power cut action, we are able to estimate the effect of power cuts on default. The estimate coefficients are three to four times larger than the ones obtained with the linear model, showing that power cuts are a powerful policy to deter default.

An alternative way to study the relationship between income, collection actions, and default is to consider consumers living in subnormal clusters. By considering subsamples of consumers located inside and outside subnormal clusters, we find that the magnitude of symbolic cutoff and cutoff is higher for consumers outside the clusters. These results suggest that consumers living outside the clusters may respond more to energy cutoffs, reducing default, than consumers living in the clusters.

This study contributes to two bodies of literature. The first one is the effect of electricity prices on household behavior. The effect of price on electricity consumption is well-documented in the literature (for a literature review, see Zhu et al. (2018)). This literature suggests that residential electricity demand is almost price-inelastic in the short term. However, recent evidence shows that residential consumers respond to changes in price structure Fowlie et al. (2021). In this study, we utilize the difference in tariff revisions between two concession areas to identify the causal effect on the probability of non-payment of electricity bills. Our results indicate that variations in electricity prices affect the likelihood of keeping electricity bill payments up to date. However, this effect is heterogeneous over time. Residential consumers respond more quickly to a reduction in electricity prices compared to an increase in electricity prices.

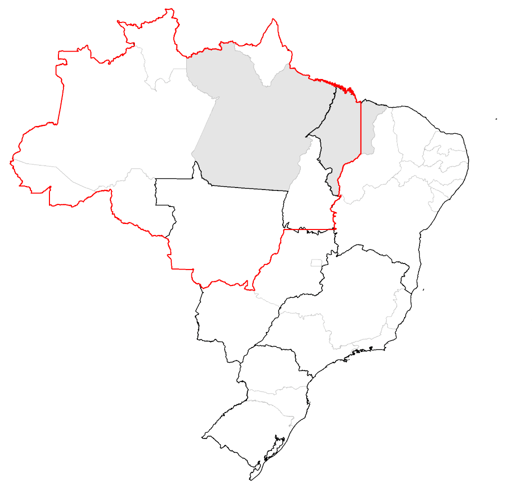
The second literature contribution is how the actions of distributors can affect consumer behavior, particularly in relation to non-payment of electricity bills. The literature suggests that non-payment is a significant issue for electricity utilities and has a negative impact on their financial performance (Murwirapachena et al., 2022; Khanna and Rowe, 2020). Papers show that informational campaigns can increase payment rates (Szabó and Ujhelyi, 2015). Overall, the papers indicate that non-payment is a complex issue requiring innovative solutions and that reducing non-payment can have positive effects on utility financial performance. In this regard, our findings first indicate that power cuts represent the primary tool for combating default. Furthermore, by analyzing the change in the power cut policy due to non-payment during the Covid pandemic, we found that allowing such cuts can reduce the default duration by up to 8%.

The remaining sections of this paper are structured as follows. Section 2 provides a description of the institutional background. Section 3 outlines the details of the database used in this study. In Section 4 focuses on estimating the impact of tariffs on default rates using a Difference-in-Differences (DiD) approach. In Section 5, we analyze the effects of punitive measures implemented by the distributor, specifically examining the impact of power cuts. Lastly, in Section 6, we provide concluding remarks and discuss the implications of our findings.

2 Background

Brazil is a diverse country with a vast territory and a wide range of socioeconomic characteristics. In this article, our focus is on the states of Pará and Maranhão, which encompass two concession areas of Equatorial Energia. Pará and Maranhão are two states that exhibit several similarities. Situated in the northern region of Brazil, both states bear a significant influence from the Amazon rainforest (Figure 1). They possess abundant natural resources, including minerals, timber, and a diverse range of biodiversity. Consequently, the economies of both states heavily depend on industries such as agriculture, mining, and forestry.

Figure 1: States of Pará and Maranhão



Source: Authors' elaboration using data from IBGE.
Note: The figure illustrates the geographical placement of Pará and Maranhão, two states in Brazil. The gray lines represent the state borders, while the black line signifies the border demarcating the five regions of the country. Furthermore, the red line represents the boundary of the Amazon region.

2.1 Regulation of Electricity Tariffs in Brazil

In Brazil, ANEEL oversees the regulation of electricity tariffs for residential consumers. As an electricity regulatory agency, its primary goals are to ensure the financial stability of distribution companies and to maintain affordable tariffs for consumers. ANEEL establishes the rules and criteria for setting and adjusting electricity tariffs in the country.

The first step in the tariff regulation process is the periodic tariff review. This review, which takes place every four years, establishes the foundation for calculating electricity tariffs. This process involves a detailed analysis of the distributor's operational costs and considers investments and improvements made in the electrical system. During the quadrennial tariff review, ANEEL can adjust the tariff structure, i.e., how the electricity tariff is composed. Additionally, the quadrennial tariff review may include quality targets for the electricity distributor, aiming to improve the quality of service provided to consumers.

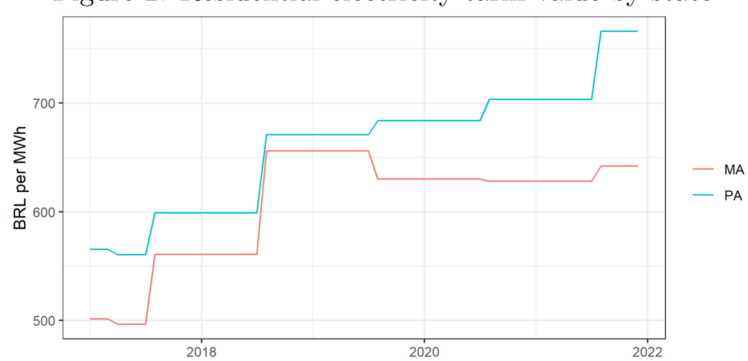
In addition to the tariff review, ANEEL implements annual adjustments to electricity tariffs. The annual adjustment of electricity tariffs is carried out also according to the concession contract anniversary of the electricity distributor. These adjustments are based on factors such as inflation, variations in operational costs, and the need for necessary investments in the electricity sector.

ANEEL also conducts public hearings to facilitate public participation and gather input from various entities, such as consumers, electricity distributors, and regulatory bodies. This participatory approach aims to ensure that the interests and concerns of all parties are taken into account before setting new tariffs.

It is worth noting that electricity tariffs can vary across different regions of Brazil due to disparities in the costs associated with generation, transmission, and distribution. This regional differentiation takes into account the unique characteristics and challenges faced by each area, ensuring a more targeted and tailored approach to tariff regulation.

Figure 2 illustrates the residential tariff per megawatt-hour (MWh) in the states of Maranhão and Pará from 2017 to 2021. The contractual anniversary for both concession areas is August. It is notable that until 2019, the tariff variations in both states were positively correlated. However, starting from August 2019, the tariff adjustments in these states followed different trends. We will utilize this information in Section 4 to identify the effect of tariffs on default.

Figure 2: Residential electricity tariff value by state



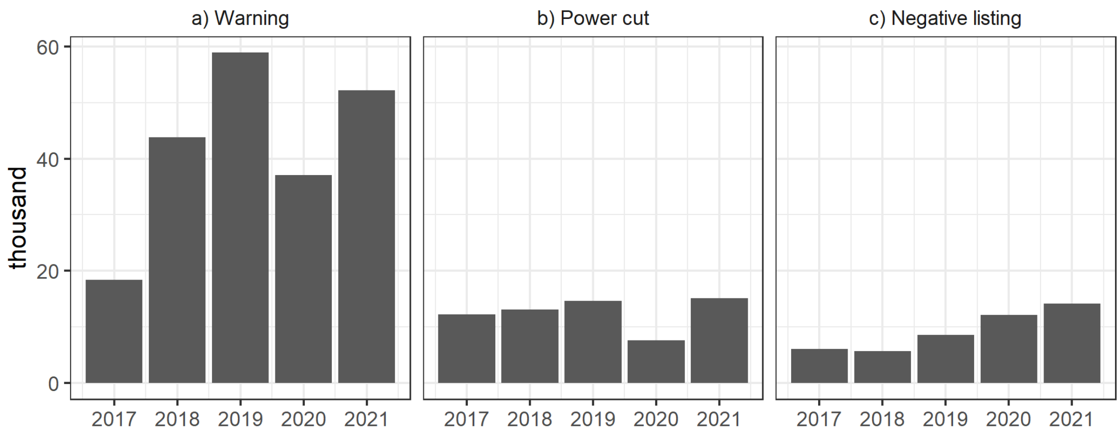
Source: Authors' elaboration using data from ANEEL.
Note: The tariff corresponds to group B1, residential class, conventional modality.

2.2 Default rate in the residential sector

Electricity distributors have several tools to combat consumer default, starting from issuing warnings about outstanding debts to including consumers in negative lists. The most extreme measure is the power cut due to non-payment. According to ANEEL regulations, the interruption of electricity supply can only occur 15 days after notifying the consumer of the overdue payment. However, ANEEL has established a maximum period of 90 days for an unpaid invoice to result in a power disconnection.

In our sample of consumers in the concession areas corresponding to the states of Pará and Maranhão (for more details, see Section 3), Figure 8 illustrates the number of actions taken by the distributor to combat default between 2017 and 2021. The three main measures implemented are as follows: warning, power cut, and negative listing.

Figure 3: Number of actions to combat default per year



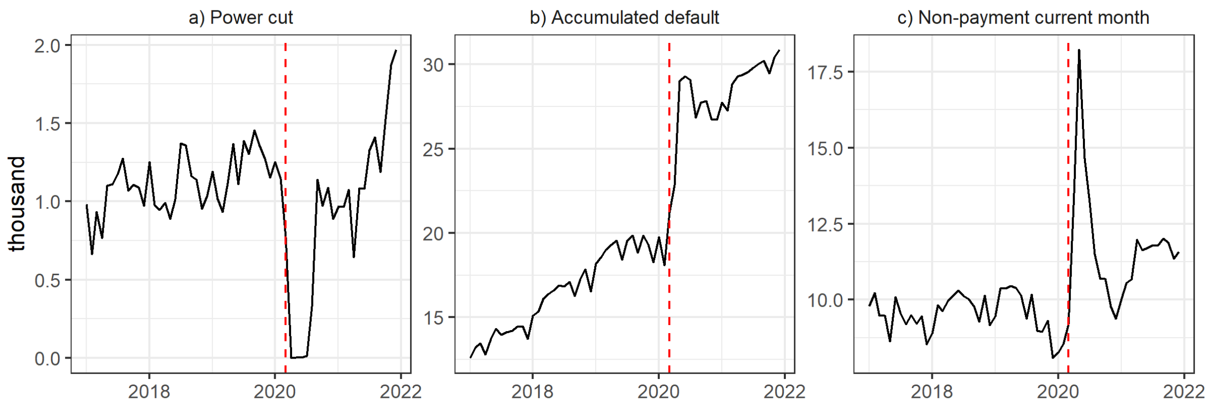
Source: Authors' elaboration using data from Equatorial.
Note: This graph shows the number of collection actions for a sample of residential consumers in the states of Maranhao and Para between 2017 and 2021.

The warning measure involves a visit from an agent to inform customers with overdue invoices about the risk of a power cut due to non-payment. The number of warning actions, along with power cut actions, demonstrates an increasing trend until 2019. However, during the early stages of the Covid-19 pandemic (between April and September 2020), ANEEL suspended power cuts for defaulting consumers. This policy's impact is evident in the decline of actions in 2020, as shown in Figure 8. On the other hand, negative listings continued to exhibit an upward trend throughout the entire period, unaffected by the pandemic-related policy changes.

In addition to the increase in default after the onset of the pandemic, the average electricity consumption, calculated using our sample data, also increased. The pre-pandemic average consumption of approximately 105 kWh rose to 115 kWh. Several reasons can explain the increase in average consumption, such as the prohibition of electricity power cut, increased values of income transfer programs, and a higher number of people working from their homes.

Figure 4 below shows an upward trend in default between 2017 and 2019. However, at the beginning of the Covid-19 pandemic in March 2020, the suspension of energy cutoffs mandated by ANEEL, as shown in the first panel of Figure 4, combined with the severe economic crisis caused by the pandemic, resulted in a surge in default, as shown in the second panel. The third panel shows that default reached its peak in the early months of the pandemic, rapidly declining afterward. However, the delays during those few months increased the stock of accumulated delays, a fact observed until the end of our sample period in June 2022.

Figure 4: Number of cutoff actions and overdue bills per month



Source: Authors' elaboration using data from Equatorial.
Note: This graph shows the number of cutoff actions and the number of overdue contracts per month for a sample of residential consumers in the states of Maranhão and Pará between January 2017 and June 2022. The dashed red line indicates the beginning of the Covid-19 pandemic in March 2020. The first graph on the left shows the number of cutoff actions per month. The one in the middle shows the cumulative stock of overdue bills, while the one on the right shows the amount of overdue bills per month.

3 Data

In this article, the database is built from information from a sample of contracts from the distributor Equatorial. We constructed a monthly panel with contract information, delinquency measures, and collection policies at the consumer level and combined it with other databases: worker characteristics from the Annual Social Information Report (RAIS) of the Ministry of Economy, average electricity tariff from the National Electric Energy Agency (ANEEL), and location of subnormal clusters from the Brazilian Institute of Geography and Statistics (IBGE).

Electricity billing data

The main source of data used in this study is the monthly information from a sample of consumers of the Equatorial electricity distributor in the concession areas corresponding to the states of Maranhão and Pará. Based on customer registration data, extracted in June 2022, we randomly selected a representative sample of residential consumers. Thus, one percent of the contracts for each ZIP code in the states corresponding to the distributor's concession area were selected.

Once the sample was defined, the company provided microdata on contracts in the states of Maranhão and Pará for the period between 2016 and 2022. The microdata contains registration information (contract number, CPF, CNPJ, and ZIP code), monthly billing history (due date, invoice clearance date, invoice amount, billed consumption, and measured consumption), and collection actions (action date and action type).

To reduce potential outliers and measurement errors, we imposed restrictions on the database. We excluded contracts that did not have electricity consumption during the period. Finally, we excluded contracts containing the top 0.5% highest consumption values in the history. Thus, the final sample consists of 65,582 contracts, totaling 4,099,864 observations between July 2016 and June 2022.

Based on the set of available microdata, we constructed a monthly panel by aggregating the registration data, billing history, and collection actions at the individual (contract) level. Therefore, the unit of analysis in this study corresponds to the monthly information for each contract (contract-month). To construct the default duration, we identified the month in which each bill for each contract was paid or left unpaid. We used the default duration to analyze how this variables are affected by default prevention actions taken by the company. The punitive actions are the main variables of interest: warning, power cut, and negative listing.

Electricity retail tariff

The electricity tariff is constructed based on the dataset "Homologated Tariffs of Electricity Distributors" provided by ANEEL (Brazilian Electricity Regulatory Agency). This dataset includes the values of Energy Tariffs (TE) and Distribution System Usage Tariffs (TUSD) per distributor, resulting from the tariff readjustment processes of electricity distributors. Additionally, it includes the start date and validity period of the tariffs. Therefore, in this article, the tariff corresponds to the sum of the TE and TUSD tariffs selected from group B1, residential class, and conventional modality.

Employment

The Annual Social Information Report (RAIS) is a database from the Ministry of Economy (ME) that supports the preparation of labor statistics and the provision of information on the formal labor market to government entities. Among other data, RAIS contains information about worker characteristics and characteristics of their occupation.

Based on a confidentiality agreement, we have access to the microdata of RAIS identified by the worker's CPF number and the firms' CNPJ number. This way, we can identify the characteristics of the contract holders in the Equatorial sample who are employed in the formal labor market. The data includes education level, age, gender, race, and work remuneration.

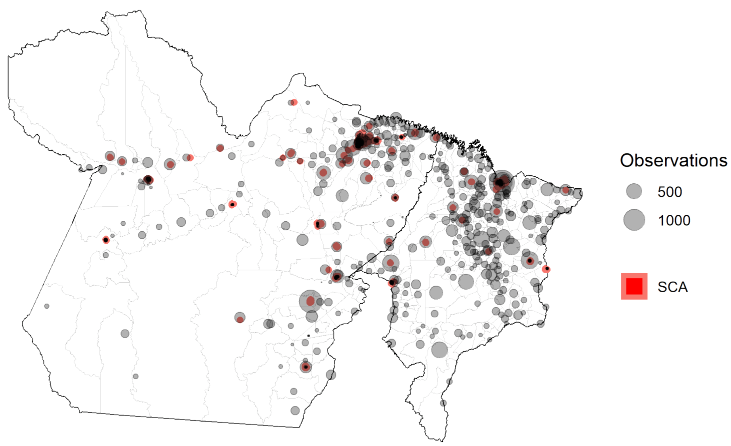
Since the RAIS universe only includes the formal market, we were able to retrieve the characteristics of 22% of the contract holders. Furthermore, due to the high data attrition, i.e., the number of workers who leave the formal labor market during the analyzed period, we identified 11% of the observations with work remuneration values.

Subnormal Clusters

The effectiveness of default prevention actions can be affected by the characteristics of the neighborhood where the consumer units are located, as is the case with subnormal clusters areas (SCA). According to the classification by IBGE, SCA is a form of irregular occupation of public or private land for housing purposes in urban areas, generally characterized by irregular urban planning, lack of essential public services, and location in areas with occupation restrictions.

We used the information on subnormal clusters, made available by IBGE in 2019, to analyze the effect on electricity default. By knowing the location of consumer units, we identified consumers located within SCA. Figure 5 shows the SCA locations and the number of observations by Zip Code.

Figure 5: Observations by Zip Code and Subnormal Clusters Areas



Source: Developed by the authors using data from Equatorial and IBGE.

Table 1 shows the statistical summary of the main variables.

4 Effect of tariff changes on consumer default

In general, electricity tariffs are adjusted annually on the anniversary date of the concession contract. The regulator typically considers key factors when determining tariff adjustments for the upcoming period, including monetary correction and the cost of purchased energy.

Figure 6 illustrates the homologated tariff values (blue curve) in the states of Maranhao (MA) and Para (PA). It can be observed that in August 2019, there was a decrease in the tariff in Maranhao and a slight increase in Para. In contrast, in August 2021, there was a significant increase in the tariff in Para and a minor increase in Maranhao. The figure reveals a correlation between variations in the tariff value and the frequency of payment delays in the current month (red curve).

Table 1: Statistical summary

	Mean	Std.Dev	Min	Median	Max
Default indicators					
Default	0.430	0.495	0	0.00	1.000
Overdue bills	3.972	8.996	0	0.00	65.000
Default duration	9.106	15.665	0	0.00	65.000
Collection actions					
Warning	0.072	0.259	0	0.00	1.000
Power cut	0.022	0.145	0	0.00	1.000
Negative listing	0.016	0.126	0	0.00	1.000
Covariates					
Tariff (R$ per MWh)	636.580	59.859	496.41	630.18	765.970
Bill value (R$)	110.895	136.956	0	71.21	2018.765
Consumption (kWh per month)	117.222	125.077	0	90.00	1864.500
Distributed generation (DG)	0.002	0.044	0	0.00	1.000
Social tariff	0.158	0.364	0	0.00	1.000
Formal worker	0.133	0.339	0	0.00	1.000
Subnormal cluster area (SCA)	0.153	0.360	0	0.00	1.000

4.1 Aggregate effect

In this section, we aim to estimate the effect of exogenous variations in electricity tariffs on consumer default probability using observations from 2019 and 2021. We employ the differences-in-differences (DiD) strategy to assess the causal effect of electricity tariffs on consumer default probability. We leverage the differential tariff adjustments in Para and Maranhao, which enables us to classify consumers into treatment and control groups. Furthermore, we restrict the analysis period to three months before and three months after the tariff adjustment to ensure that the tariff effect is not contaminated by other changes that may also affect default rates.

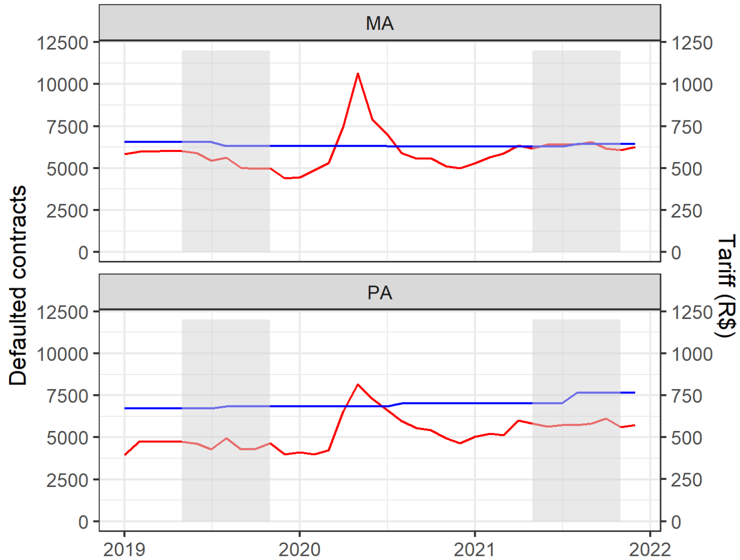
The DID specification is described by a two-way fixed effects model, as shown in Equation (1):

$$Y_{ist} = \beta D_{st} + \gamma X_{it} + \theta_i + \mu_t + \varepsilon_{ist} \tag{1}$$

where Y_{it} is a binary variable indicating whether consumer i in state s has any overdue bills in period t; D_{st} is a dummy variable that identifies whether there was an increase or decrease in electricity tariff in state s; X_{it} is a matrix of consumer characteristics; θ_m represents the individual fixed effects; μ_t captures the month-year fixed effect; ε_{ist} is the random term; and β and γ are parameters. We cluster the standard errors at the municipality level to mitigate the potential autocorrelation among individuals within the same locality.

The estimated coefficient β provides an estimate of the causal effect of the tariff increase on

Figure 6: Retail electricity tariff and defaulted contracts



Note: This graph shows the number of defaulted (red line) and the value of the electricity tariff (blue line). The tariff corresponds to group B1, residential class, conventional modality.

consumer default probability. By comparing the differences in default probabilities between the treatment and control groups before and after the tariff adjustment, we can isolate the treatment effect from other confounding factors.

It is important to note that the causal interpretation of the estimated effects relies on certain assumptions. First, the validity of conditional parallel trends assumes that, in the absence of treatment, similar consumers would exhibit similar default trends. Second, the assumption of no anticipation of the treatment implies that consumers have no prior knowledge of the magnitude of the tariff change.

Table 2 presents the estimated results using Equation 1. Columns (1) and (2) display the outcomes associated with the reduction of tariffs in Maranhão in 2019. Columns (2) and (4) present the results associated with the increase in tariffs in Pará in 2021. In columns (1) and (3), no covariates were included. However, in columns (2) and (4), we included the logarithm of electricity consumption to correct potential violations of parallel trends.

The estimation results presented in Table 2 reveal the statistical significance of the estimated parameters at the 1% level. Specifically, the coefficient of interest exhibits a negative sign in 2019, providing evidence that a reduction in tariffs corresponds to a decrease in the probability of default, as observed in columns 1 and 2. Conversely, the positive coefficient associated with the tariff increase in 2021 indicates an increase in the likelihood of default. Notably, the inclusion of a covariate, the logarithm of electricity consumption in the current month, does not alter the statistical significance of the results. Therefore, these empirical findings substantiate the hypothesis that higher (lower) tariff rates lead to an increase (decrease) in default rates among

Table 2: Effect of electricity tariff on default

	2019		2021	
	(1)	(2)	(3)	(4)
Tariff change	-0.007***	-0.008***	0.008***	0.008***
	(0.002)	(0.002)	(0.002)	(0.002)
Dep.Var. mean	0.354	0.354	0.482	0.482
Treated units	MA	MA	PA	PA
Covariates		Yes		Yes
Observations	308661	308661	367332	367332
R^2	0.863	0.863	0.889	0.889

Notes: Covariates: electricity consumption (log), social tariff, distributed generation, power cut. Standard errors clustered at the municipality level. Significance *** 1 percent, ** 5 percent, and * 10 percent levels.

consumers.

4.2 Dynamic effect

In the second application of the DiD, we examine the dynamic treatment effects. We extend the DiD approach by incorporating in Equation 1 leads and lags of the treatment as additional regressors in an event study design. It enables us to estimate the average dynamic effects of discrete shocks. This empirical exercise allows us to investigate the duration and magnitude of the impact of tariffs on altering the probability of consumer default. We adopt a specification that accounts for both pre- and post-treatment periods and simultaneously estimates the average treatment effect. Equation 2 outlines the event study model implemented:

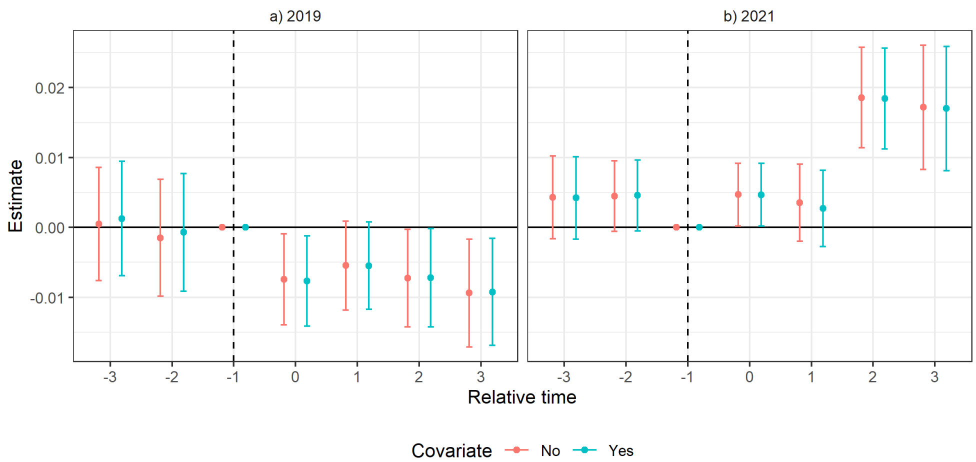
$$Y_{ist} = \sum_{\tau=-3}^{-2} \beta_{\tau}^{pre} D_{st} + \sum_{\tau=0}^{3} \beta_{\tau}^{post} D_{st} + \gamma X_{it} + \theta_i + \mu_t + \varepsilon_{ist} \tag{2}$$

By incorporating leads and lags of the treatment variable, this event study specification allows us to assess the temporal dynamics of the treatment effects, providing insights into how the impact of tariffs on default probability evolves over time. Following the standard strategy in event study analysis, we test the significance of the coefficients β^{pre} to account for any pre-existing trends. The hypotheses for correctly identifying the parameter of interest remain the same as those described in Equation 1.

Figures 7 depict the dynamic effect of tariffs on default probability using Equation 2. Each data point represents a distinct average treatment effect, accompanied by a 95% confidence interval. The figures display the results obtained with and without accounting for covariates.

The point estimates of the average effect for each pre-treatment period do not exhibit statistical significance, indicating any evidence to reject the assumption of parallel trends.

Figure 7: Effect of electricity tariff on default: event-study



Note: Each point presents a different ATT and the 95% confidence interval.

In the post-treatment period, the empirical analysis presented in Figure 7 provides evidence that consumers demonstrate a prompt response to tariff changes, as reflected by a decrease in default probability following a tariff reduction. Conversely, in the case of tariff increases implemented in 2021, the results reveal a subsequent increase in default probability two months after the tariff hike. These findings suggest that the impact of tariff changes on default probability exhibits temporal heterogeneity. While a causal relationship between tariff changes and default probability is evident, the magnitude of the effect varies over time.

5 Household response to utility enforcement

The aim of this chapter is to comprehend the relationship between distributors' billing policies and consumer electricity default. Initially, we employ a linear model that encompasses various tiers of fixed effects, covariates, and lagged variables related to specific actions, namely warnings, power cuts, and negative listings. Subsequently, we exploit the policy enacted during the COVID-19 pandemic, which temporarily prohibited the disconnection of electricity supply due to non-payment, in order to identify the causal impact on the occurrence of electricity default.

5.1 Effects of warnings, power cuts and negative listings

To examine the relationship between distributor actions and electricity consumer default, we employ the following model:

$$Y_{it} = X_{it} + W_{it} + \theta_i + \mu_t + \varepsilon_{ist} \quad (3)$$

where Y_{it} represents a vector of individual i's default measures in month t, X_{it} is the matrix containing potential determinants of default, β is the vector of parameters of interest, W_{it} is a matrix of covariates, θ_i captures individual fixed effects, μ_t represents time fixed effects, and ε_{ist} denotes the idiosyncratic error term. The individual fixed effects account for time-invariant consumer characteristics, while the time fixed effects capture common shocks among consumers in each month, such as macroeconomic fluctuations. In all models, standard errors are clustered at the municipality level. This approach aims to mitigate autocorrelation among observations within the same municipality, which may arise from local-level default prevention policies, for example.

Tables 3 and 4 present the results regarding the duration of electricity bill default and the number of unpaid bills, respectively. The *Total* columns provide the estimated effects when considering the entire sample. Conversely, the *Selection* columns focus on consumers who experienced at least one month of delinquency between 2017 and 2022. By narrowing the sample, we concentrate our analysis on the effects of the policy specifically on consumers with a higher likelihood of non-payment.

In each table, Column 1 incorporates solely the individual fixed effect (contract). Column 2 extends the model to include both individual and contract fixed effects. In Column 3, we further augment the model by including the logarithm of electricity consumption as a covariate. Notably, the variables of interest are lagged by one period, reflecting their values in the month preceding the observed consumer response.

Table 3 shows the parameters of the binary variables *warnings* and *power cuts* are statistically significant at the 1% level and exhibit a negative sign. On the other hand, the parameter for *negative listing* becomes negative and statistically significant at least at the 5% level when the time fixed effect is included. These results suggest that distributor actions can reduce consumer default. Furthermore, among the actions considered, "power cuts" exhibit the largest parameter magnitude.

Table 4 presents the estimated parameters for the binary variables *warnings* and *power cuts*, which are found to be statistically significant at the 1% level and exhibit a negative coefficient. Conversely, the parameter for *negative listing* becomes negative and statistically significant at least at the 5% level when the time fixed effect is included in the estimation for the selected sample; however, it is not statistically significant for the complete sample. These results suggest that the actions of *warnings* and *power cuts* are potentially more effective for the distributor in reducing default rates. Furthermore, among the considered actions, *warnings* exhibits the largest magnitude of the parameter. This outcome implies that, conditional on fixed effects and controls, consumers may respond more to the threat of tangible actions taken by the distributor.

The negative signs indicate that both *warnings* and *power cuts* have a downward effect

Table 3: Effect of enforcement on default: duration

	Total			Selection		
	(1)	(2)	(3)	(1)	(2)	(3)
Warning	-0.118	-0.708***	-0.252***	-0.161	-1.693***	-1.149***
	(0.081)	(0.080)	(0.070)	(0.245)	(0.138)	(0.111)
Power cut	-2.168***	-1.336***	-1.390***	-2.665***	-1.313***	-1.378***
	(0.107)	(0.058)	(0.116)	(0.174)	(0.093)	(0.140)
Negative listing	1.093***	-0.178**	-0.291***	1.485***	-0.845***	-0.940***
	(0.091)	(0.086)	(0.087)	(0.147)	(0.089)	(0.087)
Num.Obs.	3223948	3223948	3223948	788259	788259	788259
R2	0.669	0.793	0.798	0.594	0.825	0.828
Contract fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects		Yes	Yes		Yes	Yes
Covariates			Yes			Yes

Notes: Covariates: electricity consumption (log), social tariff, distributed generation, power cut. Standard errors clustered at the municipality level. Significance *** 1 percent, ** 5 percent, and * 10 percent levels.

Table 4: Effect of enforcement on default: bills

	Total			Selection		
	(1)	(2)	(3)	(1)	(2)	(3)
Warning	-0.159***	-0.388***	-0.077**	-0.308***	-0.911***	-0.436***
	(0.015)	(0.036)	(0.033)	(0.049)	(0.068)	(0.060)
Power cut	-0.668***	-0.366***	-0.436***	-0.815***	-0.301***	-0.391***
	(0.041)	(0.032)	(0.054)	(0.071)	(0.054)	(0.081)
Negative listing	0.534***	0.127**	0.038	0.628***	-0.218***	-0.312***
	(0.052)	(0.062)	(0.058)	(0.069)	(0.074)	(0.069)
Num.Obs.	3223948	3223948	3223948	788259	788259	788259
R2	0.767	0.804	0.812	0.739	0.806	0.813
Contract fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects		Yes	Yes		Yes	Yes
Covariates			Yes			Yes

Notes: Covariates: electricity consumption (log), social tariff, distributed generation, power cut. Standard errors clustered at the municipality level. Significance *** 1 percent, ** 5 percent, and * 10 percent levels.

on consumer delinquency. This implies that when consumers receive warnings or experience power cuts as a consequence of non-payment, they are more likely to pay their electricity bills promptly and avoid default. Similarly, the negative parameter for *negative listing* indicates that consumers who have negative listings associated with their payment history are also less likely to default. These findings provide empirical evidence that distributor actions play a crucial role in mitigating consumer delinquency in the electricity sector.

Moreover, the significant negative parameter for *power cuts* suggests that this action has the strongest impact on reducing default rates among the actions considered. This may be attributed to the immediate and tangible consequences of power cuts, which serve as a strong incentive for consumers to prioritize bill payment in order to maintain uninterrupted access to electricity services.

The absence of a clear identification strategy limits our interpretation of the causal relationship between the variables. Due to the presence of reverse causality between the variables, the estimated parameters in the models presented in this section generally reflect conditional correlation rather than a causal relationship. Therefore, the results may reflect the distributor's collection initiative upon the occurrence of default, rather than the effect of collection actions on default. Moving forward, our objective is to assess the causal relationship between *power cuts* and default.

5.2 Suspension of power cuts during the Covid-19 pandemic

As indicated previously, among the available instruments for the distributor, electricity power cuts emerged as the action that could be most effective in reducing consumer default. To further evaluate the causal effect of this action, we explore a policy design implemented during the COVID-19 pandemic. This policy temporarily prohibited the suspension of electricity supply due to non-payment. By leveraging this unique policy variation, we aim to identify the causal impact on the incidence of electricity default.

At the onset of the Covid pandemic, the electricity regulator mandated that starting from April 2020, distributors were prohibited from implementing power supply cuts due to non-payment. This policy initially applied to all residential units between April 2020 and July 2020. Subsequently, from July 2020 until September 2021, the suspension of power supply cuts was only maintained for low-income families. Additionally, this policy for low-income families was extended in December 2020 and March 2021.

Figure 8 illustrates the number of power cuts in our sample. It is noteworthy that between April 2020 and July 2020 (dark-shaded area), no power cuts occurred. However, starting from July 2020, with the resumption of power cuts for consumers not classified as low-income, the frequency of these actions increases over time (light-shaded area).

Based on Equation 1, we employ the dates of electricity supply suspension for different consumer groups to identify the causal effect on default. Adopting a difference-in-differences (DID) strategy between April 2020 and September 2021, a period during which low-income families were protected from power cuts due to non-payment, we define the treatment group as consumers who became eligible for the social electricity tariff after the analysis period, i.e., after September 2021, but were not eligible during the analysis period. Treatment happens in July 2020 for this group. The control group consists of low-income families who were beneficiaries of the social electricity tariff. This approach aims to create a more homogeneous control and treatment group.

Figure 8: Number of power cuts due to consumer default

Note: This graph shows the number of cut-off actions per month for a sample of residential consumers in the states of Maranhão and Pará between January 2017 and June 2022. The dashed red line indicates the beginning of the Covid-19 pandemic in March 2020.

Table 5 presents the results for the amount of time in default, considering three sub-samples: i) total, ii) subnormal cluster areas (SCA), and iii) outside subnormal cluster areas. In the first sub-sample, we include all observations based on the selection described above. In the *SCA* sub-sample, we consider only consumers residing in subnormal cluster areas. In the sub-sample labeled *Outside SCA*, we include only consumers living outside subnormal clusters. In columns (1), we do not include covariates, while in columns (2), we include the logarithm of consumption as a covariate.

Table 5: Effect of power cut on default duration: DiD - duration

	Total		SCA		Outside SCA	
	(1)	(2)	(1)	(2)	(1)	(2)
Power cut allowed	-1.490***	-1.486***	-1.155***	-1.160***	-1.527***	-1.524***
	(0.080)	(0.081)	(0.134)	(0.138)	(0.090)	(0.090)
Dep.Var. mean	17.67	17.67	20.23	20.23	17.25	17.25
Covariates		Yes		Yes		Yes
Observations	143640	143640	18018	18018	125622	125622
R^2	0.972	0.972	0.979	0.980	0.971	0.971

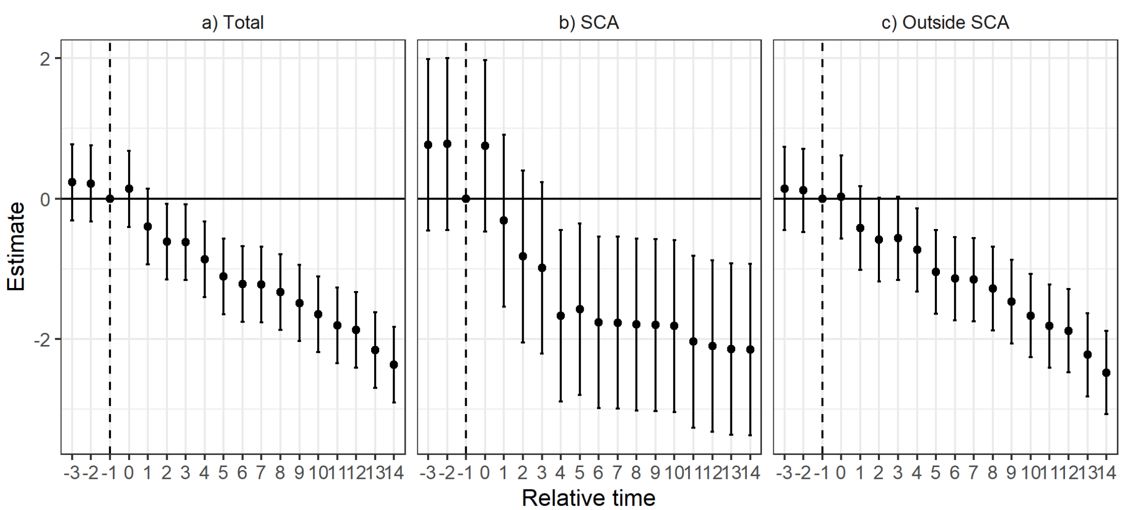
Notes: Covariates: electricity consumption (log), social tariff, distributed generation, power cut. Standard errors clustered at the municipality level. Significance *** 1 percent, ** 5 percent, and * 10 percent levels.

The results from Table 5 demonstrate that the effect of power cuts is statistically significant at the 1% level with a negative sign for all sub-samples and specifications. This indicates that, as suggested by the results in Table 3, power cuts reduce default rates. The results do not change significantly when including the covariate.

The results for the total sample and the sample outside of subnormal clusters are not statistically different. Considering these samples, the power cut policy reduces default rates by approximately 1.5 months. Given that the average duration of default is around 17 months, this effect can be translated into a reduction of approximately 9%. On the other hand, the magnitude of the effect, in absolute terms, is smaller within subnormal clusters. In this case, the power cut policy reduces default rates by approximately 1 month, which corresponds to a 5% reduction considering an average default duration of 20 months.

Figure 9 reveals that the effect of power cuts on default rates is not homogeneous over time. The point estimates of the average effect for each pre-treatment period do not demonstrate statistical significance, indicating any evidence to reject the assumption of parallel trends. For the total sample and the sample outside of subnormal clusters, this policy measure implemented by the distributor progressively reduces default rates throughout the entire period. Conversely, within subnormal clusters, the effect declines more sharply up to four months after the power cuts permission.

Figure 9: Effect of power cut on default duration: event-study (duration)



Note: Each point presents a different ATT and the 95% confidence interval.

Therefore, we provides empirical evidence on the effectiveness of power cuts as a policy tool to reduce default rates in the electricity sector. The results reveal that power cuts have a statistically significant negative effect on default rates across different sub-samples and specifications, indicating their efficacy in promoting timely payment behavior. Moreover, the analysis demonstrates that the impact of power cuts on default rates varies over time.

These results contribute to our understanding of the effectiveness of policy interventions in mitigating default rates in the electricity sector. The findings highlight the importance of tailoring such policies to local conditions and characteristics, as the effects may differ across different consumer groups and geographic areas. Policymakers and electricity distributors can utilize these insights to design targeted and effective strategies for reducing default rates and promoting financial sustainability in the sector.

6 Conclusion

This paper initially examines the impact of tariffs on default rates. The findings demonstrate that an increase (decrease) in tariffs leads to an increase (decrease) in default occurrences.

This result complements another finding that suggests short-term electricity demand is inelastic. Due to the higher tariff, consumers face difficulties in reducing their electricity consumption in the short term, resulting in an increase in defaults.

Furthermore, our results indicate that immediate reductions in electricity tariffs lead to a decrease in default rates, while tariff increases cause defaults to rise with a lag of two months. This delayed effect may be attributed to the cumulative debt resulting from higher electricity tariffs, although we cannot currently confirm this hypothesis.

Secondly, the paper examines the impact of utility-enforced measures on consumer defaults. Estimating causal effects poses a significant challenge in this aspect since defaults trigger the implementation of utility measures. To address this issue, we utilize the suspension of power cuts during the COVID-19 pandemic as an exogenous variation of this policy. The findings reveal that power cuts serve as an important tool for mitigating defaults, reducing default duration by approximately 9% when this policy was reinstated.

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