On the Effects of Shocks in the Electricity Market: New Evidence from Brazil

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Abstract

This paper investigates the effects of structural shocks to electricity supply, aggregate demand, and unanticipated regulatory interventions—referred to as electricity-specific shocks—in Brazil between 1998 and 2024. Using a structural vector autoregressive (SVAR) model identified through sign and narrative restrictions, we disentangle the distinct impacts of these shocks on electricity generation, output, tariffs, and inflation. Supply shocks significantly reduce generation and output but have limited influence on tariffs and inflation. In contrast, aggregate demand shocks and electricity-specific shocks are more relevant to the dynamics of tariffs and inflation. Electricity-specific shocks play a pivotal role in explaining changes in tariffs, while exerting modest effects on real activity. These findings provide insights for the ongoing reform of Brazil's electricity sector, highlighting the importance of policy transparency and coherence to mitigate economic distortions.

Keywords: Electricity prices. Supply and demand shocks. Sign and narrative restrictions. Energy policy.

JEL classification: C32. E31. Q41. L94.

Resumo

Este artigo investiga os efeitos de choques estruturais na oferta de eletricidade, na demanda agregada e em intervenções regulatórias imprevistas — denominados choques específicos do setor elétrico — no Brasil entre 1998 e 2024. Utilizando um modelo de vetor autorregressivo estrutural (SVAR), identificado por meio de restrições de sinal e narrativa, destrinchamos os distintos impactos desses choques na geração, produção, tarifas e inflação de eletricidade. Choques de oferta reduzem significativamente a geração e a produção, mas têm influência limitada sobre as tarifas e a inflação. Em contraste, choques de demanda agregada e choques específicos do setor elétrico são mais relevantes para a dinâmica das tarifas e da inflação. Choques específicos do setor elétrico desempenham um papel fundamental na explicação das variações tarifárias, enquanto exercem efeitos modestos sobre a atividade real. Essas descobertas fornecem insights para a reforma em andamento do setor elétrico brasileiro, destacando a importância da transparência e da coerência das políticas para mitigar distorções econômicas.

Palavras-chave: Preços de eletricidade. Choques de oferta e demanda. Restrições de sinal e narrativa. Política energética.

Classificação JEL: C32. E31. Q41. L94.

Área 6 - Infraestrutura, transporte, energia, mobilidade e comunicação.

On the Effects of Shocks in the Electricity Market: New Evidence from Brazil

1. Introduction

Recent shocks and structural transformations have brought electricity markets back to the forefront of energy policy debates. Globally, concerns stem primarily from the demand side: in 2024, global electricity consumption grew by 4.3% and is projected to increase by approximately 4% annually through 2027. Estimates suggest that 85% of this growth will come from emerging economies, particularly from Asia, spurred by electrification, greater use of air conditioning, and the expansion of data centres (IEA, 2025). In Europe, challenges primarily arise from the supply side. The energy crisis triggered by the war between Russia and Ukraine led to higher electricity prices and accelerated the shift towards renewable sources, which represented 48% of the electricity generation mix in 2024. While this shift has reduced CO_2 emission intensity, it has also increased the system's exposure to climate variability. In Brazil, attention has turned to regulatory redesign. Proposed measures include tariff exemptions for small consumers, redistribution of thermoelectric generation costs between regulated and free market consumers, and expanding access to the free market. However, considerable uncertainty remains about the cost structures associated with these reforms.

The Brazilian electricity market has distinct characteristics compared to other markets. Brazil ranks among the world's ten largest electricity consumers, with approximately 90% of its generation coming from renewable sources, predominantly hydroelectric. Its vast territory poses significant logistical challenges for transmission and regional system integration. Despite the sector's importance, we find limited empirical evidence on how demand, supply, and electricity-specific shocks influence tariffs, output, and inflation. To address this gap, we propose a structural vector autoregressive (SVAR) model based on the framework originally developed by Kilian (2009) for the oil market and later adapted to other energy commodities. However, unlike oil, electricity is non-storable. This limitation prevents us from using inventories as an explanatory variable and from identifying precautionary demand shocks driven by expectations of future scarcity. Therefore, we define electricity-specific shocks as unexpected regulatory events, which we cannot directly observe from existing variables, justifying our use of a structural modelling approach.

The study most closely related to ours is that of Ganepola, Shubita and Lee (2023) for the United Kingdom. However, we differ from these authors in our identification assumptions. They assume that, contemporaneously, the electricity supply curve is perfectly inelastic and that regulatory shocks do not affect output. This assumption may be overly restrictive, as it implies a price elasticity of supply equal to zero and rules out any contemporaneous response of output to unexpected regulatory changes. In contrast, we relax these assumptions by imposing economically grounded sign restrictions at impact. Furthermore, we enhance identification by incorporating narrative information about important events during the period studied.

We find that electricity supply shocks significantly affect generation and output but have limited influence on tariffs and inflation. In contrast, aggregate demand shocks primarily drive unexpected fluctuations in electricity tariffs and inflation. Electricity-specific shocks, associated with regulatory changes, have modest effects on real variables but are crucial for understanding tariff and inflation dynamics during unexpected policy interventions. These results remain robust when replacing industrial production with a broader measure of economic activity and when imposing sign restrictions up to six periods after the initial impact. Our findings provide relevant insights for regulators, policymakers, and academics, particularly in the context of the ongoing reforms in Brazil's electricity sector.

The remainder of the paper is structured as follows. Section 2 reviews the related literature, highlighting the scarcity of studies examining the effects of demand and supply shocks in electricity markets. Section 3 outlines the methodology and data, with particular emphasis on the identification strategy for structural shocks. Section 4 presents the empirical results, emphasising the dynamic responses to shocks and the historical contribution of each shock to the evolution of generation, output, tariffs, and inflation from 1998 to 2024. Section 5 concludes with a discussion of the policy implications.

2. Literature Review

The literature on supply and demand shocks in energy commodity markets primarily focuses on oil. The seminal article by Kilian (2009) challenges the assumption of exogenous oil price shocks. The author proposes a recursively identified structural VAR (SVAR) model to distinguish between supply, aggregate demand, and precautionary demand shocks. The results indicate that demand shocks—particularly precautionary ones—exert more persistent and significant impacts on oil prices compared to supply shocks and differently affect US GDP and inflation.

Kilian's (2009) framework has become a standard in subsequent research. For instance, Kilian and Murphy (2014) use this model to assess the role of inventories and financial speculation in determining oil prices, controlling for fundamental supply and demand factors. Employing a SVAR identified via sign restrictions, the authors show that global demand shocks primally drove the price increases between 2003 and 2008, challenging the prevalent speculation-based narrative of that period.

The literature also extensively examines structural shock identification strategies within SVAR models in the oil market. Kilian and Murphy (2012) argue that agnostic sign restrictions are insufficient for adequately distinguishing supply and demand shocks, thus imposing additional economically plausible elasticity constraints. Antolín-Díaz and Rubio-Ramírez (2018) refine this approach by integrating narrative sign restrictions based on widely recognised events. Alternatively, Herwartz and Plödt (2016) propose a factor-analysis-based strategy without predefined structural labels. Despite different identification approaches, these studies generally corroborate Kilian's (2009) findings.

This modelling approach has been adapted across different economic contexts. Van de Ven and Fouquet (2017) estimate the effects of energy supply and demand shocks in the UK, incorporating not only oil but also natural gas and electricity. They use a time-varying parameter SVAR with sign restrictions. Their findings demonstrate that shock intensities vary significantly across decades, being more pronounced in the 1970s–1980s and becoming milder after the 2000s.

In emerging markets, Ji, Liu, and Fan (2015) apply Kilian's methodology to the BRICS countries (Brazil, Russia, India, China, and South Africa). Their results indicate supply shocks generally reduce GDP, while demand shocks can boost production and appreciate currencies in certain cases, such as Russia. Precautionary shocks tend to exert inflationary pressure. Azad and Serletis (2022) conduct a similar analysis for EM7 countries (China, India, Brazil, Russia, Mexico, Indonesia, and Turkey), employing sign restrictions following Kilian and Murphy (2012). They find expansionary effects from aggregate demand shocks, persistent negative impacts from supply shocks, and ambiguous responses to expectation-related shocks.

The methodology has also been extended to other energy commodities. Alessandri and Gazzani (2025) estimate supply shocks for natural gas, global demand shocks, and geopolitical risk shocks in the eurozone. The natural gas market has gained increasing prominence following the European energy crisis triggered by the war in Ukraine. The authors employ a TVP-FAVAR-SVAR model identified via sign restrictions. Results suggest geopolitical shocks produce more persistent inflationary pressures and stronger contractionary effects than typical supply shocks, especially since 2020.

However, applications to the electricity market remain limited. Ganepola, Shubita, and Lee (2023) investigate determinants of electricity price fluctuations in the UK, focusing on the Covid-19 pandemic and the Russia–Ukraine conflict. They estimate the impacts of shocks related to natural gas supply, gas prices, consumer demand, and electricity-specific factors using recursive identification with data from 1996 to 2022. Their findings show that gas price shocks and regulatory factors, such as tariff caps, increase electricity prices, while demand shocks reduce them, causing temporary inflationary effects and declines in industrial production.

Maciejowska (2014) analyses the effects of wind generation (supply) shocks, demand shocks, natural gas price (generation cost) shocks, and speculative shocks on UK electricity prices using daily data from 2010 to 2012 in a recursively identified SVAR. Results indicate speculative shocks account for up to 95% of electricity price volatility, while supply and demand shocks have distinct effects during peak and off-peak hours, with stronger impacts in high-demand periods. While these studies focus on specific generation sources like natural gas and wind power, we use total electricity generation to capture broader effects.

In the Brazilian context, the literature is even more limited. Although Brazil ranks among the world's ten largest electricity consumers and the largest in Latin America, no studies apply Kilian's (2009) structural model to its electricity sector. Kornelius and Divino (2024) employ a Dynamic Stochastic General Equilibrium (DSGE) model to estimate structural productivity shocks in the economy and the energy sector (supply), energy intensity shocks in residential and industrial sectors (demand), and government consumption shocks. Their results indicate that non-energy shocks explain most GDP variations, while energy-related shocks have modest effects. Energy prices are predominantly influenced by supply shocks.

Brandão and Divino (2020) estimate a panel VAR (PVAR) model with fixed effects using monthly data from 2003 to 2016 across Brazil's five regions (North, Northeast, Central-West, Southeast, and South). Endogenous variables include natural affluent energy (ENA), diesel prices, industrial production, spot price (PLD), average tariffs, consumption, total generation, and fiscal and monetary policy proxies. They identify shocks using Cholesky decomposition. Although described as structural, this methodology captures only dynamic relationships and responses to exogenous disturbances, limiting causal interpretations.

Given the paucity of studies applying Kilian's (2009) structural model to Brazil's electricity market, we adapt this framework to analyse the effects of electricity supply and demand shocks in the country.

3. Methodology and Data

We adopt the algorithm proposed by Antolín-Díaz and Rubio-Ramírez (2018). Let $1 \leq t \leq T$, where T is the sample size. The SVAR can be expressed as:

$$y_t' A_0 \; = \; x_t' A_+ + \varepsilon_t' \qquad (1)$$

where y_t is an $(n \times 1)$ vector of endogenous variables, and A_0 is an invertible matrix of contemporaneous parameters capturing the instantaneous relationships among the elements of y_t. The matrix $A_+' = [A_1' \cdots A_p' c']$ has dimension $(m \times n)$, and $x_t' = [y_{t-1}, \dots, y_{t-p}, 1]'$ is a vector of dimension $(m \times 1)$, with $m = np + 1$, where $p = 6$ is the lag order chosen to ensure sufficient dynamics in the system. The reduced form of equation (1) is $y_t' = x_t' B + u_t'$, where $B = A_+ A_0^{-1}$, $u_t' = \varepsilon_t' A_0^{-1}$, and $E[u_t u_t'] = \Sigma = (A_0 A_0')^{-1}$.

Table 1 presents the four variables of the vector y_t. All series are expressed as year-on-year growth rates, $\ln(y_{t-12}/y_t) \times 100$, to address seasonality and non-stationarity issues. The sample spans January 1998 to March 2024, starting just after the major regulatory reforms introduced in the Brazilian electricity sector during the 1990s (see Appendix A1 for further details). Figure 1 depicts the time series evolution.

Table 1. Summary of variables.

Variable	*Measure*	*Source*
Total Generation	TWh	ONS
Industrial Production Index	Index	OECD
Real Average Tariff	BRL	ANEEL
Broad National Consumer Price Index	Index	IBGE

Note: sources include the National Electric System Operator (ONS), the Organization for Economic Co-operation and Development (OECD), the Brazilian Electricity Regulatory Agency (ANEEL), and the Brazilian Institute of Geography and Statistics (IBGE).

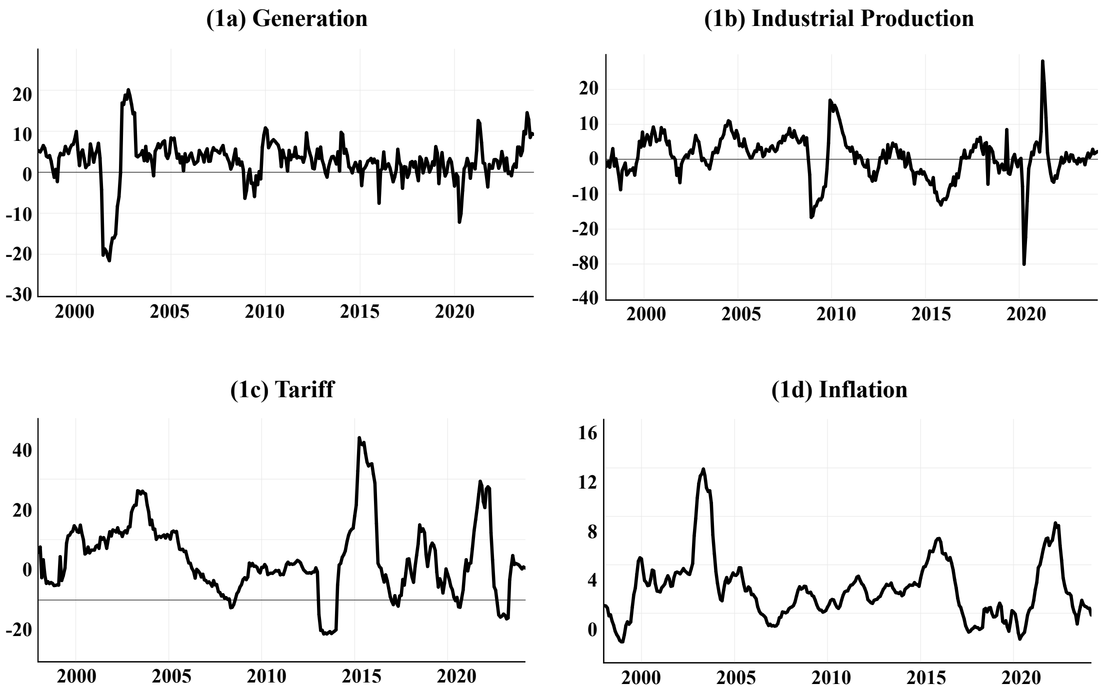

Figure 1. Time series evolution.

Note: all series are expressed as year-on-year growth rates, $\ln(y_{t-12}/y_t) \times 100$.

3.1 Identification

Model (1) is not identified. One approach to achieve identification is to impose sign restrictions on the IRFs or the structural parameters. The following function characterises sign restrictions:

$$\Gamma(\Theta) = (e'_{1,n}F(\Theta)'S'_1, \ldots, e'_{n,n}F(\Theta)'S'_n)' > 0 \tag{2}$$

where Θ collects the value of parameters, and $e_{j,n}$ is the jth column of I_n. The matrix $F(\Theta)$ is constructed by vertically stacking the IRFs across the relevant horizons, and S_j is an $(s_j \times r_j)$ matrix composed of 0s, 1s, and -1s indicating which sign restrictions apply to which variables and at which horizons.

Three shocks—electricity supply, aggregate demand, and electricity specific—are identified within this four-variable SVAR model. The remaining residual shock captures idiosyncratic dynamics or economically uninterpretable innovations. This identification strategy is consistent with prior contributions in the literature (Kilian and Murphy, 2014; De Santis and Tornese, 2023; De Santis, 2024). Table 2 outlines the sign restrictions imposed on impact.

Table 2. Sign restrictions on impact responses.

	Electricity Supply Shock	*Aggregate Demand Shock*	*Electricity specific shock*
Generation	–	+	–
Output	–	+	+
Tariff	+	+	–
Inflation	+	+	–

We posit that an adverse supply shock should reduce generation and output and increase electricity tariffs and inflation. Conversely, a demand shock raises all four variables. These sign restrictions are consistent with the seminal articles by Kilian and Murphy (2012) and Baumeister and Peersman (2012).

The electricity-specific shock captures regulatory variation orthogonal to fundamental supply and demand conditions. It primarily reflects unexpected policy interventions, such as the imposition of tariff ceilings or *ad hoc* reductions. This interpretation follows Ganepola, Shubita, and Lee (2023), who adopt a similar approach in the context of the British electricity market.

We assume that an electricity-specific shock reduces generation, tariffs, and inflation, while it raises output on impact. Setting tariffs below the market-clearing level distorts price signals, thereby inducing excess demand. Lower tariffs reduce inflation contemporaneously. Following Kilian and Murphy (2012), we impose restrictions only on impact to allow for potential sign reversals over time.

3.2 Narrative information

Antolín-Díaz and Rubio-Ramírez (2018) introduce a framework for incorporating narrative sign restrictions to improve model identification. This approach helps to exclude economically implausible parameters. Restrictions may be placed on the sign of structural shocks or on their historical contribution over a pre-specified period. We adopt the latter case.

Formally, let $1 \leq v \leq s_j$, if the absolute value of the contribution of the jth shock to the historical decomposition is larger than the sum of the absolute contributions of all other shocks to the unexpected change in the $i_1, \ldots, i_{S_j}$th variables from periods $t_1, \ldots, t_{S_j}$ to $t_1 + h_1, \ldots, t_{S_j} + h_{S_j}$:

$$\left|H_{i_v,j,t_v,t_v+h_v}\left(\Theta, \varepsilon_{t_v}(\Theta), \ldots, \varepsilon_{t_v+h_v}(\Theta)\right)\right| - \sum_{j' \neq j}\left|H_{i_v,j',t_v,t_v+h_v}\left(\Theta, \varepsilon_{t_v}(\Theta), \ldots, \varepsilon_{t_v+h_v}(\Theta)\right)\right| > 0 \quad (3)$$

One example of a shock in the Brazilian electricity market whose exogeneity is widely recognised is the 2001 supply crisis (see Appendix A1 for further details). Accordingly, we impose that the electricity supply shock is the most important contributor to the unexpected change in generation between June and October 2001.

Another relevant case is the concession renewal policy implemented in early 2013. Although the policy was not entirely unanticipated, its actual content took market participants by surprise. For instance, the decision to renew existing concessions early without competitive auctions and to impose unfavourable conditions on firms seeking renewal diverged from prior expectations. This intervention led to a sharp drop in electricity tariffs at the beginning of 2013 (see Appendix A1). Therefore, we impose that the electricity-specific shock is the most important contributor to the unexpected change in tariffs in February 2013.

4. Results

Figure 2 presents the impulse response functions (IRFs) of the four endogenous variables to the three structural shocks considered. The light grey areas represent the 68% posterior credible set that satisfies only the sign restrictions, while the dark grey areas delineate the subset of trajectories also meeting the narrative restrictions. Following Antolín-Díaz and Rubio-Ramírez (2018), the solid lines represent the pointwise median for illustrative purposes, acknowledging that not all admissible structural models are equally plausible.

An electricity supply shock causes a contraction in electricity generation, followed by a gradual reversal completed within a one-year horizon. This dynamic aligns with the emergency substitution of hydroelectric generation by thermoelectric sources, a regime persisting until reservoir levels normalise. The shock triggers an immediate reduction in economic output, with recovery commencing only from the fifth month onwards. Electricity tariffs respond with a short-term increase, while inflation exhibits a modest and temporary effect. The inclusion of narrative restrictions exerts a limited influence on the set of admissible trajectories.

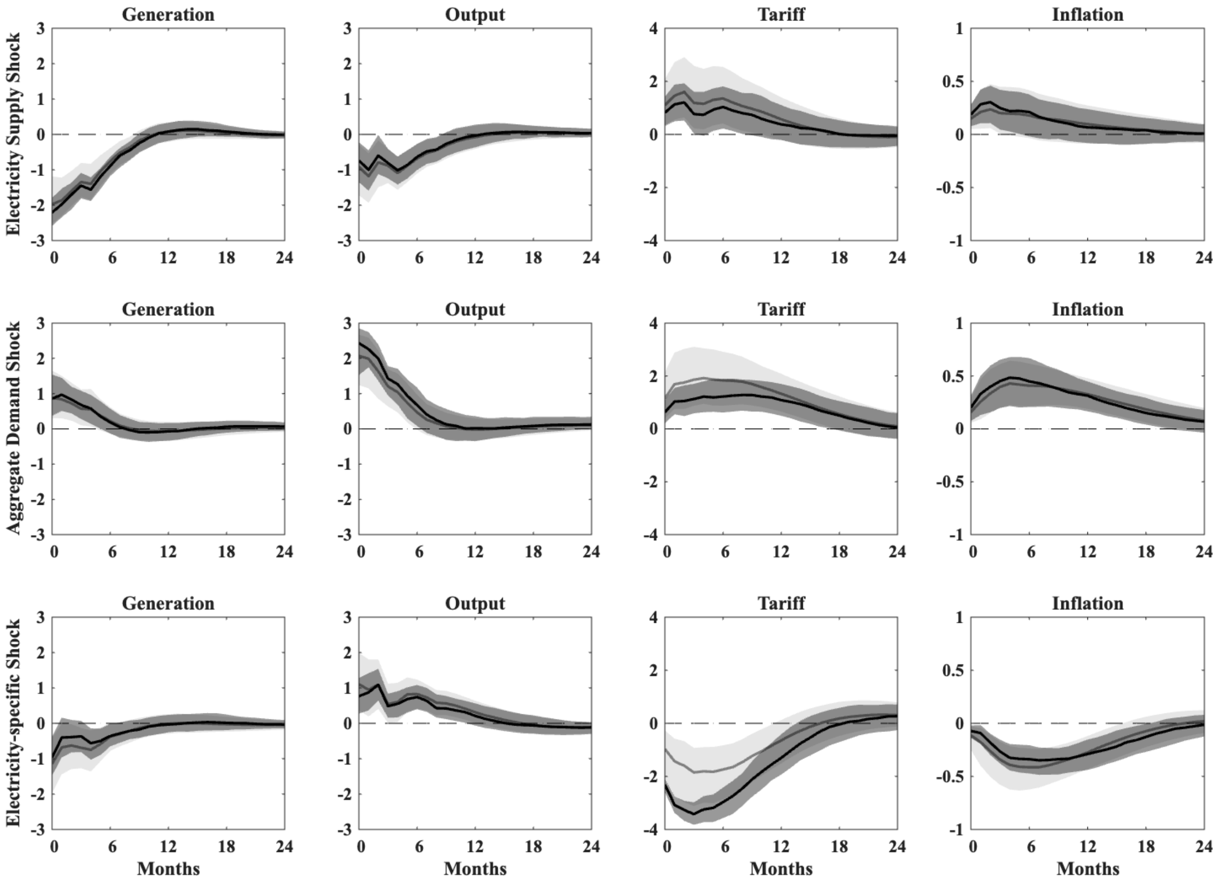

Figure 2. IRFs with and without narrative restriction.

Note: The light grey areas represent the 68% posterior credible set that satisfy the sign restrictions only. The dark grey areas correspond to the set that additionally satisfy the narrative restriction.

The aggregate demand shock significantly impacts economic output in the short term, though these effects are transient. Electricity generation likewise increases on impact, reverting to the previous trend within six months. In contrast, effects on electricity tariffs are more persistent, with upward pressure remaining significant for approximately 18 months before dissipating. Inflation follows a similar trajectory, reflecting this persistence.

The electricity-specific shock, associated with regulatory changes, initially results in a reduction of tariffs that deepens in the three subsequent months before reversing fully over twelve months. This response mirrors observed tariff behaviour during the implementation of the concession renewal policy in 2013. Inflation dynamics follow a comparable pattern. Effects on output and electricity generation, however, are modest and short-lived, indicating limited impacts of these shocks on real economic variables.

Figure 3 displays the historical decomposition of the unexpected variation in the four model variables. As in Kilian (2009), examining specific historical episodes provides instructive insights. The drop in electricity generation in 2001, followed by its recovery in 2002, is attributed primarily to electricity supply shocks, with narrative restrictions aligning the estimated trajectory closely to established historical narratives. Aggregate demand shocks explain a substantial portion of unexpected movements in electricity generation during periods of significant global economic downturns, such as the international financial crisis and the COVID-19 pandemic. Generally, electricity-specific shocks contribute modestly to historical variations in generation.

The economic contraction observed in the last quarter of 2001 is attributed to electricity supply shocks. In contrast, the prolonged downturn in economic activity between the second quarter of 2014 and the end of 2016—a period marked by a deep and multifaceted recession—arises from the overlapping of the three structural shocks identified in the model. Notably, electricity-specific shocks play an important role in this episode, suggesting that regulatory interventions in the electricity sector may have amplified the severity of the economic downturn.

Electricity supply shocks play a secondary role in explaining unexpected tariff variations. An illustrative example is the sharp tariff increase in 2003, predominantly explained by aggregate demand and electricity-specific shocks. This episode aligns with the politico-economic context of the period: despite market participants anticipating a shift in economic policy following the presidential election, the new administration adopted a fiscally responsible stance. This positive reassessment restored market confidence, thereby stimulating consumption and investment.

Electricity-specific shocks largely capture the effects of unexpected regulatory changes. Although several measures adopted in the early 2000s were responses to the 2001 water crisis, their formulation and implementation were often opaque to market agents. A prominent example is the Programme of Incentives for Alternative Electricity Sources (Proinfa), whose proposals lacked clarity regarding cost structures and implementation schedules (see Appendix A1). Such regulatory uncertainties may have influenced expectations, generating significant price shocks within the sector.

Tariff dynamics observed between 2013 and 2014 are predominantly explained by electricity-specific shocks. The imposition of narrative restrictions during this interval reinforces the interpretation in the historical decomposition that the concession renewal policy artificially suppressed tariffs in the short term, creating distortions subsequently requiring correction.

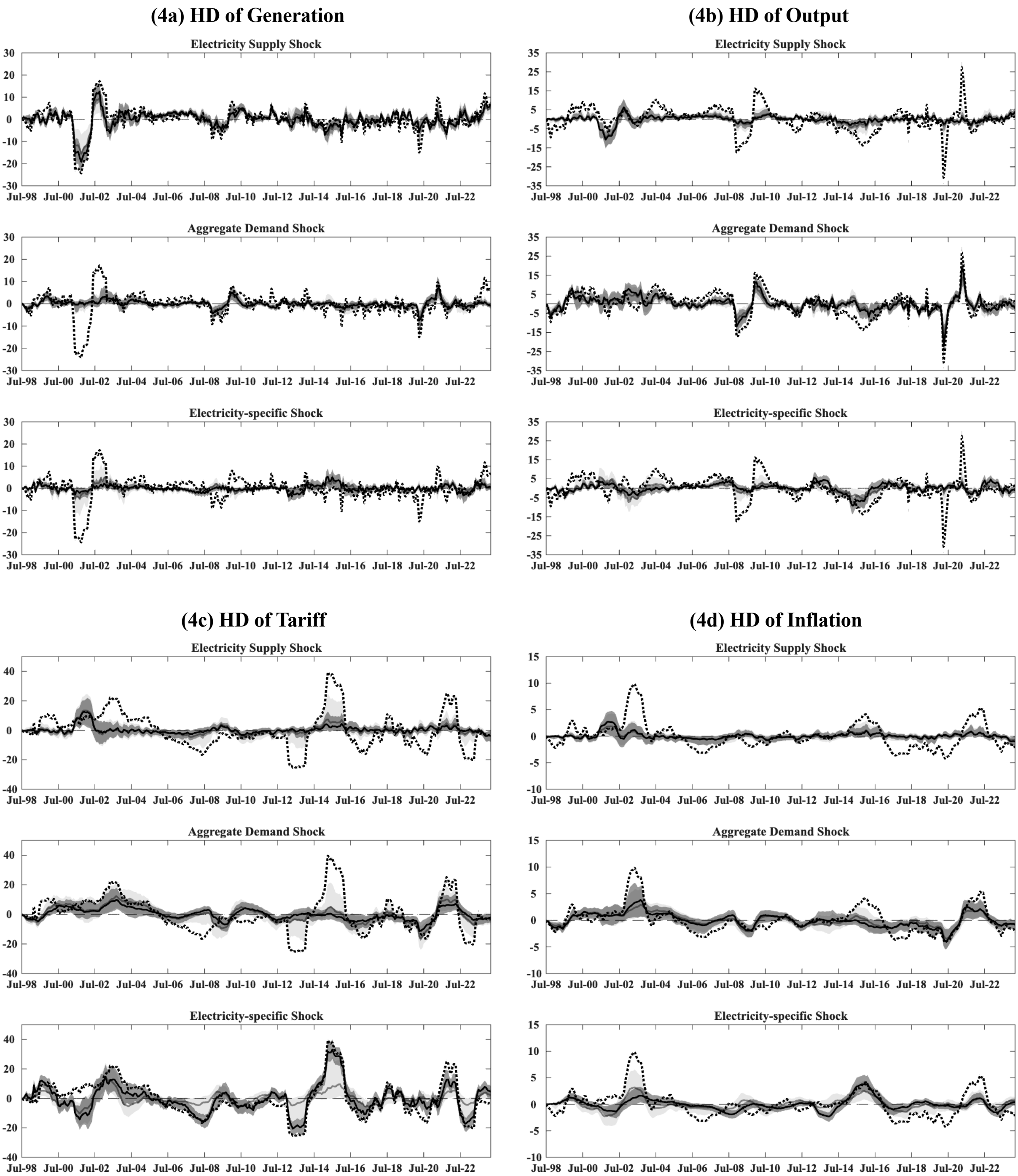

Figure 3. HDs with and without narrative restriction.

Note: The dotted line represents the unexpected change observed. The light grey areas represent the 68% set of HDs that satisfy the sign restrictions only. The dark grey areas correspond to the subset of models that additionally satisfy the narrative restriction.

Unexpected fluctuations in inflation are primarily explained by aggregate demand shocks and, to a lesser extent, electricity-specific shocks. The inflationary episode of 2003 reflects an optimistic revision of economic expectations, driving increased domestic demand. Conversely, the inflation reduction in 2009 is associated with the severe impact of the global financial crisis on international trade, which abruptly reduced Brazilian industrial production and exports. Inflationary pressures in 2015 are attributed to electricity-specific shocks, consistent with second-order effects arising from tariff reversals following the concession renewal policy.

4.1 Robustness

Although industrial production is widely employed as a proxy for economic activity, there remains debate in the literature regarding the most appropriate measure. Baumeister and Peersman (2012) utilise world industrial production, while Kilian (2009) proposes an index based on dry bulk freight rates. Considering this discussion, we replace industrial production with the monthly GDP indicator estimated by the Central Bank of Brazil. The results, reported in Appendix A2, are generally similar to those of the baseline model, except for the response of output to structural shocks. The response of GDP to aggregate demand shocks remains similar on impact but exhibits a slower reversal, taking up to 24 months. In contrast, the effects of supply and electricity-specific shocks dissipate within approximately three months. This discrepancy may reflect the broader scope of GDP, rendering it more susceptible to shocks not explicitly modelled.

Following the literature, we impose sign restrictions beyond the contemporaneous period. Previous studies, such as the seminal work by Baumeister and Peersman (2013), justify this approach based on empirical evidence or consolidated beliefs about the sector's dynamics. The results from our baseline model already appear well aligned with the observed reality and consistent with the narrative described in Appendix A1. Nonetheless, we imposed additional restrictions extending six periods beyond the initial shock, as a means of testing the robustness of our findings. We find that the main conclusions remain largely unchanged.

4.2 Discussion

The results indicate that electricity supply shocks have significant effects on generation and output but exert limited influence on tariffs and inflation. Aggregate demand shocks emerge as key drivers of unexpected fluctuations in electricity prices and inflation, particularly during turning points in the economic cycle. Electricity-specific shocks—of a regulatory nature—although generally modest in their real effects, prove essential to explaining tariff and inflationary movements in specific episodes.

The limited impact of supply shocks on energy prices is consistent with findings from the electricity literature (Ganepola, Shubita, and Lee, 2023; Maciejowska, 2014), as well as for other energy commodities such as oil (Kilian, 2009). For the European natural gas market, Alessandri and Gazzani (2025) similarly show that adverse supply shocks reduce output and increase inflation, in line with our results.

With respect to aggregate demand shocks, our results suggest persistent inflationary pressures, whereas Ganepola, Shubita, and Lee (2023) find an initially disinflationary effect. This divergence may stem from differences in the chosen proxies—industrial production in our case, versus consumer confidence in the British context—as well as from institutional differences across countries.

In the Brazilian context, our findings align with Kornelius and Divino (2024) regarding the role of electricity shocks in the 2001 contraction and in interpreting the 2014–2016 recession as the outcome of overlapping shocks. Our model, however, advances the discussion by explicitly identifying regulatory shocks, whereas those authors attribute residual tariff fluctuations to a measurement error component. In line with Ganepola, Shubita, and Lee (2023), we underscore that regulatory interventions are central to understanding specific inflationary episodes.

5. Conclusion and Policy Implications

Recent concerns over European energy security, intensified by the war between Russia and Ukraine, alongside the growing global demand for electrification, air conditioning, and the expansion of data centres, have brought electricity markets back to the forefront of energy policy debates. In Brazil, a wide-ranging reform of the electricity sector is currently under discussion, involving measures such as exemptions for small consumers, cost redistribution, and the expansion of access to the free market. However, as with previous reforms, the current proposal lacks transparency regarding its cost structure, generating uncertainty about its actual effects on tariffs and the broader economy.

Despite the significance of this market, the literature offers limited empirical evidence on the effects of structural shocks to demand, supply, and electricity-specific factors. We aim to fill that gap by providing new evidence on the impacts of such shocks on output, inflation, and electricity tariffs in Brazil from 1998 to 2024. Methodologically, our approach differs from models based exclusively on exclusion restrictions—such as that of Ganepola, Shubita and Lee (2023)—by combining sign restrictions with narrative information about significant events, thereby offering greater flexibility.

Our results indicate that electricity supply shocks reduce generation and output, but exert limited effects on tariffs and inflation. Aggregate demand shocks have significant yet transitory effects on output and generation, but more persistent impacts on prices. Electricity-specific shocks, linked to unexpected regulatory decisions, are crucial in explaining the trajectory of both tariffs and inflation. Historical decomposition shows that supply shocks played a key role in the economic downturn of the fourth quarter of 2001, while electricity-specific shocks may have exacerbated the severity of the 2014–2016 recession. These shocks were also central during episodes such as the implementation of the Proinfa programme (2002–2003) and the concession renewal policy (2013–2014), directly influencing the dynamics of tariffs and inflation.

The findings provide relevant insights for regulators and policymakers in the context of the ongoing reform of the sector. We suggest that policies of this nature should be more transparent with respect to their cost structure, implementation timeline, and monitoring mechanisms. Furthermore, it is essential that the government ensures coherence between the design and execution of its proposed measures, in order to mitigate uncertainty and safeguard institutional credibility. Future research could deepen the analysis of regulatory interventions—for instance, what would have been the trajectory of electricity tariffs in the absence of the 2013 concession renewal policy?

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The data supporting this study are available in the database of the Institute of Applied Economic Research (IPEA) at http://www.ipeadata.gov.br/ and in the Time Series Management System of the Central Bank of Brazil (BCB) at https://www3.bcb.gov.br/sgspub/.

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References

Alessandri, P., and Gazzani, A. 2025. "Natural gas and the macroeconomy: not all energy shocks are alike." *Journal of Monetary Economics* 151: 103749. https://doi.org/10.1016/j.jmoneco.2025.103749.

Antolín-Díaz, J., and J. F. Rubio-Ramírez. 2018. "Narrative sign restrictions for SVARs." *American Economic Review* 108 (10): 2802-2829. https://doi.org/10.1257/aer.20161852.

Azad, N. F., and Serletis, P. 2022. "Oil price shocks in major emerging economies." *The Energy Journal* 43(4): 199-214. https://doi.org/10.5547/01956574.43.4.naza.

Baumeister, C., and G., Peersman. 2012. "Time-Varying Effects of Oil Supply Shocks on the U.S. Economy." Working paper, Ghent University.

Baumeister, C., and Peersman, G. 2013. "The role of time-varying price elasticities in accounting for volatility changes in the crude oil market. *Journal of applied econometrics*." 28(7): 1087-1109. https://doi.org/10.1002/jae.2283.

Brandão, L., and Divino, J. A. 2020. "An analysis of the dynamics of the Brazilian electricity sector using Panel VAR." *Revista Econômica do Nordeste* 51(2): 47-64. https://doi.org/10.61673/ren.2020.1086.

Brandão, R., M. T. Tolmasquim, M. Maestrini, A. F. Tavares, N. J. Castro, L. Ozorio, and A. C. Chaves. 2021. "Determinants of the economic performance of Brazilian electricity distributors." *Utilities Policy* 68:101142. https://doi.org/10.1016/j.jup.2020.101142.

Cavaliero, C. K. N., and E. P. Da Silva. 2005. "Electricity generation: regulatory mechanisms to encourage renewable alternative energy sources in Brazil." *Energy policy* 33 (13): 1745-1752. https://doi.org/10.1016/j.enpol.2004.02.012.

De Santis, R. A. 2024. "Supply chain disruption and energy supply shocks: impact on euro area output and prices." ECB Working Paper No 2884. https://doi.org/10.2866/29240.

De Santis, R. A., and T. Tornese. 2023. "Energy supply shocks' nonlinearities on output and prices." ECB Working Paper No 2834. https://doi.org/10.2866/610849.

Ganepola, C. N., M. Shubita, and L. Lee. 2023. "The electric shock: Causes and consequences of electricity prices in the United Kingdom." *Energy Economics* 126:107030. https://doi.org/10.1016/j.eneco.2023.107030.

Herwartz, H., and Plödt, M. 2016. "The macroeconomic effects of oil price shocks: Evidence from a statistical identification approach." *Journal of International Money and Finance* 61: 30-44. https://doi.org/10.1016/j.jimonfin.2015.11.001.

International Energy Agency. 2025. "Electricity Report 2025." Accessed July 10, 2025. https://iea.blob.core.windows.net/assets/0f028d5f-26b1-47ca-ad2a-5ca3103d070a/Electricity2025.pdf.

Ji, Q., Liu, M. L., and Fan, Y. 2015. "Effects of structural oil shocks on output, exchange rate, and inflation in the BRICS countries: A structural vector autoregression approach." *Emerging Markets Finance and Trade* 51 (6): 1129-1140. https://doi.org/10.1080/1540496X.2015.1080505.

Kilian, L. 2009. "Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market." *American Economic Review* 99 (3): 1053-1069. https://doi.org/10.1257/aer.99.3.1053.

Kilian, L., and D. P. Murphy. 2012. "Why agnostic sign restrictions are not enough: understanding the dynamics of oil market VAR models." *Journal of the European Economic Association* 10 (5): 1166-1188. https://doi.org/10.1111/j.1542-4774.2012.01080.x.

Kilian, L. and D. P. Murphy. 2014. "The role of inventories and speculative trading in the global market for crude oil." *Journal of Applied econometrics* 29 (3): 454-478. https://doi.org/10.1002/jae.2322.

Kornelius, A., and J. A. Divino. 2024. "Renewable Energy Shocks and Business Cycle Dynamics with Application to Brazil." Central Bank of Brazil Working Paper Series No 592.

Maciejowska, K. 2014. "Fundamental and speculative shocks, what drives electricity prices?" 2014 11th International Conference on the European Energy Market (EEM), Kraków, Poland, 1-5. IEEE. https://doi.org/10.1109/EEM.2014.6861289.

Resende, M., and V. Cardoso. 2019. "Mapping service quality in electricity distribution: An exploratory study of Brazil." *Utilities Policy* 56: 41-52. https://doi.org/10.1016/j.jup.2018.08.009.

Van de Ven, D. J., and Fouquet, R. 2017. "Historical energy price shocks and their changing effects on the economy." *Energy Economics* 62: 204-216. https://doi.org/10.1016/j.eneco.2016.12.009.

Appendix

A1. Major Events in the Brazilian Electricity Market

Between 1995 and 1998, the Brazilian electricity sector underwent significant restructuring. Laws No. 8,987 and No. 9,047, enacted in 1995, laid the foundation for the transition from a system dominated by state-owned companies to a market-oriented model based on public service concessions. In 1996, the Brazilian Electricity Regulatory Agency (ANEEL) was established to regulate the electricity market. By 1998, legislation was introduced to restructure Eletrobras, the leading state-owned company operating across all segments of the sector, and the National Electric System Operator (ONS) was created to coordinate generation and transmission operations.

In 2001, hydroelectric plants accounted for 83% of installed generation capacity, while other sources accounted for the remaining 17%. At that time, Brazil experienced a severe drought that significantly reduced water levels in the reservoirs. Electricity generation declined by about 21% between May and September 2001. To mitigate the impact, the federal government imposed a rationing of 20% for households and 15% to 25% for firms, depending on the type of economic activity (Cavaliero and Da Silva, 2005). Rationing helped keep tariffs stable during the crisis.

The 2001 water crisis triggered a second reform of the electricity sector between 2002 and 2004, with emphasis on the Programme of Incentives for Alternative Electricity Sources (Proinfa). Announced in April 2002, the programme set quotas for each energy source and offered long-term contracts guaranteed by state-owned companies. However, it did not specify its financial impact or implementation timeline. These details only became clear when the programme was launched in January 2003. Proinfa adopted a feed-in tariff scheme, with costs passed on to final consumers.

The reform also reshaped the contracting environment through a new institutional framework. The market split into two segments: a regulated market, where auctions supply electricity to captive consumers, and a free market, where large consumers negotiate directly with generators. Additionally, two new institutions emerged: the Energy Research Office (EPE), responsible for long-term planning, and the Chamber of Electric Energy Commercialization (CCEE), which manages financial settlements among market participants.

Even after restructuring, the sector still lacked clear criteria for concession renewals. In 2008, the government created a working group to address this issue, which ultimately led to the enactment of Law No. 12,783 in January 2013, which allowed for the early renewal of generation, transmission, and distribution concessions due to expire between 2014 and 2017, extending them for an additional 30 years.

The new policy required the government to compensate companies for unamortised or undepreciated assets in the generation and transmission sectors. In return, company revenues would be limited to covering operational expenditures and regulatory charges (Resende and Cardoso, 2019). As a result of these measures, between January and March 2013, the real electricity tariff fell by approximately 18.5%.

However, the policy had significant flaws. In the generation sector, companies were barred from selling their energy on the market, as it was allocated as a physical guarantee, with hydrological risk shifted entirely onto captive consumers. Consequently, some generation companies rejected the renewal terms and allowed their contracts to expire as originally scheduled (Brandão et al., 2021). In 2015, the non-renewed assets were auctioned to bidders willing to accept the lowest grant bonus, which became an additional charge for captive customers.

In the transmission sector, the new policy reduced the companies' Permitted Annual Revenue (RAP) by 60%. However, the indemnity calculation excluded unamortised assets acquired before 2000. Following strong opposition from transmission companies, these assets were included in the indemnity, with the costs gradually passed on to tariffs in subsequent years. As a result, the initial tariff reduction was gradually reversed, leading to a sharp increase to cover the high costs imposed on the generation and transmission sectors.

A2. IRFs with monthly GDP indicator

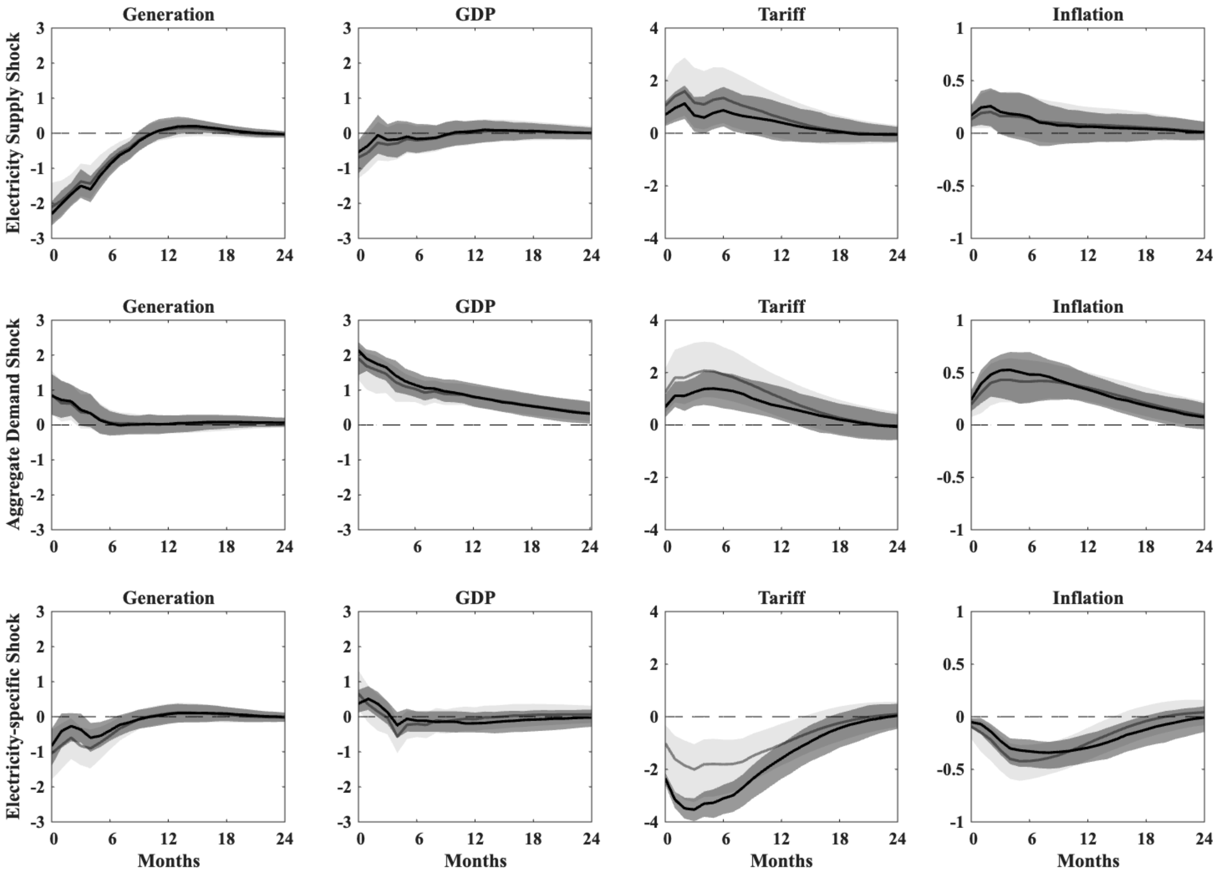

Figure 4. IRFs with and without narrative restriction.

Note: The light grey areas represent the 68% posterior credible set that satisfy the sign restrictions only. The dark grey areas correspond to the set that additionally satisfy the narrative restriction.