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ECONOMIC UNCERTAINTY AND STICKY COSTS: AN ANALYSIS OF ELECTRICITY DISTRIBUTION COMPANIES IN BRAZIL (2011-2023)

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ABSTRACT

This study investigates the effects of economic uncertainty, measured using the Economic Uncertainty Indicator for Brazil (IIE-Br) as a proxy, on the cost behavior of electricity distribution concessionaires in Brazil between 2011 and 2023. To this end, the model proposed by Anderson et al. (2003) was adopted and estimated through balanced panel data regressions, with econometric tests applied to assess the adequacy and assumptions of the models. The results suggest asymmetric behavior in total operating costs, although without statistical robustness, with a sign consistent with the phenomenon known as anti-sticky costs. In substantive terms, on average, a 1% reduction in net revenue is associated with a 0.91% decrease in total operating costs, a magnitude greater than the 0.73% increase observed in periods of revenue growth. Although the marginal effect of the economic uncertainty proxy (IIE-Br) was not statistically significant, its interaction with the variable indicating a reduction in net sales revenue (NSR) indicates that, in periods of greater economic uncertainty, the anti-sticky behavior of total operating costs becomes statistically significant. In addition, the crises faced by the electricity sector exhibit moderating effects, suggesting that, during crisis periods, costs become more sensitive to revenue variations. Conversely, when manageable operating costs are considered in isolation, no statistically significant associations are identified with variations in NSR, economic uncertainty, or sectoral crises. Thus, this result suggests that the aggregate measure of distribution companies' manageable operating costs may not adequately capture short-term managerial adjustments.

Keywords: economic uncertainty, cost asymmetry, electricity distribution companies.

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1 INTRODUCTION

Cost behavior research has evolved from an approach that assumes a symmetric and proportional relationship between costs and activity levels to a contemporary perspective that recognizes asymmetries in this relationship. Anderson, Banker, and Janakiraman (2003) demonstrated that selling, general, and administrative (SG&A) costs exhibit asymmetric behavior in response to fluctuations in activity levels due to managerial decisions and the presence of adjustment costs (Kremer, 2015; Richartz, 2016; Barbosa, 2020; Richartz & Borgert, 2021).

Since then, numerous studies have shown that costs may respond differently to increases and decreases in activity levels. The sticky cost phenomenon occurs when costs increase more in response to growth in activity than they decrease following an equivalent decline. In contrast, anti-sticky costs are characterized by larger cost reductions in response to a decline in activity than the cost increases observed under an equivalent expansion (Abu-Serdaneh, 2014; Kremer, 2015; Barbosa, 2020; Bubeck & Silva, 2025).

Subsequently, the literature shifted its focus from merely identifying cost asymmetries to investigating their determinants and economic and managerial implications (Malik, 2012). Although most studies suggest that the primary drivers of cost asymmetry are firm specific factors, such as cost structure, available cash flow, firm size, and agency conflicts, the present study emphasizes the role of economic uncertainty. Economic uncertainty is expected to affect expectations regarding future demand and may induce managerial behavior characterized by greater caution, postponed resource adjustments, and resource preservation, thereby influencing the intensity of cost behavior (Bloom, 2014; Kremer, 2015; Richartz & Borgert, 2021; Santos, 2022).

From this perspective, the macro accounting approach argues that macroeconomic variables create incentives capable of reshaping expectations and resource adjustment decisions and, consequently, influencing the dynamics of firms' cost structures (Bubeck & Silva, 2025). Yükçü and Özkaya (2011) found that cost asymmetry tends to be more pronounced during periods of economic stability, suggesting that the degree of cost stickiness is conditioned by the macroeconomic environment. Furthermore, Li et al. (2020) argued that economic uncertainty increases unpredictability regarding future economic conditions, making planning more difficult, exacerbating information asymmetry, and consequently intensifying agency conflicts. The authors also emphasized that the influence of macroeconomic factors on cost asymmetry has received only limited attention in the literature.

Against this backdrop, the debate concerning the influence of economic uncertainty on cost behavior becomes even more relevant in regulated industries. Regulated sectors, such as the electricity industry, are characterized by a tension between (i) a rigid cost structure, marked by high asset intensity, substantial fixed costs associated with maintaining generation and distribution infrastructure, and mandatory continuity in the provision of public services, and (ii) revenue constraints imposed by price regulation mechanisms, particularly through tariff setting (Kremer, 2015; Richartz, 2016; Barbosa, 2020).

In Brazil, the electricity distribution sector operates under a regulatory framework characterized by tariff adjustments and periodic tariff reviews, monitoring mechanisms, efficiency benchmarking, and penalties for inefficiency. These mechanisms may affect cost behavior in response to fluctuations in activity levels, particularly those arising from economic uncertainty. Moreover, through Normative Resolution No. 396/2010, the Brazilian Electricity Regulatory Agency (ANEEL) established regulatory accounting, which differs substantially from financial accounting governed by International Financial Reporting Standards (IFRS) with respect to key aspects relevant to tariff setting, including the recognition, measurement, and disclosure of assets and liabilities (Brazilian Electricity Regulatory Agency [ANEEL], 2010; Carvalho, 2013; Ferreira et al., 2021).

Under regulatory accounting, costs are classified as non-manageable (Portion A) or manageable (Portion B). While Portion A primarily reflects exogenous conditions and pass-through items, Portion B comprises expenditures that are under managerial control, including personnel, materials, services, and other operating expenses, which are more directly associated with resource adjustment decisions. Consequently, the cost metric adopted in studies of cost behavior should be explicitly defined, since the composition of costs between Portions A and B may influence empirical results (Carvalho, 2013; ANEEL, 2022c; ANEEL, 2024).

Brazilian studies on cost asymmetry have largely relied on financial accounting data and multisector samples, which may limit the understanding of this phenomenon in environments where regulation and regulatory accounting systems shape firms' cost adjustment processes. Although Bubeck and Silva (2025) examined asymmetric cost behavior in publicly traded Brazilian companies across different phases of the business cycle, empirical evidence regarding this phenomenon in regulated industries remains limited.

For electricity distribution companies, the existence of regulatory accounting, tariff mechanisms, and efficiency incentives creates a distinctive institutional environment for cost adjustment, thereby justifying a sector specific investigation. Accordingly, further evidence on cost asymmetry in the Brazilian electricity distribution sector remains warranted using regulatory financial statements, objective measures of macroeconomic uncertainty, and the institutional characteristics of the regulatory framework (Malik, 2012; Kremer, 2015).

Within this context, the present study identifies a research gap concerning the implications of macroeconomic uncertainty for the asymmetric cost behavior of Brazilian electricity distribution companies based on regulatory accounting information. Accordingly, this study investigates the effects of economic uncertainty, measured by the Brazilian Economic Uncertainty Indicator (IIE-Br) developed by the Brazilian Institute of Economics of the Getulio Vargas Foundation (FGV IBRE), on the cost behavior of electricity distribution companies in Brazil during the period from 2011 to 2023. Specifically, the study seeks to answer the following research question: **What is the influence of economic uncertainty on the cost behavior of electricity distribution concessionaires in Brazil?**

This study offers both theoretical and empirical contributions. From a theoretical perspective, it extends the literature on cost asymmetry by examining the phenomenon within a regulated environment, where tariff incentives, such as efficiency benchmarking, and operational constraints may alter firms' patterns of resource adjustment. From an empirical perspective, by employing regulatory accounting data together with a well established proxy for economic uncertainty, the study provides evidence that may contribute to a better understanding of cost behavior in electricity distribution companies and inform discussions on efficiency and cost management within a regulatory context. Furthermore, consistent with the regulatory distinction between non-manageable costs (Portion A) and manageable costs (Portion B), costs are operationalized using regulatory financial statements. The empirical model is estimated both for the aggregate cost measure and, as a robustness analysis, for Portion B, where managerial discretion is expected to exert a more direct influence on short-term resource adjustment.

2 THEORETICAL BACKGROUND

2.1 Asymmetric Cost Behavior

The traditional classification of costs according to their relationship with production volume distinguishes them into fixed and variable costs (Martins, 2021). Under this framework, fixed costs remain unchanged regardless of changes in activity levels, whereas variable costs are assumed to respond symmetrically to fluctuations in production volume, increasing and decreasing proportionally with the number of units produced (Kremer, 2015; Barbosa, 2020; Richartz & Borgert, 2021).

In the late 1990s, Noreen and Soderstrom (1997) challenged the assumption of symmetry between costs and production volume through an empirical investigation of the temporal behavior of hospital overhead costs in the state of Washington. Their findings indicated that certain indirect costs respond disproportionately to changes in activity levels, increasing more sharply during periods of expanding production than they decrease during periods of declining production (Kremer, 2015).

Subsequently, Anderson et al. (2003) examined the relationship between selling, general, and administrative (SG&A) costs and activity levels, measured by net sales revenue (NSR), using a sample of 7,629 firms over the period from 1979 to 1998. The authors compared changes in SG&A costs with changes in NSR, distinguishing between periods of revenue increases and revenue declines. They found that SG&A costs increased by 0.55% for every 1% increase in sales but decreased by only 0.35% for every 1% decline in sales. This asymmetric cost behavior was subsequently termed *sticky costs* (Kremer, 2015; Barbosa, 2020).

Asymmetric cost behavior depends not only on the magnitude of revenue changes but also on their direction, whether positive or negative (Barbosa, 2020). According to Anderson et al. (2003), although operating costs generally increase and decrease in response to changes in revenue, the proportional increase in costs is greater than the proportional decrease, characterizing the positive form of cost asymmetry known as *sticky costs*. Conversely, the percentage reduction in costs may exceed the percentage increase, resulting in the opposite pattern. This phenomenon was first identified by Balakrishnan, Petersen, and Soderstrom (2004) and later designated by Weiss (2010) as *anti-sticky costs*. Accordingly, Barbosa (2020) argues that the concepts of cost asymmetry and asymmetric cost behavior encompass both *sticky costs* and *anti-sticky costs*.

Furthermore, the literature on cost asymmetry can be classified into three major streams: the existence of cost asymmetry, its determinants, and its consequences (Malik, 2012). According to Richartz (2016, p. 39), subsequent studies following Anderson et al. (2003) have consistently confirmed the presence of asymmetric cost behavior "across firms, within the same firm over time, across industries, and across countries." Consequently, the existence of cost asymmetry is now widely recognized in the academic literature (Richartz, 2016).

The determinants of cost asymmetry may be categorized as either internal or external to the firm. Internal determinants include cost structure, available cash flow, firm size, asset and liability intensity, deliberate managerial decisions, agency conflicts, delays in cost adjustments, and excess capacity. External determinants, in contrast, include market regulation, labor legislation, and the macroeconomic environment. The consequences of cost asymmetry remain comparatively underexplored, with existing studies focusing primarily on its implications for earnings forecasting and earnings management (Kremer, 2015; Richartz, 2016; Barbosa, 2020).

Finally, studies that identify the macroeconomic environment as a determinant of cost asymmetry have generally employed gross domestic product (GDP) as the proxy for macroeconomic conditions (Anderson et al., 2003; Yükçü & Özkaya, 2011; Abu-Serdaneh, 2014; Richartz, 2016; Li et al., 2020).

Within this context, the following alternative hypothesis is proposed:

H1: The total operating costs of electricity distribution concessionaires respond asymmetrically to revenue changes, such that the sensitivity of costs when revenue decreases differs from that observed when revenue increases.

2.2 Economic Uncertainty

Uncertainty is characterized as a phenomenon that cannot be directly measured or observed, representing an inherent element of unpredictability. It influences the decision making of economic agents because, under conditions of high uncertainty, individuals and firms tend to prefer liquidity over consumption and investment, thereby generating negative shocks to economic activity. Consequently, an inverse relationship exists between uncertainty and economic activity, with adverse effects on the macroeconomic environment (Ferreira et al., 2017; Franco, 2019; Sabino, 2022).

In this context, the effects of economic uncertainty on the decisions of economic agents operate through three principal transmission channels: real options effects, risk premium effects, and precautionary savings effects. Under the real options channel, investment and expansion decisions are postponed until additional information becomes available, leading firms to delay hiring and capital expenditures (Bloom, 2014; Ferreira et al., 2017; Franco, 2019; Sabino, 2022).

The risk premium channel reflects the positive relationship between heightened uncertainty and the probability of default. Under conditions of elevated economic uncertainty, investors and creditors require higher risk premiums to compensate for increased perceived risk. This raises financing costs and may discourage investment and expansion decisions. Finally, precautionary savings effects represent defensive responses adopted by both individuals and firms to protect themselves against potential adverse future shocks during periods of heightened macroeconomic uncertainty (Bloom, 2014; Ferreira et al., 2017; Franco, 2019; Sabino, 2022).

Moreover, studies examining the relationship between uncertainty and economic activity following the 2008 global financial crisis have shown that developing economies tend to experience higher levels of uncertainty and that its effects persist for longer periods than in advanced economies (Ferreira et al., 2017; Zerbinatti et al., 2021; Maquiaveli et al., 2022).

Against this background, several proxies have been developed to measure economic uncertainty, particularly those based on web scraping techniques, such as the Brazilian Economic Uncertainty Indicator (IIE-Br), developed by the Getulio Vargas Foundation (FGV). This indicator has been widely employed in studies investigating the effects of uncertainty on the Brazilian economy. The IIE-Br currently consists of two components: the IIE-Br Media Index and the IIE-Br Expectations Index (Ferreira et al., 2017; Souza et al., 2019; Maquiaveli et al., 2022; Sabino, 2022).

The IIE-Br Media Index captures economic uncertainty reflected in news coverage published by the newspapers *Folha de São Paulo*, *Valor Econômico*, *O Globo*, *O Estado de São Paulo*, *Correio Braziliense*, and *Zero Hora*. The IIE-Br Expectations Index, in turn, measures specialists' forecasts released by the Central Bank of Brazil for key macroeconomic variables, including the exchange rate, the Selic policy interest rate, and the Broad National Consumer Price Index (IPCA). In the construction of the IIE-Br, the Media Index accounts for 80% of the overall indicator, while the Expectations Index contributes the remaining 20% (Ferreira et al., 2017; Souza et al., 2019; Maquiaveli et al., 2022; Sabino, 2022).

Within this context, the following alternative hypothesis is proposed:

H2: Economic uncertainty, measured by the Brazilian Economic Uncertainty Indicator (IIE-Br) developed by the Getulio Vargas Foundation (FGV), moderates cost asymmetry, such that during periods of greater economic uncertainty, the sensitivity of costs to revenue changes differs from that observed during periods of lower economic uncertainty among electricity distribution concessionaires.

2.3 Accounting in the brazilian electricity sector and tariff adjustments

The Brazilian electricity sector is regulated by the Brazilian Electricity Regulatory Agency (ANEEL), an autonomous federal agency linked to the Ministry of Mines and Energy. ANEEL's primary responsibilities include regulating electricity generation, transmission, distribution, and commercialization; overseeing concessions, authorizations, and electricity services; implementing national policies and guidelines governing the electricity sector; establishing the tariffs charged by concessionaires and licensees; resolving administrative disputes; and granting concessions, permits, and authorizations for electricity projects and services (ANEEL, 2022a).

To meet its regulatory objectives, ANEEL established the regulatory accounting system for the electricity sector in 2010, applicable to electricity distribution and transmission companies. This initiative was motivated by the recognition that, following Brazil's adoption of International Financial Reporting Standards (IFRS), financial accounting no longer fully satisfied the regulator's informational requirements (ANEEL, 2010).

From the regulator's perspective, regulatory accounting provides a more appropriate representation of the economic and financial position of electricity distribution and transmission companies, while remaining consistent with the legal framework governing tariff regulation (ANEEL, 2010).

The electricity tariff setting process comprises three mechanisms: periodic tariff reviews, conducted approximately every four years; extraordinary tariff reviews, implemented whenever significant changes occur in a concessionaire's cost structure; and annual tariff adjustments, which are applied in the years between periodic tariff reviews (ANEEL, 2022b).

Until 2010, regulatory efficiency was assessed by comparing each electricity distribution company with a reference utility. Beginning in 2011, this approach was replaced by a benchmarking model based on Data Envelopment Analysis (DEA). Under this framework, an efficient cost frontier is estimated through comparative analysis across distribution companies, and each firm's costs are evaluated relative to this efficiency benchmark (ANEEL, 2024).

During tariff adjustment processes, distribution companies that fail to achieve the efficiency levels established by the DEA model are subject to regulatory penalties, as the costs associated with inefficiency cannot be fully incorporated into electricity tariffs. Consequently, electricity distribution companies are provided with strong incentives to pursue efficient cost management.

Within this regulatory environment, DEA based benchmarking and the penalties associated with inefficiency may operate as disciplinary mechanisms by altering the incentive structure faced by management (ANEEL, 2022b, 2024; Kremer, 2015). From the perspective of the sticky cost literature, these regulatory instruments may increase the economic cost of maintaining excess capacity and resource structures above operational requirements during periods of declining activity, since inefficient costs are not fully recoverable through regulated tariffs (Anderson et al., 2003; Richartz, 2016; Barbosa, 2020). Accordingly, managers may respond more rapidly to declines in activity or revenue by implementing more aggressive adjustments to discretionary costs, such as renegotiating service contracts, reducing administrative expenditures, and rescheduling operating expenses. From a theoretical standpoint, this behavior is consistent with the anti-sticky cost phenomenon, whereby costs exhibit greater sensitivity during periods of contraction than during periods of expansion (Weiss, 2010; Barbosa, 2020).

In the Brazilian electricity sector, the operating costs of electricity distribution companies are classified into two principal categories: non-manageable costs (Portion A) and manageable costs (Portion B). This classification reflects whether costs are under the direct control of management, thereby facilitating the implementation of cost optimization strategies.

Furthermore, the tariff structure itself suggests that cost asymmetry should be interpreted in light of the degree of managerial discretion associated with each cost category (ANEEL, 2022b, 2022c, 2024; Carvalho, 2013; Ferreira et al., 2021). Analytically, cost components characterized by pass through mechanisms and exogenous determination, typically associated with non-manageable costs, primarily reflect contractual, regulatory, or price shocks and are therefore less informative regarding managerial resource adjustment decisions (ANEEL, 2022c; Carvalho, 2013). In contrast, expenditures that are directly controlled by management and closely linked to operational efficiency and regulatory performance targets constitute the cost category in which sticky or anti-sticky cost behavior is expected to be more clearly observable (Kremer, 2015; Anderson et al., 2003). Consequently, the regulatory distinction between Portion A and Portion B provides a theoretical foundation for arguing that the regulatory incentives described above may influence both the direction and the magnitude of cost asymmetry, particularly for manageable costs, while also guiding the interpretation of the coefficients estimated in the empirical model (ANEEL, 2022c, 2024; Anderson et al., 2003; Weiss, 2010).

Non-manageable operating costs consist of expenditures that are beyond the direct control of electricity distribution companies, including electricity purchased for resale, corresponding to the cost of energy acquired to supply consumers; transmission charges associated with electricity transportation; and regulatory charges, comprising mandatory fees and taxes. In contrast, manageable costs are those that firms can directly control or influence, including personnel expenses, materials and services, infrastructure investments, and the remuneration of capital. This distinction enables a more accurate assessment of economic influences and financial management practices, thereby contributing to the efficiency and sustainability of the electricity sector (ANEEL, 2022c; Carvalho et al., 2014).

Among the non-manageable costs incurred by electricity distribution companies, the cost of electricity purchased for resale is particularly significant, as it depends on prices established through electricity auctions conducted by the Electric Energy Trading Chamber (CCEE). These prices fluctuate according to supply and demand conditions and tend to increase whenever electricity generation is insufficient to meet national demand, a situation that characterizes periods of crisis in the electricity sector.

According to the *2024 Statistical Yearbook of Electric Energy*, hydroelectric power accounted for more than 60% of Brazil's electricity generation between 2014 and 2023. It is noteworthy that, during the severe hydrological crisis of 2021, which resulted in electricity rationing, the share of hydroelectric generation declined to 55.30%, as presented in Table 1 (EPE, 2024). Consequently, Brazil remains highly dependent on rainfall conditions capable of sustaining hydrological stability and, therefore, preserving its electricity generation capacity.

Table 1
Percentage share of electricity generation in brazil by energy source, 2014 to 2023

Source	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Hydropower	62.63%	61.87%	65.80%	63.08%	64.68%	63.53%	63.81%	55.30%	63.07%	60.16%
Wind power	2.05%	3.72%	5.78%	7.21%	8.06%	8.94%	9.18%	11.02%	12.05%	13.53%
Biomass	7.54%	8.15%	8.51%	8.40%	8.63%	8.32%	8.95%	7.88%	7.65%	7.61%
Solar power	0.003%	0.01%	0.01%	0.14%	0.58%	1.06%	1.73%	2.55%	4.45%	7.15%
Natural gas	14.42%	13.67%	9.77%	11.16%	9.03%	9.61%	8.61%	13.24%	6.19%	5.45%
Nuclear power	2.58%	2.53%	2.74%	2.68%	2.61%	2.58%	2.26%	2.24%	2.15%	2.05%
Other sources	2.27%	2.34%	2.34%	2.38%	2.35%	2.27%	2.15%	2.31%	2.15%	1.97%
Coal	3.08%	3.28%	2.94%	2.76%	2.36%	2.45%	1.92%	2.68%	1.18%	1.24%
Oil derivatives	5.42%	4.42%	2.11%	2.20%	1.71%	1.25%	1.38%	2.78%	1.11%	0.85%
TOTAL	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Statistical Yearbook of Electric Energy (2024).

Given this heavy reliance on hydropower, crises in the Brazilian electricity sector are typically accompanied by hydrological crises that compromise the country's electricity generation capacity. During the twenty first century, Brazil has experienced three major electricity sector crises, as presented in Table 2.

Table 2
Timeline of crises in the brazilian electricity sector in the twenty first century

	2001	2013	2021
Time Period	Jun 01 to Feb 02	Oct 12 to Mar 16	Jan 21 to Apr 22
Duration (months)	9	42	16

Source: Instituto E+ Energy Transition (2024).

To align the timing of the electricity sector crises, which are defined on a monthly basis, with the annual structure of the panel dataset covering the period from 2011 to 2023, the CRISIS variable was operationalized at the annual level. Accordingly, CRISIS = 1 for years in which at least one month falls within the crisis periods presented in Table 2, and CRISIS = 0 otherwise. This coding strategy provides a parsimonious way of capturing the presence of an adverse sectoral environment during a given year, consistent with the identification of critical periods reported by sectoral sources.

Based on the foregoing discussion, electricity distribution companies are expected to be encouraged to reduce costs during years characterized by sectoral crises in order to avoid being penalized for potential cost management inefficiencies during the tariff setting process. This expectation leads to the following hypothesis:

H3: In years classified as sectoral crisis periods, the elasticity of costs with respect to revenue changes differs from that observed in non-crisis years for electricity distribution concessionaires.

H4: Cost asymmetry is more pronounced when measured using manageable costs (Portion B) than when measured using aggregate operating costs in electricity distribution concessionaires.

3 METHODOLOGICAL PROCEDURES

The study population comprises the 42 electricity distribution concessionaires, both state owned and privately owned, affiliated with the Brazilian Association of Electricity Distribution Companies (ABRADEE), operating across all geographic regions of Brazil. Collectively, these companies serve approximately 86 million customers, representing 99.6% of Brazilian electricity consumers (ABRADEE, n.d.). As shown in Table 3, the final sample consists of the companies for which complete data were available throughout the study period. For the analysis of manageable operating costs, companies that did not report Portion A and Portion B costs separately were also excluded.

Table 3
Sample composition for the 2011 to 2023 period

Concessionaires	42
(-) Number of Companies with Missing Values, Total Operating Costs	2
(=) Number of Companies, Total Operating Costs	40
(-) Number of Companies with Missing Values, Manageable Operating Costs	6
(=) Number of Companies, Manageable Operating Costs	36

Notes. Number of observations for total operating costs: **N = 40** and **T = 13**; therefore, **N × T = 520**. Number of observations for manageable operating costs: **N = 36** and **T = 13**; therefore, **N × T = 468**. **N** denotes the number of companies, and **T** denotes the number of years.
Source: Prepared by the authors based on the research data (2025).

The financial data were collected from the annual regulatory financial statements covering the period from 2010 to 2023. The analysis of the effects of economic uncertainty on the cost behavior of electricity distribution concessionaires encompasses the period from 2011 to 2023. The year 2010 was used solely as the baseline for calculating the year over year changes observed in 2011. The regulatory financial statements were obtained from ANEEL's Economic and

Financial Information Center. Whenever the required data were unavailable in ANEEL's database, they were collected from the investor relations sections of the respective electricity distribution companies' websites.

The dependent cost variable is constructed from the regulatory financial statements of electricity distribution concessionaires. Initially, the model is estimated using aggregate operating costs, which comprise both non-manageable costs (Portion A) and manageable costs (Portion B). In addition, as a robustness analysis and consistent with the regulatory distinction between pass through items and expenditures subject to greater managerial discretion, the model is re-estimated using only manageable costs (Portion B) as the dependent variable.

Because the manageable cost accounts of electricity distribution companies include expense offset items that occasionally exceed the amount of manageable costs reported for a given period, these items were excluded to avoid introducing noise into the data, as they do not represent costs but rather cost reductions. Accordingly, amounts reported as other operating income and expense recoveries were added back to operating costs. Likewise, amounts reported under the account "other operating expenses/other operating income," when disclosed on a net basis, were either added to or subtracted from operating costs depending on their reported sign, since it was not possible to separately identify the portion attributable exclusively to other operating income.

Data for the Brazilian Economic Uncertainty Indicator (IIE-Br), developed by the Brazilian Institute of Economics of the Getulio Vargas Foundation (FGV IBRE), were obtained from the official FGV website. The IIE-Br is calculated on a monthly basis and is disseminated in two ways: daily through the Bloomberg Terminal for subscribers and monthly through the FGV website.

Because the present study uses annual data from the regulatory financial statements of electricity distribution concessionaires, it was necessary to ensure temporal consistency between the macroeconomic variable and the annual panel data structure. Accordingly, the IIE-Br was annualized by calculating the simple arithmetic mean of the monthly observations from January through December of each year, following the procedure adopted in previous studies that employ the indicator in annual panel data analyses (Ferreira et al., 2019; Quinteiro et al., 2020). Formally, the annualization procedure is expressed in Equation 1:

$$\mathrm{IIE(Br)}_{t} = \frac{1}{12}\sum_{m=1}^{12} IIE(Br)_{m,t} \qquad (1)$$

Where:
$\mathrm{IIE(Br)}_t$ = denotes the annual value of the Brazilian Economic Uncertainty Indicator - Brazil in year t, and $\mathrm{IIE(Br)}_{m,t}$ corresponds to the monthly value of the indicator in month *m* of year *t*.

This procedure is intended to reduce the short term volatility of the monthly indicator and capture the average level of uncertainty faced by firms throughout the fiscal year, thereby aligning it with the periodicity of the accounting variables used in the econometric model.

In addition, descriptive statistics, including the mean, standard deviation, minimum, and maximum, were used to describe the variables over the period analyzed. Multiple linear regression for short and balanced panel data was also employed to analyze the data in this study.

Initially, model selection tests, namely the Chow F test, the Breusch-Pagan Lagrange Multiplier test, and the Hausman test, were performed to determine which specification, pooled OLS, fixed effects, or random effects, was most appropriate for the data used in this research. Subsequently, diagnostic tests were conducted to assess the assumptions of the regression model, including tests for normality, multicollinearity, heteroscedasticity, autocorrelation, and cross sectional dependence.

3.1. Econometric Model

The model proposed by Anderson et al. (2003) was adopted to perform the statistical analyses aimed at examining the influence of economic uncertainty on the behavior of total and manageable operating costs of electricity distribution concessionaires. Accordingly, Equation (2) presents the original model.

$$log\left[\frac{COST_{i,t}}{COST_{i,t-1}}\right] = \beta_0 + \beta_1 * log\left[\frac{NSR_{i,t}}{NSR_{i,t-1}}\right] + \beta_2 * Red * log\left[\frac{NSR_{i,t}}{NSR_{i,t-1}}\right] + \varepsilon_{i,t} \quad (2)$$

Where:

COST $_{i,t}$ = total or manageable operating cost of the ith electricity distribution concessionaire in period t (current period);
COST $_{i,t-1}$ total or manageable operating cost of the ith electricity distribution concessionaire in period t − 1 (previous period);
NSR $_{i,t}$ = net sales revenue of the *i*th electricity distribution concessionaire in period t (current period);
NSR $_{i,t-1}$ = net sales revenue of the *i*th electricity distribution concessionaire in period *t-1* (previous period);
Red = dummy variable indicating a decline in net sales revenue, taking the value of 1 when **NSR** decreases in period *t* relative to period $t-1$, and 0 when NSR increases in period *t* relative to period *t-1*;
β_0 = intercept of the model, representing the expected value of $log\left[\frac{COST_{i,t}}{COST_{i,t-1}}\right]$ when all independent variables are equal to zero;
β_1 = cost elasticity with respect to NSR;
β_2 = coefficient measuring the additional effect on cost variation when NSR decreases; and
$\varepsilon_{i,t}$ = random error term associated with the *i*th electricity distribution concessionaire in period *t*.

After examining cost behavior using the first equation, the analysis proceeds to investigate the effects of the Brazilian Economic Uncertainty Indicator (IIE-Br), together with the control variables, as specified in Equation (3).

$$log\left[\frac{COST_{i,t}}{COST_{i,t-1}}\right] = \beta_0 + \beta_1 * log\left[\frac{NSR_{i,t}}{NSR_{i,t-1}}\right] + \beta_2 * Red * log\left[\frac{NSR_{i,t}}{NSR_{i,t-1}}\right] + \beta_3 * \log[IIEBr] + \beta_4 * Red * log\left[\frac{NSR}{NSR_{i,t-1}}\right] * log[IIEBr] + \beta_5 * Crise * log\left[\frac{NSR}{NSR_{i,t-1}}\right] + \varepsilon_{i,t} \quad (3)$$

Where:

<u>**COST**</u> $_{i,t}$ = total or manageable operating cost of the *i*th electricity distribution concessionaire in period *t* (current period);
<u>**COST**</u> $_{i,t-1}$ total or manageable operating cost of the *i*th electricity distribution concessionaire in period $t-$ 1 (previous period);
<u>**NSR**</u> $_{i,t}$ = net sales revenue of the *i*th electricity distribution concessionaire in period *t* (current period);
<u>**NSR**</u> $_{i,t-1}$ = net sales revenue of the *i*th electricity distribution concessionaire in period *t-1* (previous period);
Red = dummy variable indicating a decrease in net sales revenue, taking the value of **1** when NSR decreases in period *t* relative to period $t-1$, and 0 when NSR increases in period *t* relative to period $t-1$;
Crisis = dummy variable that takes the value of 1 for crisis years and 0 otherwise.
β_0 = intercept of the model, representing the expected value of $log\left[\frac{COST_{i,t}}{COST_{i,t-1}}\right]$ when all independent variables are equal to zero;
β_1 = cost elasticity with respect to NSR;
β_2 = coefficient measuring the additional effect on cost variation when NSR decreases;
β_3 = elasticity coefficient measuring the effect of economic uncertainty on operating costs;
β_4 = conditional elasticity coefficient measuring the joint effect of a decline in NSR and economic uncertainty on the model's dependent variable, namely operating costs;
β_5 = crisis elasticity coefficient with respect to NSR; and

$\varepsilon_{i,t}$ = random error term associated with the *i*th electricity distribution concessionaire in period *t*.

The results of the Chow, Breusch-Pagan Lagrange Multiplier (LM), and Hausman tests indicated that the random effects model was the most appropriate specification for all four econometric models based on Equations (2) and (3), including the two models in which the dependent variable was total operating costs and the two models in which the dependent variable was restricted to manageable operating costs.

Because the empirical specification includes interaction terms, multicollinearity was assessed using the Variance Inflation Factor (VIF). The initial specifications exhibited substantial VIF inflation (Mean VIF = 2,265.583 for the total operating cost model and Mean VIF = 3,402.308 for the manageable operating cost model). Therefore, the continuous variables involved in the interaction terms were mean centered, a procedure commonly recommended to reduce collinearity between the main effects and the interaction term without altering the economic interpretation of the estimated coefficients. After mean centering, all VIF values fell below 2, indicating the absence of meaningful multicollinearity.

To address the problems of heteroscedasticity, residual autocorrelation, and cross sectional dependence identified in all econometric models through the Breusch-Pagan test, the Wooldridge test, and the scaled Pesaran LM test, respectively, the models were estimated using Driscoll and Kraay (1998) robust standard errors with a maximum lag length of one period. Additional estimations using maximum lag lengths of two and three periods were also performed to confirm the robustness of the results.

For the models using the logarithmic change in manageable operating costs as the dependent variable, the range of the estimated residuals (minimum ≈ −6.4; maximum ≈ 6.3) indicated that the presence of outliers was distorting the regression estimates. This issue was not observed in the models using total operating costs as the dependent variable, for which the residual range remained within acceptable limits (minimum ≈ −0.7; maximum ≈ 0.9). Accordingly, a two sided 1% winsorization was applied to the dependent variable in the models analyzing manageable operating costs.

Finally, the last stage of the analysis examined asymmetric cost behavior (sticky cost theory) as a function of the Brazilian Economic Uncertainty Indicator (IIE-Br) using Equation (3), which extends the model proposed by Anderson et al. (2003) by incorporating a proxy variable to capture economic uncertainty. All statistical analyses were performed using the RStudio statistical software.

4 RESULTS

4.1. Descriptive Statistics

Table 4 presents descriptive statistics, expressed in absolute values, for changes in net sales revenue and operating costs. The results show that positive changes predominated for both net sales revenue (NSR) and total operating costs (including both manageable and non-manageable costs), accounting for 77.1% and 76.5% of the observations, respectively. A similar pattern is observed in the sample used for the analysis of manageable operating costs only, in which positive changes represented 77.4% of the observations for NSR and 76.9% for manageable operating costs.

Because only approximately 25% of the sample consists of revenue or cost decreases, caution is warranted when generalizing the results of the inferential models, as the sample contains substantially more observations with positive than with negative changes.

Furthermore, the average variation in NSR exceeded that of total operating costs, while both variables exhibited relatively high standard deviations across the two samples. These findings suggest that, during periods of expansion, NSR increased more rapidly than operating costs, whereas during periods of contraction, operating costs declined more rapidly than NSR, despite the considerable variability across observations. Overall, this descriptive analysis underscores the importance of investigating asymmetric cost behavior.

Table 4

Descriptive statistics for changes in net sales revenue and operating costs (2011-2023)

Sample: Total Operating Costs (520 Observations)						
Variable	**Positive Change**	**Negative Change**	**Mean Change**	**Standard Deviation of the Change**	**Minimum Change**	**Maximum Change**
NSR	401 (77,1%)	119 (22,9%)	249.227	670.074	-127	5.352.462
Total Operating Costs	398 (76,5%)	122 (23,5%)	226.962	693.550	111	4.399.849

Sample: Manageable Operating Costs (468 Observations)						
Variable	**Positive Change**	**Negative Change**	**Mean Change**	**Standard Deviation of the Change**	**Minimum Change**	**Maximum Change**
NSR	362 (77,4%)	106 (22,6%)	271.429	697.240	-127	5.352.462
Manageable Operating Costs	360 (76,9%)	108 (23,1%)	129.037	438.048	178	3.185.501

Source: Prepared by the authors based on the research data (2025).

It should be noted that, to facilitate the interpretation of the descriptive statistics, Table 4 reports the variables in absolute monetary values (Brazilian reais), whereas the regression analyses use the logarithmic transformation of their rates of change, following the original model proposed by Anderson et al. (2003). Accordingly, the magnitudes reported in the descriptive statistics are not directly comparable with those estimated in the econometric models, as they are expressed on different scales and represent distinct measurement concepts.

4.2. Econometric Model

The original model proposed by Anderson et al. (2003) [see Equation (2)] was applied to the study data. The results obtained using the logarithmic change in total operating costs as the dependent variable indicated that the residuals do not follow a normal distribution, according to the Shapiro-Wilk test ([W = 0.79034; p < 2.2 \times 10^{-16}]). The Wald test ([Chi\text{-}square = 150.49; p < 2.2 \times 10^{-16}]) rejected the null hypothesis that all coefficients of the independent variables are equal to zero. The Wooldridge test for autocorrelation ([Chi\text{-}square = 127.47; p < 2.2 \times 10^{-16}]) indicated significant serial correlation in the model residuals. The Breusch-Pagan test for heteroscedasticity ([BP = 8.9101; p < 0.01162]) confirmed that the error variance is not constant. In addition, the scaled Pesaran test confirmed the presence of cross sectional dependence. Finally, the Variance Inflation Factor (VIF) indicated no evidence of problematic multicollinearity among the independent variables ([VIF = 1.813771]).

Given the presence of heteroscedasticity, serial autocorrelation, and cross sectional dependence, Driscoll and Kraay (1998) robust standard errors were employed to avoid the potential underestimation of standard errors. The models were estimated using a maximum lag length of one period and subsequently re-estimated with maximum lag lengths of two and three periods to confirm the robustness of the estimates. The significance levels of the coefficients remained unchanged across specifications.

The results indicate that changes in net sales revenue (**LOG_VAR_NSR**) exerted a positive and statistically significant effect on changes in operating costs ([β_1 = 0.737639; p < 2.2 \times

10^{-16}]), whereas lagged decreases in net sales revenue (**RED_LOG_VAR_NSR**) had a positive but statistically insignificant effect on cost changes ([β_2 = 0.180700; p = 0.26413]). These findings indicate that a 1% increase in net sales revenue is associated with a 0.73% increase in operating costs, whereas a 1% decrease in net sales revenue corresponds to a 0.91% reduction in operating costs. The estimated R^2 indicates that the independent variables explain 50.752% of the variation in the dependent variable. Although these results reveal a pattern of cost asymmetry consistent with the anti-sticky cost phenomenon, the absence of statistical significance for the coefficient associated with revenue decreases prevents a strong statistical inference and therefore does not support the acceptance of H1.

The asymmetric cost behavior identified in this study partially corroborates the findings of Kremer (2015), who documented the existence of anti-sticky costs in firms subject to regulatory agencies. Similarly, Richartz and Borgert (2021) reported evidence of cost asymmetry among nonfinancial companies listed on B3 during the period from 1995 to 2014. Barbosa (2020) also identified asymmetric cost behavior in publicly traded nonfinancial companies in the Brazilian chemical industry between 1995 and 2018.

The estimation of Equation (2) using the logarithmic change in manageable operating costs as the dependent variable revealed the same diagnostic issues observed in the model based on total operating costs. The assumption tests indicated that the residuals are not normally distributed ([W = 0.8242; p < 2.2 \times 10^{-16}]); the set of independent variables does not significantly explain the dependent variable ([Chi\text{-}square = 1.0401; p = 0.5945]); and there is no evidence of multicollinearity ([VIF = 1.761572]). However, the results revealed heteroscedasticity ([BP = 10.647; p = 0.004875]), serial autocorrelation ([Chi\text{-}square = 108.41; p < 2.2 \times 10^{-16}]), and cross sectional dependence ([z = 18.569; p < 2.2 \times 10^{-16}]).

Accordingly, the reported estimates are based on Driscoll and Kraay (1998) robust standard errors with a maximum lag length of one period. Additional estimations using maximum lag lengths of two and three periods yielded identical inference for the coefficients, thereby confirming the robustness of the results.

The estimated R^2 revealed a very low explanatory power of the independent variables for manageable operating costs, accounting for only 0.07% of their variation. This finding may be attributed to the presence of short term rigid costs, such as depreciation and amortization, which cannot decrease or increase proportionally with revenue, as well as provisions for doubtful accounts and legal contingencies, which primarily reflect credit risk, regulatory risk, and legal events rather than fluctuations in revenue. It is also noteworthy that Portion B includes additional cost components with limited short term managerial discretion, such as long term contractual commitments and costs conditioned by the operational and institutional environment in which each distribution company operates.

These findings suggest that the aggregate measure of manageable operating costs may not constitute the most appropriate proxy for capturing short term managerial cost adjustments. Consequently, it may generate potentially distorted incentives, including the management of accounting estimates and the intertemporal smoothing of expenses, which do not necessarily reflect actual changes in operational efficiency.

The estimated coefficients likewise indicate the limited explanatory power of the independent variables. Neither changes in net sales revenue ([β_1 = -0.097648; p = 0.4581]) nor lagged decreases in net sales revenue ([β_2 = 0.063630; p = 0.7116]) were statistically significant. These findings therefore do not support the acceptance of H4.

Table 5 presents the regression results obtained from Equation (3), which incorporates economic uncertainty variables associated with net sales revenue, using total operating costs as the dependent variable. The coefficient of LOG_VAR_NSR, representing the change in net sales revenue, was positive and statistically significant at the 1% level ([β_1 = 0.663101; p < 2.2 \times 10^{-16}]). This result indicates that a 1% increase in net sales revenue is associated, on average, with a 0.66% increase in the operating costs of electricity distribution concessionaires. This finding is consistent with the literature on asymmetric cost behavior and corroborates the results reported by Anderson et al. (2003) and Barbosa (2020), although with a lower magnitude than that observed in the baseline model estimated using Equation 1.

Table 5
Results of the random effects model for total operating costs

Variables	Coefficient	Standard Error	t Statistic	*p*-value
Intercept	-0.249960	0.184325	-1.3561	0.175669
LOG_VAR_RLV	0.663101	0.052363	12.6634	< 2.2e-16***
RED_LOG_VAR_RLV	0.044440	0.205271	0.2165	0.828688
LOG_IIE_Br	0.057791	0.039855	1.4500	0.147660
MED_CENT_RED_LOG_VAR_RLV_LOG_IIE_Br	1.114438	0.419764	2.6549	0.008179***
CRISE_LOG_VAR_RLV	0.169733	0.078344	2.1665	0.030732**
Tests				
Shapiro-Wilk (W)	0.79325			< 2.2e-16
Mean VIF	1.985675			
Teste de Wald (Chisq)	940.04			< 2.2e-16
Wooldridge (Chisq)	118.05			< 2.2e-16
Breusch-Pagan (BP)	12.57			0.02776
Pesaran LM	13.374			< 2.2e-16
Note: Adjusted R²0.51123				
Number of observations: 520				
Prob > chi2: < 2.22e-16				

Note. *** ignificant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.
Source: Prepared by the authors based on the research data (2025).

In contrast, the variable RED_LOG_VAR_NSR, representing changes in net sales revenue during periods of decline, was not statistically significant ([β_2 = 0.044440; p = 0.828688]). This finding indicates that there is no statistical evidence that revenue reductions, in isolation, significantly affect operating costs within the model that incorporates economic uncertainty, consistent with the results obtained using the original specification proposed by Anderson et al. (2003). Furthermore, the very small estimated coefficient suggests that, on average, costs exhibit symmetric behavior, with no meaningful difference between positive and negative revenue changes.

Regarding economic uncertainty, the variable LOG_IIE_Br was not statistically significant ([β_3 = 0.057791; p = 0.147660]). However, the interaction between revenue reductions and economic uncertainty (MEAN_CENT_RED_LOG_VAR_LOG_IIE_Br) was positive and statistically significant ([β_4 = 1.114438; p = 0.008179]). The positive sign of this coefficient suggests that higher economic uncertainty acts as a moderating factor that reduces cost rigidity and induces anti-sticky cost behavior. This finding is consistent with the evidence reported by Bubeck and Silva (2025), insofar as cost asymmetry does not manifest uniformly in the Brazilian context. Nevertheless, whereas those authors documented shifts between sticky and anti-sticky cost patterns across different phases of the business cycle, the present study finds that anti-sticky behavior emerges in association with increasing economic uncertainty within a regulated industry.

Finally, the interaction between the electricity sector crisis dummy variable and changes in net sales revenue (CRISIS_LOG_VAR_NSR) was statistically significant ([β_5 = 0.169733; p =

0.030732]), indicating that periods of crisis in the electricity sector act as a moderating factor associated with greater cost sensitivity to changes in net sales revenue. Specifically, whereas in non-crisis years a 1% increase in net sales revenue is associated with an average increase of 0.66% in operating costs ([$\beta_1 = 0.663101$]), during crisis years this elasticity rises to approximately 0.83% ([$\beta_1 + \beta_5 = 0.832834$]), demonstrating that operating costs become more responsive to revenue fluctuations under adverse sectoral conditions.

These findings support the acceptance of H2, which proposes that the IIE-Br proxy amplifies cost asymmetry, and H3, which posits that the elasticity of costs with respect to net sales revenue differs between years characterized by sectoral crises and non-crisis years.

The lack of statistical significance for the marginal effect of the IIE-Br proxy on cost asymmetry contrasts with the findings reported by Maquiaveli et al. (2022), who concluded that the IIE-Br explains variations in total operating costs and administrative expenses of publicly traded companies listed on B3. One possible explanation for this discrepancy is that Maquiaveli et al. (2022) relied on statutory financial accounting data, whereas the present study is based on the regulatory accounting framework established by ANEEL.

According to Carvalho et al. (2014) and Monteiro et al. (2021), substantial differences exist between statutory and regulatory accounting with respect to total assets, concession income, net revenue, operating income, and net income. Furthermore, Ferreira et al. (2021) argue that although both accounting systems provide information relevant to investors, statutory accounting offers a more comprehensive representation of the underlying economic reality because it is principles based and emphasizes substance over form, whereas regulatory accounting in the electricity sector is primarily governed by tariff specific and regulatory rules.

With respect to the estimation of Equation (3) using manageable operating costs as the dependent variable, the results obtained from the original Anderson et al. (2003) model had already shown that variations in these costs are not explained by changes in net sales revenue. Therefore, it was expected that the extended specification incorporating economic uncertainty and electricity sector crisis variables would likewise exhibit limited explanatory power, which was confirmed by the estimated R^2 of only 0.64%. In addition, none of the explanatory variables reached statistical significance.

These findings indicate that variations in manageable operating costs are not explained by changes in net sales revenue, economic uncertainty, or crises affecting the electricity sector. This result suggests that Portion B comprises manageable operating costs whose variation is driven primarily by internal factors and accounting estimates with long term effects rather than by external fluctuations in revenue.

Finally, Table 6 presents the results of the hypothesis tests.

Table 6
Results of the hypothesis tests

HYPOTHESIS	DECISION
H_1: Total operating costs of electricity distribution concessionaires respond asymmetrically to changes in revenue, such that cost sensitivity when revenue decreases differs from that observed when revenue increases.	The null hypothesis cannot be rejected
H_2: Economic uncertainty, measured by the Getulio Vargas Foundation's Brazilian Economic Uncertainty Indicator (IIE-Br), moderates cost asymmetry such that, during periods of greater economic uncertainty, the sensitivity of costs to changes in revenue differs from that observed during periods of lower economic uncertainty in electricity distribution concessionaires.	The null hypothesis is rejected.

H3: In years classified as sectoral crisis periods, the elasticity of operating costs with respect to changes in revenue differs from that observed in non-crisis years for electricity distribution concessionaires.	The null hypothesis is rejected.
H4: Cost asymmetry is more pronounced when measured using manageable operating costs (Portion B) than when measured using aggregate operating costs in electricity distribution concessionaires.	The null hypothesis cannot be rejected

Source: Prepared by the authors based on the research data (2025).

5 CONCLUSION

This study investigated the effects of economic uncertainty, measured using the Brazilian Economic Uncertainty Indicator (IIE-Br) developed by the Brazilian Institute of Economics of the Getulio Vargas Foundation (FGV IBRE), on the cost behavior of electricity distribution concessionaires in Brazil during the period from 2011 to 2023, based on the model proposed by Anderson et al. (2003).

The results suggest the presence of asymmetric behavior in the total operating costs of electricity distribution concessionaires. Specifically, a 1% increase in net sales revenue (NSR) is associated with a 0.73% increase in operating costs, whereas a 1% decrease in NSR corresponds to a 0.91% reduction in operating costs. This finding is consistent with the results reported by Kremer (2015), Richartz and Borgert (2021), and Barbosa (2020). However, it should be noted that the econometric model did not provide statistically significant evidence supporting this behavior for the electricity distribution companies included in the sample.

Furthermore, the results indicate that the marginal effect of the IIE-Br (LOG_IIE_Br) was not statistically significant. Nevertheless, the interaction term between revenue reduction and economic uncertainty (Red × LOG_VAR_NSR × LOG_IIE_Br) was statistically significant, suggesting that economic uncertainty moderates the asymmetric behavior of total operating costs during periods of revenue contraction. The crisis dummy variable also exhibited a statistically significant moderating effect at the 5% level ($p = 0.030732$), indicating that, during years characterized by sectoral crises, the sensitivity of total operating costs to changes in revenue is greater than that observed during non-crisis years. These findings differ from those reported by Maquiaveli et al. (2022). One possible explanation for this discrepancy lies in the use of different accounting frameworks, as Maquiaveli et al. (2022) relied on statutory financial statements, whereas the present study adopted the regulatory accounting framework established by ANEEL.

Overall, the findings indicate that the behavior of total operating costs in Brazilian electricity distribution concessionaires between 2011 and 2023 does not provide statistically robust evidence of cost asymmetry, although the estimated coefficients are consistent with the anti-sticky cost phenomenon. Likewise, the economic uncertainty proxy represented by the IIE-Br did not exert a significant marginal effect on cost asymmetry during the period analyzed. However, the interaction between revenue reductions and economic uncertainty was statistically significant, suggesting that, during periods of heightened economic uncertainty, the anti-sticky behavior of total operating costs becomes statistically significant. The results also indicate that periods of crisis in the electricity sector are associated with greater sensitivity of total operating costs to changes in net sales revenue. These findings extend the evidence reported by Bubeck and Silva (2025) by suggesting that, in addition to the business cycle, economic uncertainty and sector-specific regulation are also important dimensions for understanding cost asymmetry in Brazil.

The analyses focusing exclusively on Portion B of the distributors' costs revealed that variations in net sales revenue, economic uncertainty, and sectoral crises have limited explanatory power with respect to changes in manageable operating costs. These findings suggest that, when considered in aggregate, the costs included in Portion B may not adequately capture short term managerial adjustments.

Regarding the limitations of this study, the analysis is restricted to the electricity distribution sector, and therefore the findings cannot be generalized to other regulated industries. In addition, only approximately 25% of the observations correspond to periods of declining revenue or costs, requiring caution when generalizing the results of the inferential models. Nevertheless, these limitations do not diminish the relevance of the study's findings.

Finally, future research should replicate this analysis in other regulated industries characterized by different tariff structures. It would also be valuable to examine asymmetric cost behavior by incorporating additional macroeconomic variables, such as GDP growth and the inflation rate, with the objective of improving empirical models designed to measure the effects of the macroeconomic environment on cost asymmetry.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

DATA AVAILABILITY

The complete dataset supporting the findings of this study is available from the authors upon reasonable request.

AUTHOR CONTRIBUTIONS

Roles	1º author	2º author	3º author	4º author
Conceptualization	♦	♦	♦	
Data Curation	♦	♦		
Formal Analysis	♦	♦		
Funding Acquisition				
Investigation	♦	♦		
Methodology	♦	♦		
Project Administration	♦	♦		
Resources				
Software				
Supervision			♦	♦
Validation		♦		
Writing – Original Draft Preparation	♦	♦		
Writing – Review & Editing	♦	♦	♦	
Conceptualization	♦	♦	♦	♦

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