Privatizing Local Refining Monopolies*

Leonardo C. B. Cardoso†
Pietro M. B. Figueiredo ‡

May 12, 2024

Abstract

In 2020, Petrobras held more than 98% of Brazil's total refining capacity. One of the reforms promoting competition in this market involved Petrobras' divestment. We assess the impacts of this policy by focusing on the privatization of two refining plants: Refinaria Landulpho Alves (2021) and Refinaria Isaac Sabbá (2022). Using difference-in-differences research designs, our analysis reveals that consumers in the states of Bahia and Amazonas, who were most directly affected by the privatization, experienced significant increases in end-user fuel prices compared to the rest of the country. On average, gasoline prices were overpriced by 0.29 BRL per liter, diesel prices by 0.14 BRL per liter, and ethanol prices by 0.21 BRL per liter. Furthermore, by estimating demand curves and conducting back-of-the-envelope calculations, we quantify the welfare impact of privatization sales. From January 2021 to October 2023, consumers in Amazonas and Bahia experienced a welfare loss of 2.6 billion BRL. These outcomes are attributed to the initial positioning of refineries as local monopolies within an integrated national system, subsequently privatized as if they were competitive firms.

Keywords: Privatization, refining market, welfare, event study, fuel prices.
JEL Codes: R40, L12, L33.

*We are grateful to Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for funding this research. We also thank Rosangela Aparecida Soares Fernandes and Cleiton Silva de Jesus for their valuable comments. Any remaining errors are our own.

†Departamento de Economia Rural, Programa de Pós-Graduação em Economia Aplicada (PPGEA), Universidade Federal de Viçosa (UFV). Corresponding author at leonardocardoso@ufv.br.

‡PPGEA, UFV, pietro.figueiredo@ufv.br.

1 Introduction

In Brazil, the oil refining market has long been dominated by a monopoly held by Petrobras. Before 1997, the company had exclusive rights to oil exploration and refining in the country. After 1997, when private companies were permitted to enter the market, they displayed limited interest. Besides competing with a well-established monopoly posed inherent challenges, Petrobras' pricing strategy occasionally aligned with political objectives, selling fuel below international market prices, and dissuading the entry of new players. Two recent energy policy reforms have been implemented to promote competition within the refining market in Brazil. First, in October 2016, Petrobras introduced the import parity policy (IPP), ensuring domestic refining prices aligned with international benchmarks. IPP promotes transparent pricing and reduces potential political influences on Petrobras' pricing decisions. It would indirectly increase the probability of new players in the refining market (Petrobras, 2016, 2023). Secondly, in a more direct approach, Petrobras signed an agreement with the Brazilian Competition Authority, the Administrative Council for Economic Defense (CADE), to address a complaint of abuse of economic power and committed to divesting half of its refining market share by selling eight refineries as part of the agreement (CADE, 2019).

This study investigates the welfare implications of the second approach – a divestment plan in the refining sector in Brazil. Our specific focus lies on the welfare impacts arising from the privatization of the initial two refining facilities within this divestment plan: Refinaria Landulpho Alves (RLAM), privatized in late 2021, and Refinaria Isaac Sabbá (REMAN), privatized in late 2022. RLAM, the country's second-largest refinery, commanded a 12% share of the total refining market in 2022, the most significant privatization in Brazil's refining sector to date. It is located in the state of Bahia, the biggest state in the Northeast region of Brazil. The second privitized plant, REMAN, is located in the state of Amazonas and contributes 1.7% to the refining market. REMAN is the sole refinery in the entire North region of Brazil[1](ANP, 2023).

Our analytical framework has two parts. Firstly, we quantify the price shifts resulting from privatization, employing event study designs and difference-in-differences models. We compare end-user prices of gas stations located in Bahia and Amazonas (the treated group) with those in other regions across Brazil (the control group) to establish the causal effects of those privatization sales on pump prices. Our preferred analysis excluded the other states in the Northeast and North due to the potential spillovers of privatization on these markets. In the second phase, we measure the welfare implications of privatization-induced price shifts. Consequently, we estimate the gasoline, diesel, and

[1]Brazil is geographically divided into 27 states and 5 regions: North, Northeast, Midwest, Southeast, and South.

ethanol fuel demand in these two states using city-month panel data. It allows us to examine the consumption impact of price fluctuations caused by privatization. Finally, we used some back-of-the-envelope calculations to quantify the welfare effects stemming from the privatization of RLAM and REMAN on these three markets (gasoline, diesel, and ethanol)[2].

The primary motive behind privatization is the belief that private firms will outperform their state-owned counterparts (Brada, 1996; Megginson & Netter, 2001). Introducing competition and effective regulation is believed to yield welfare gains, particularly in improving the quality, availability, and affordability of goods and services. The shift towards profit maximization is expected to be offset by production efficiencies, thus avoiding any deadweight losses (Bradburd, 1995). Therefore, discussion surrounding privatization focuses on identifying the necessary conditions to achieve these desired outcomes – *i.e.*, how it can be properly designed and implemented to benefit society at large (Estache et al., 2001). Among these conditions, the first is a deep knowledge of market structure.

In this regard, the privatization of RLAM and REMAN offers a compelling case for studying privatizations of local oil refining monopolies. The Brazilian refining market was initially structured as a monopoly, with each geographical area being served by a single refinery, all of which was owned by Petrobras. Like most of the refineries in Brazil, RLAM and REMAN are local monopolies. The closest RLAM rival is located more than 805 kilometers away (500 miles), and the closest REMAN rival is located more than 2000 kilometers away (more than 1200 miles) (see the map in Figure 1, in the next section). The initial intuition is that these privatizations should have followed a regulatory framework closely aligned with the privatization of natural monopoly public enterprises and monopolistic industries (Bradburd, 1995; Bortolotti & Siniscalco, 2004), but that was not the case. Several features make our setting ideal for asserting a causal effect of privatizing local refining monopolies. First, we conduct surveys of gas station prices before and after privatization. Second, neither consumers nor gas station owners influence the privatization process; it is solely a government decision. Third, despite widespread dissemination of news regarding privatization, consumers cannot store fuel in anticipation of higher prices or hedge against fuel price fluctuations if they expect future lower prices.

Contrary to the intuition that privatization would lead to better prices, the findings from a difference-in-differences (DiD) design from Gardner et al. (2023) revealed that consumers in Bahia and Amazonas are worse off following the privatization. When comparing the end-user prices of gas stations most exposed to privatization with the rest of

[2]Our scope is the liquid fuel market (gasoline, diesel, and ethanol fuels). However, it is possible to do a similar research design evaluating the effects on the liquefied petroleum gas (LPG) market or other energy goods.

Brazil (excluding the North and Northeast region), the average overpricing amounts to 27 cents, 14 cents, and 21 cents of Brazilian real per liter in the gasoline, diesel, and ethanol markets, respectively. Including all states in the analysis, the overpricing shows a marginal difference, with prices 4 cents lower in the gasoline market, 3 cents in the ethanol market, and 2 cents in the diesel market. Utilizing a dynamic DiD proposed by Wooldridge (2021), we found an absence of a trend toward a zero effect of overpricing. It indicates a lasting impact from both privatization sales. To provide a sense of the economic importance of the overpricing caused by this policy, back-of-the-envelope calculations showed that consumers in Bahia and Amazonas incurred a welfare loss exceeding 2.6 billion BRL from January 2022 to October 2023.

If we were to inquire with oil workers' unions about the fairness of the sale prices of Petrobras' refineries and whether prices have decreased following privatization sales, their response is no on both accounts. Conversely, if we were to pose the same questions to policymakers involved in the process, the answer would likely be the opposite. Thus, the primary contribution of this study lies in its provision of meaningful and in-depth data analysis to inform this debate. In doing so, we undertake the first empirical examination of the causal effect of privatizing Brazil's refineries, part of the broader plan to privatize the nation's oil refinery market. Given the ongoing privatization plan, our paper is a warning flag pointing out that not all privatization benefits consumers and that we need to rethink how privatization can be better designed to enhance overall welfare within Brazil's fuel market. We also contribute by estimating the fuel demand in those two states using a city-month database to accurately estimate the demand reduction resulting from overpricing. It allows our welfare analysis to go beyond a simple multiplication of overpricing by the quantity of fuel sold in Bahia and Amazonas, providing a better understanding of those privatization effects.

Our paper contributes to the literature on political economy by investigating the economic impacts of transitioning the provision of goods from a state-owned company to a private entity (Vickers & Yarrow, 1991; Spulber & Sabbaghi, 2012; Viscusi et al., 2018). Specifically, within the oil market context, Laguna (2004) presents a successful case of privatization in the petrochemical sector in Mexico. Similarly, Wolf (2009) compares the economic performance of state-owned and national oil companies worldwide, concluding in favor of private companies. In the Brazilian energy sector, Muller & Rego (2021) and Silvestre et al. (2010) analyze the privatization of electricity distribution, providing evidence that privatization led to improved financial indicators for the companies without negatively affecting quality or prices for consumers. Moreover, in the Brazilian market, Arnold (2022) found that the sequential privatization of public enterprises, which the country underwent, resulted in lower wages for workers from privatized enterprises. Regarding the environmental repercussions of privatization, Meyer & Pac (2013) suggests

that privatized energy utilities in Eastern Europe exhibit lower emission levels. There is limited microevidence on how privatization affects price changes. Much of the existing literature exploring the effects of privatization on the refining market relies on empirical setups characterized by simultaneous sales of numerous privatization instances or the complete privatization of the entire sector in a single event. In our study, we leverage a distinctive quasi-experiment, wherein privatization plans unfold at different times while the remainder of the refining market remains unchanged.

This paper is organized as follows. Section 2 provides an overview of Brazil's refining market and details the privatizations of RLAM and REMAN. Section 3 delves into the price effects of privatization. In Section 4, we estimate the demands for gasoline, diesel, and ethanol, specifically in Bahia and Amazonas, and leverage the findings from the previous sections to conduct a welfare analysis. Finally, Section 5 concludes the paper and provides some policy implications based on our results.

2 Background

The oil refining market in Brazil traces its roots back to the 1930s when small refineries emerged. Two decades later, in 1953, Petrobras' creation established the oil monopoly in Brazil. Mendes et al. (2018) point out that a pivotal moment in the history of the Brazilian refining market was the inauguration of the first major refinery, originally called Refinaria Mataripe, which was later renamed the Landulpho Alves-Mataripe Refinery (RLAM)[3].

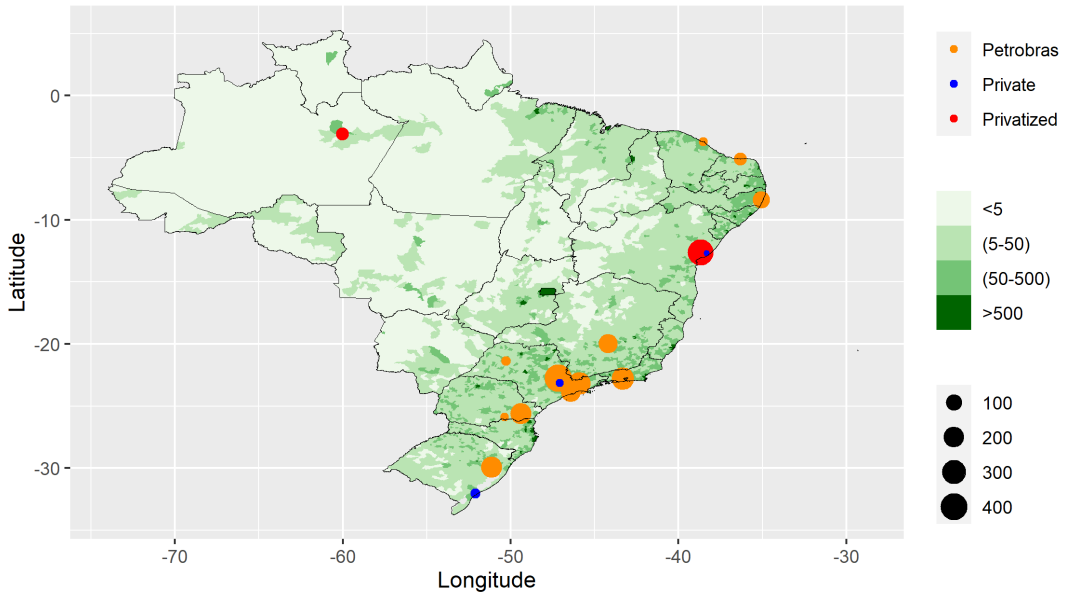
Petrobras operates as a mixed economy company, balancing the interests of its shareholders and the Brazilian government. Responding to market forces as a publicly traded company while being influenced by public policies and price support initiatives. Until 1997, the company held a legal monopoly in the Brazilian oil refining market, and the most significant investments in refineries took place from 1953 to 1997. Since the end of the legal monopoly, Petrobras has maintained its dominant position in the market and has been responsible for most investments in the refining sector. As of 2020, Petrobras held an impressive 98.6% of Brazil's total refining capacity (ANP, 2021). According to Bridgman et al. (2011), the dominant position of Petrobras does not necessarily imply inefficiency. The threat of competition after the end of the legal monopoly would spurred Petrobras to improve its efficiency, leading to a doubling of efficiency within a six-year period.

Given the high market concentration observed in the refinery market, common policy

[3]For a comprehensive review of the historical path of the oil refining market in Brazil, please refer to the works of Mendes et al. (2018) and CADE (2022*b*).

recommendations were attempts to reduce it. We have examples of those in news articles (Ordonez & Rosa, 2018), research papers (Rojas & Leite, 2018; Cabral, 2020), and government reports (CNPE, 2019; MME, 2017). In fact, if we were to provide recommendations to improve the energy sector in Brazil, increasing the number of players in refining would undoubtedly be one of those. Nevertheless, a vital aspect is understanding how to increase players without creating local monopolies in this transference of refinery ownership from the state to the private sector. Local monopolies would emerge because the Brazilian refining market was initially structured as a monopoly – "construction was optimized to maximize production scale economies and minimize distribution scale diseconomies" (Tavares et al., 2006, p.3030). The concern about privatization leading to the emergence of local monopolies is especially true in the North and Northeast regions. See Figure 1 to visualize how refineries were distributed in Brazil in 2021 and the country's population density.

Figure 1: Refining Capacity and Population Density in Brazil (2022)



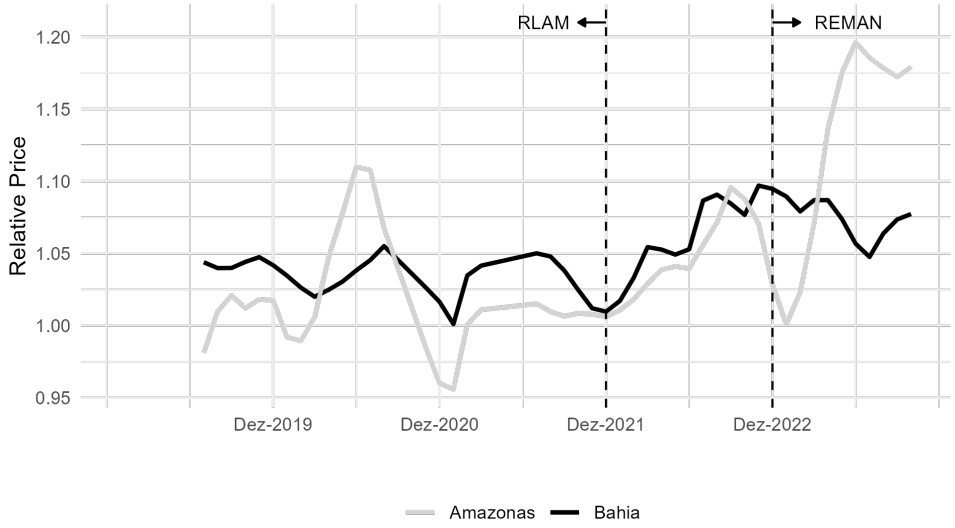
Source: Authors with data from ANP (2023) for refineries and IBGE (2023*a*) for population density. Notes: The sizes of the circles represent the refining capacity in thousands of barrels per day for each refinery. The red color corresponds to the Refinaria de Mataripe (formerly RLAM), which was acquired in 2021 by the Emirati group Mabudala Capital, and Refinaria Isaac Sabbá (REMAN), acquired in 2022 by Atem group. The blue color represents privately operated refineries, while the orange represents refineries owned by Petrobras. The intensity of green represents the population density by city in 2022 (people per square kilometer).

In this context, two important reforms have been implemented to reduce Petrobras's dominance in the refining sector and foster competition. One was introducing the import parity policy (IPP) in October 2016. This policy aimed to convey potential competitors that Petrobras would no longer engage in politically motivated pricing practices, aligning its fuel prices with international market prices, promising "prices never lower than international benchmarks" (Rojas & Leite, 2018, p.26). It would indirectly encourage

competition by increasing the probability of new players entered in the market. IPP ended in May 2023 (Petrobras, 2016, 2023).

The second policy implemented to address the concentration of power in the refining market was the agreement between Petrobras and CADE[4], signed in June 2019. This agreement would divest half of Petrobras' refining market share, including selling 8 of the company's 13 refineries. The agreement resulted from an inquiry initiated in August 2017 to investigate allegations of market power abuse within the refining sector. In July 2021, CADE approved the first sale[5], the acquisition of Refinaria Landulpho Alves (RLAM) by the Emirati group Mubadala Capital (CADE, 2022*a*). In December 2021, operational control of RLAM transitioned to the Mumbala Group. Concerning the REMAN sale, the contract for the refinery's sale was signed in August 2021, and by December 2022, the Atem Group assumed operational control of the refining plant.

Figure 2: Relative Price of Gasoline in Bahia and Amazonas Pre and Post-Privatization



Source: Data from ANP (2023). Notes: The graph illustrates a relative price comparison calculated by dividing the average monthly prices in Bahia or Amazonas (treated cohorts) by the average price of the control group. The solid black line represents the average relative prices in Bahia, while the gray solid line represents the average relative prices in Amazonas. The vertical dashed lines mark the timing of privatization for RLAM and REMAN.

RLAM holds a significant share of the national market, accounting for 12% of the total. RLAM is the dominant player in Bahia, with no comparable competitors. Although there is another refinery called Dax Oil in Bahia, its refining capacity is significantly smaller, representing only 0.5% of RLAM's capacity. RLAM's influence extends beyond Bahia,

[4]CADE refers to the "Conselho Administrativo de Defesa Econômica". It serves as the antitrust authority, tasked with ensuring fair competition, preventing monopolistic practices, and safeguarding consumer welfare in economic activities.

[5]How a power abuse investigation ended on an agreement to sell refining plans is comprehensively reviewed in Griebeler da Motta & Pastore (2022).

as it is a major player in the Northeast region. The combined refining capacity of the other two refineries in the Northeast, Lubnor, and Rnest, amounts to only one-third of RLAM's capacity (ANP, 2022).

REMAN is the sole refinery in the North region, with no competitors within a radius exceeding 2000 kilometers. Given that only 8% of Brazil's population resides in the North region, the relatively lower population primarily influences the decision to have only one refinery. Despite REMAN's modest market share of 1.7%, it plays a vital role as the most significant player for the North region due to the regional monopoly. The North and Northeast regions are among the least affluent in Brazil. In 2022, they accounted for approximately 62% and 63% of the country's per capita income, as reported by IBGE (2023*b*). Therefore, the price impacts of these privatization sales affect Brazil's poorest regions.

Opponents of privatization would predict higher end-user prices, while proponents would expect lower prices. Therefore, thoroughly examining the data is necessary, and Figure 2 offers valuable insights. Following the privatization of RLAM and REMAN, relative prices in Bahia and Amazonas increased compared to the control group. Before privatization, prices in Bahia were 3% higher than those of the control group. However, relative prices surged to 7% above the control group post-privatization. In Amazonas, the impact was even more pronounced, with relative prices initially 2% higher than the control group, escalating to a substantial 14% higher after privatization[6].

While eyeballing the relative prices is an interesting initial approach to assessing the potential impact of RLAM and REMAN privatization sales, it is important to ensure that any observed differences are not simply due to chance. Notably, during our study period, there was a change in state tax just before the presidential election in late June 2022, which remained in effect until the end of our sample in October 2023. This state tax change varied across states. So, in the next section, to address these potential confounding factors, we employ a difference-in-differences model to measure the effect of privatization sales on prices accurately.

3 Price Effects of Privatization

To measure the price effects of privatization, we employed a commonly used quasi-experimental identification strategy, difference-in-differences (DiD) research designs. It serves as valuable alternative to randomized controlled trials (RCTs) in cases like the privatization of RLAM and REMAN, where RCTs may not be feasible (Cunningham,

[6]One might be interested in examining a canonical DiD graph that compares outcomes pre and post-treatment in the Appendix, specifically in the section on Parallel Trends.

2021). By leveraging natural variations and exogenous shocks, the DiD allows us to analyze the causal impact of privatization sales. Assuming that fuel consumers or gas station owners did not influence the privatization sale process, which is a reasonable assumption, we can consider the privatization as a quasi-experimental setting.

We present our results in two parts. The first subsection includes the baseline specification, where we assess the average treatment effect of privatization using the Two-stage DiD method from Gardner et al. (2023). In the second subsection, we leverage time and cohort heterogeneity using the two-way Mundlak (TWM) approach, following Wooldridge (2021).

3.1 Baseline Specification

The difference-in-differences method relies on the assumption of an exogenous shock, where the treatment group experiences the intervention (privatization) while the control group does not. By comparing the changes in outcomes between these groups before and after the intervention, researchers can estimate the causal effect of the intervention. The mathematical expression representing it is defined by Equation 1.

$$P_{it}^{f} = \alpha + \beta_{Priv} T_{it} + \gamma X_{it}^{'} + \delta_i + \theta_t + \varepsilon_{it} \tag{1}$$

In the equation, P_{it}^{f} represents the price of fuel f (gasoline, diesel, or ethanol) in nominal terms at gas station i during time t. The variable T_{it} acts as the treatment indicator, indicating whether the policy is in effect. Consequently, T_{it} takes a value of 1 if the gas station is located in Bahia and time t is post-privatization of RLAM, or if the gas station is in Amazonas and time t is post-privatization of REMAN. In all other cases, T_{it} equals 0.

$X'it$ is a matrix incorporating control variables, including the brand of each gas station and a dummy variable indicating whether the gas station is situated in the state capital. δ_i and θt denote specific gas station and time effects, respectively. To clarify what we are estimating, β_{Priv} signifies the estimated average treatment effect, quantifying the privatization's average price impact per liter of fuel on consumers in Bahia and Amazonas, measured in BRL. We performed three estimations of Equation 1, one for each fuel type (gasoline, ethanol, and diesel).

On 23 June 2022, four months before the presidential election in Brazil, the incumbent president decided to reduce state taxes considerably. However, this reduction was not uniform across all states, making it challenging to fully account for it using time-fixed effects alone. To address this issue, we used an additional control variable that assumes

a value of one for the period preceding the tax variation and one minus the tax reduction after June 2022. We utilized the logarithm of this variable in our analysis.

Data used in this subsection comes from the *Sistema de Levantamento de Preços* of the *Agência Nacional do Petróleo, Gás Natural e Biocombustíveis* (ANP, 2023). The survey is released every week, and each observation has the social name of the gas station, CNPJ[7], full address (state, municipality, street, number, and zip code), gasoline, diesel, and ethanol end-user prices and gas station brand[8]. Data goes from Jan-2019 to Oct-2023. We transformed this database into monthly price observations.

In summary, our dataset includes:

- Fuel prices and other variables at the gas station level spanning from January 2019 to October 2023;
- Treatment has been applied to two states among the 27 states in Brazil. The first cohort consists of gas stations in the State of Bahia, treated in December 2021, while the second cohort comprises gas stations in the State of Amazonas, treated in December 2022;
- There is no reversibility; once gas stations in Bahia and Amazonas have undergone treatment, they remain subject to this condition until October 2023;
- In our preferred specification, we omitted gas stations from the North and Northeast regions to account for potential spillover effects from the treatment to these areas;
- Gas stations or consumers hold no influence over privatization sales.

We employed the Two-Stage DiD method from Gardner et al. (2023) due to the staggered adoption of our treatment at different times across cohorts. Hence, we estimated Equation 1 in two stages. In the first stage, P_{it}^f is estimated against the time and gas station fixed effects. In the second stage, the residual, or the adjusted outcome $(P_{it}^f - \hat{\delta}_i - \hat{\theta}t)$ is used in regression[9].

Before delving into the results, there is a consideration related to the parallel trends assumption. We opted for estimators that require a more flexible assumption, where parallel trends are conditioned on observed covariates (Roth et al., 2023). Detailed tests and information regarding parallel trends, along with summary statistics, are available

[7]CNPJ is the Brazilian acronym for "Cadastro Nacional da Pessoa Jurídica" or the National Register of Legal Entities, a unique identification number assigned by the Brazilian Federal Revenue Service to businesses for tax and regulatory purposes.

[8]In this subsection, we used data obtained from `basedosdados.org` that compiled database from ANP (2023).

[9]For more details, see Gardner et al. (2023).

in the Appendix. In sum, there are no pre-trends in the three markets (gasoline, diesel, and ethanol). Control and treated groups exhibit symmetrical trajectories before the occurrence of privatization sales (refer to Figures 5, 6, and 7 in the Appendix).

Baseline Specification Results

Privatizing RLAM and REMAN led to a relative price increase in all three markets examined. On average, there was an overprice of 27 cents in the gasoline market, 14 cents in the diesel market, and 21 cents in the ethanol market (all values in Brazilian Real) (see Panel A in Table 1). To better understand the results, average prices in Brazil before the first privatization were 6.44 BRL for gasoline, 6.40 BRL for diesel, and 5.44 BRL for ethanol. Consequently, the overprice percentages for gasoline, diesel, and ethanol were 4.5%, 2.3%, and 3.8%, respectively.

Table 1: Impact of RLAM and REMAN Privatization on Fuel Prices

	Panel A			*Panel B*		
	Gasoline	Diesel	Ethanol	Gasoline	Diesel	Ethanol
Treated	0.272***	0.138***	0.214***	0.234***	0.125***	0.182***
	(0.029)	(0.018)	(0.027)	(0.028)	(0.019)	(0.026)
Num.Obs.	684,570	357,217	620,993	870,923	435,223	759,650
Std.Errors	by: city	by: city	by: city	by: city	by: city	by: city
FE: city	✓	✓	✓	✓	✓	✓
FE: time	✓	✓	✓	✓	✓	✓
Gasoline tax as control	✓	×	✓	✓	×	✓
Control group (all states)	×	×	×	✓	✓	✓

Notes: Panel A presents results with North and Northeast states excluded from the control group, whereas Panel B displays results including those states. Both panels used the Two-stage Differences in Differences (DID) method from Gardner et al. (2023). Robust standard errors are in parentheses, adjusted for clustering by city. The symbols *, **, and *** denote rejections of the null hypothesis at significance levels of 10%, 5%, and 1%, respectively. We used prices in level, so the variable *Treated* represents the marginal effect of privatization on prices. We excluded capital fixed effects from our analysis as city fixed effects fully capture them. The control for gasoline tax variation is represented by the logarithm of one minus the tax variation.

We expanded the control group to include all states in our robustness checks (Panel B in Table 1). This alternative specification resulted in a marginal decrease of 4 cents in overpricing effects within the gasoline market, shifting from 27 to 23 cents. The outcomes in the ethanol and diesel markets showed minimal deviation, exhibiting a downward trend, with a decrease of 2 cents in the diesel market (from 14 to 12 cents) and 3 cents in the ethanol market (from 21 to 18 cents). In sum, including all states in the control group reported lower effects, highlighting the influence of RLAM and REMAN not only in Bahia and Amazonas, the most affected states, but also in the neighboring regions of the

Northeast and North.

3.2 Exploiting Heterogeneity of Privatization Effects Across Time and Cohorts

We applied the two-way Mundlak (TWM) regression method proposed by Wooldridge (2021) to examine the dynamic impact of RLAM and REMAN privatization sales on prices individually. This ordinary least squares (OLS) estimator is designed to handle staggered entry by integrating unit-specific and time-specific cross-sectional averages into Equation 1, resulting in Equation 2.

$$P_{it}^{f} = \alpha + \sum_{t}\sum_{i} \beta_{it} \cdot T_{it} \cdot t \cdot i + \gamma X_{it}^{'} + \delta_i + \theta_t + \varepsilon_{it} \tag{2}$$

Now, it becomes feasible to distinguish the varied effects of the treatment across time and between our two treated cohorts. The other variables remain consistent with the explanations provided in Equation 1.

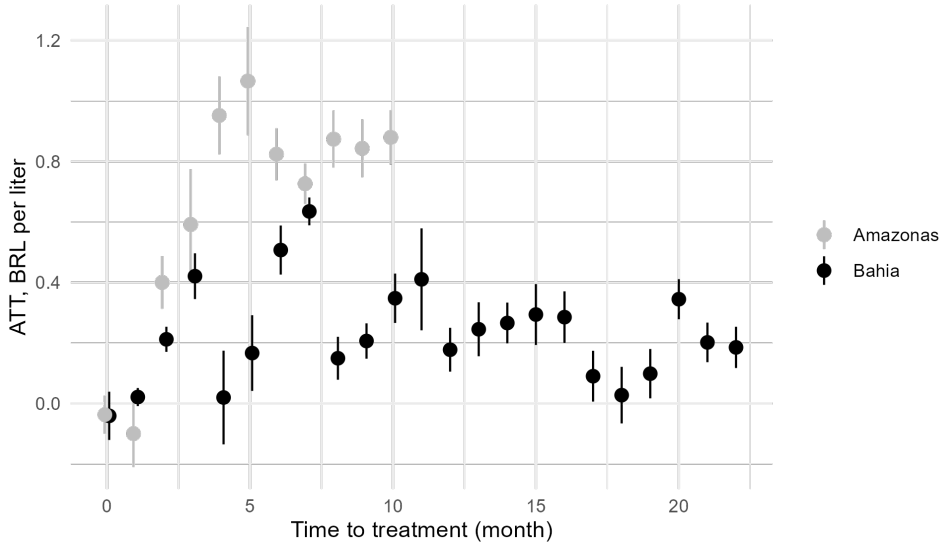
Exploiting Heterogeneity of Privatization Effects Across Time and Cohorts Results

In the gasoline market, seven months after RLAM privatization, consumers in Bahia encountered overpricing exceeding 50 cents per liter of gasoline. The overpricing confronted by consumers in Amazonas is even more pronounced, reaching values close to 1 BRL after five months of REMAN privatization (refer to Figure 3).

The diesel and ethanol markets exhibited closely aligned overpricing impacts between the two treated cohorts (see Figures 8 and 9 in the Appendix), with comparable effects faced by consumers in Bahia and Amazonas. Both markets experienced overpricing of approximately 50 cents five months after the privatization of their main oil refining.

Across the three examined markets and for both treated cohorts. In the last months of treatment observed, trajectories showing no tendency toward zero effects (see Figures 3, 9, and 8). The overpricing resulting from privatization sales in the refining market in Brazil seems to have a persistent impact.

Figure 3: Gasoline Overpricing Across Time and Cohorts (Wooldridge, 2021)



Notes: The points are the Average Treatment Effect (ATT) of privatization sales for consumers in Bahia and Amazonas over successive months post-privatization. Bars show the confidence intervals at the 95 percent level. We used the Two-Way Mundlak proposed by Wooldridge (2021). Amazonas have fewer observations due to the one-year lag in privatizing their refinery compared to Bahia's refinery.

4 Welfare analysis

Thus far, the analysis has demonstrated persistent overpricing in end-user fuels caused by RLAM and REMAN privatization sales. The absence of any signal indicating a temporary nature of this overpricing is particularly troubling. The next logical step is to gauge the welfare effects resulting from this policy. To assess this, we calculated fuel demand in the affected states, Bahia and Amazonas, and employed some back-of-the-envelope calculations.

4.1 Fuel demand in states of Bahia and Amazonas

Numerous studies have explored fuel demand in Brazil, with a predominant focus on the gasoline and ethanol markets, as seen in works such as De Freitas & Kaneko (2011), Santos (2013), Junior (2013), and Cardoso et al. (2019), among others. However, our contribution lies in scrutinizing the repercussions of price shifts within two specific states. Acknowledging the regional nuances in fuel demand parameters (Cardoso & Bittencourt, 2013), we conducted estimations to assess demand patterns specifically for Bahia and Amazonas. All the cited papers relied on more aggregated databases, encompassing either country-level or state-level observations. In contrast, our study benefited from a more granular dataset, providing city-level information every month.

There is a well-known simultaneity between price and quantity demanded. To address this issue, we used Two-Stage Least Squares (2SLS) to measure the fuel demand in Bahia and Amazonas municipalities. The first and second stages are given by:

$$First \quad Stage: \quad P_{it}^{f} = \theta + \phi Z_{it}^{f} + \eta Inc_{it} + \kappa_t + \omega_i + \upsilon_{it} \tag{3}$$

$$Second \quad Stage: \quad Q_{it}^{f} = \alpha + \hat{P_{it}^{f}} + \beta P_{it}^{a} + \gamma Inc_{it} + \lambda_t + \mu_i + \varepsilon_{it} \tag{4}$$

In the Equation 4, variables are defined as follows:

- Q_{it}^{f} represents the logarithm of the quantity in liters of fuel f (gasoline, diesel, or ethanol) sold in municipality i and period t;
- P_{it}^{f} represents the logarithm of the price of fuel f:
- $\hat{P_{it}^{a}}$ represents the price of the substitute fuel. For gasoline, ethanol is considered as the substitute, while for ethanol, gasoline is the substitute. There is no substitutability for diesel;
- The instrumental variables Z_{it}^{f} are derived from the Hausman Instrument approach, which utilizes contemporaneous prices of the same fuel in different geographic markets (Berry & Haile, 2021). Additionally, we incorporate international prices of oil for gasoline and diesel markets, and sugar prices for ethanol prices. To account for time and city variation, we multiply the international prices by the distance to the closest refinery;
- Inc_{it} represents the municipal income;
- t and i are fixed effects for time and municipality, respectively;
- ε_{it} and υ_{it} represent the idiosyncratic errors.

The demand estimation is based on a city-month database. Regarding the Hausman Instruments used, when referring to *other geographic markets*, we are specifically considering other regions within Brazil. For instance, when estimating diesel prices for a city in the North region, the instrumental variables consist of diesel prices from the other four regions in Brazil. As said, we also used international oil prices multiplied by the distance between the city and the nearest refinery. In the analysis of gasoline demand, we accounted for the endogeneity of both gasoline and ethanol prices. However, in the estimation of diesel and ethanol demand, only own-prices were treated as endogenous.

The findings, presented in Table 2, reveal that diesel demonstrates an own-price elasticity of approximately -0.5, while gasoline exhibits a price elasticity of -0.7. The cross-elasticities align with expectations, indicating positive effects on demand, with values of

0.3 for the gasoline market and 8.4 for the ethanol market. A noteworthy deviation from existing literature on fuel demand in Brazil is observed in the estimates for the ethanol market, where values are higher. This discrepancy can be attributed to the possibility that Bahia and Amazonas may not be significant ethanol consumers. Consequently, even minor price increases could lead to substantial reductions in consumption.

The diesel market exhibits an own-elasticity of approximately -0.5, and no cross-elasticity is calculated. In Brazil, there is a legal separation between gasoline and ethanol, which are used for cars and motorcycles, while diesel is designated exclusively for heavy-duty vehicles such as buses and trucks. Therefore, given the type of vehicle, there is no direct substitute for diesel.

Table 2: Fuel Demand in Bahia and Amazonas: city-month, TWFE

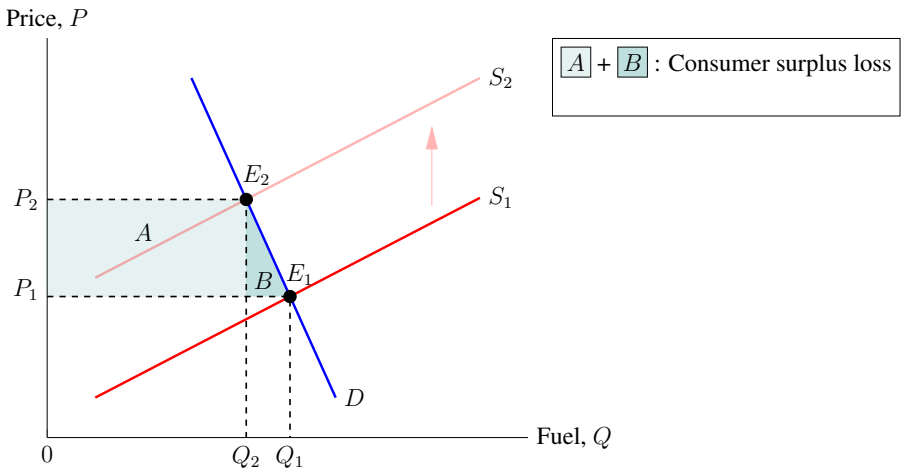
	Gasoline	Diesel	Ethanol
Gasoline price (log)	−0.719**		8.392***
	(0.282)		(1.313)
Ethanol price (log)	0.316		−8.651***
	(0.287)		(1.344)
Diesel price (log)		−0.535***	
		(0.074)	
Income proxy (log)	0.515***	0.475***	0.830***
	(0.007)	(0.010)	(0.035)
Num.Obs.	3,588	3,835	3,588
R2	0.590	0.376	0.180
Instruments			
Gasoline prices (neighbors, log)	✓		
Diesel prices (neighbors, log)		✓	
Ethanol prices (neighbors, log)	✓		✓
Distance to the closest refinery (level)	✓	✓	
Global oil price (level)	✓	✓	
Global sugar price (level)	✓		✓
Endogenous prices	gasoline and ethanol	diesel	ethanol

Notes: Standard errors are in parentheses. The symbols *, **, and *** denote rejections of the null hypothesis at significance levels of 10%, 5%, and 1%, respectively. The model is specified in a log-log form, with the estimated parameters representing elasticities.

4.2 Welfare Effects in Bahia and Amazonas

A common welfare measure is the assessment of changes in consumer surplus (Hausman & Newey, 1995; Dargay & Goodwin, 1995). Figure 4 illustrates the supply shift after the

Figure 4: Consumer surplus loss



Notes: This figure has been created based on the code provided by Bandekar (2021). The S denotes the supply curve, while D represents the demand curve. The subscripts 1 and 2 indicate the pre and post-privatization scenarios, respectively. The E represents the equilibrium points. The vertical axis represents prices, and the horizontal axis represents quantities.

privatization sales where the variation in consumer surplus is given by:

$$\Delta CS = A + B \tag{5}$$

$$\Delta CS = (\Delta P.Q_2) + (\frac{\Delta P.\Delta Q}{2}) \tag{6}$$

The change in consumer surplus (ΔCS) captures the overall welfare impact for a specific market. Thus, we repeated this calculation for the three markets targeted here (gasoline, diesel, and ethanol) and for the two privatization sales (REMAN and RLAM). ΔP denotes the difference in fuel prices caused by each privatization sale in each fuel market. The quantity of fuel sold after each privatization is denoted by Q_2, and the change in quantity sold is ΔQ. This change in quantity is estimated using demand parameters and the time and cohort-specific price effects.

Table 3 illustrates a substantial decrease in welfare, totaling approximately 2.6 billion BRL for consumers in Bahia and Amazonas. The welfare impact in Bahia's market is almost 2 billion BRL, while it amounts to 0.6 billion BRL in Amazonas. Despite encountering similar overpricing in both markets, the significant difference is attributed to Bahia being a larger market and the first cohort treated. The post-treatment period in Bahia spans 22 months, whereas it covers only 10 months in Amazonas.

The gasoline and diesel markets collectively account for 93% of the observed welfare loss among the three markets, with approximately 1.4 billion BRL for gasoline and 1 billion BRL for diesel. While overpricing in the ethanol market is noticeable, the lower

Table 3: Welfare Variation by Fuel Following Privatization Sales (in millions of BRL)

	RLAM – Bahia			*REMAN – Amazonas*			Total
	Gasoline	Diesel	Ethanol	Gasoline	Diesel	Ethanol	
Area A	1.009	816	110	378	221	41	2,575
Area B	13	16	27	13	3	3	75
A + B	1.022	832	137	391	224	44	2,650

Notes: The period of 22 months after RLAM privatization goes from January 2022 to October 2023. The period of 10 months after REMAN privatization goes from January 2023 to October 2023. Area A is the direct impact of privatization, $\Delta Price * Q_2$, while area B is the indirect impact, $\Delta Consumption * \Delta Price$, as defined in Figure 4.

levels of ethanol consumption in Bahia and Amazonas contribute to its comparatively smaller impact on the overall welfare loss.

The direct impact of overpricing, the value found by the amount of fuel sold multiplied by the overpricing, is 97% of the total effect. The indirect impact caused by changes in consumption by demand is only 3% of the total impact.

5 Conclusion and Policy Implications

In this paper, we examined the impact of the privatization of the Refinaria Landulpho Alves (RLAM) and Refinaria Isaac Sabbá (REMAN). We focused on end-user fuel prices, comparing prices in the gas stations of the two most affected states, Bahia (RLAM) and Amazonas (REMAN), to the rest of the country in a DiD approach. We also estimated fuel demands in Bahia and Amazonas and conducted a welfare analysis. Contrary to the belief that privatization always leads to lower prices, our findings show that consumers in most affected states experienced significant increases in end-user fuel prices following privatization sales. On average, gasoline prices were overpriced by 0.29 BRL per liter, diesel prices by 0.14 BRL per liter, and ethanol prices by 0.21 BRL per liter. It resulted in a welfare loss of 2.6 billion BRL for consumers in Bahia and Amazonas from January 2021 to October 2023. The diesel and gasoline markets primarily drove the decline in welfare.

We conducted initial robustness checks on our price impact estimations, altering the control group from excluding the North and Northeast gas stations to including all gas stations in the country. This adjustment led to minimal deviations, as detailed in Table 1. Additionally, we compared our chosen approach, inspired by Gardner et al. (2023) and Wooldridge (2021), with alternative estimators. For instance, our preferred method revealed a 27-cent overpricing in the gasoline market. Replicating the exact estimates using a two-way fixed-effects estimator resulted in a 28-cent overpricing, while employing the Callaway & Sant'Anna (2021) estimator yielded 23 cents of overpricing. Despite marginal differences across various estimators, the overarching narrative remains consistent.

We assert that the privatization sales have increased prices in Bahia and Amazonas due to a lack of regulation. The sale of refining plants treated them as competitive entities, but they are integral components of a national monopoly. Without additional stringent regulations, privatization sales have resulted in the formation of local monopolies. Given that the privatization of these two firms is part of a larger plan involving eight plants, *the most crucial policy recommendation* is straightforward: either halt or reconsider the entire privatization initiative in the Brazilian refining market. As privatization can take several forms, the Brazilian government needs to think of new approaches because the used ones do not work.

Our findings provide a conservative estimate of the welfare loss resulting from those privatization sales for several reasons. First, we are not considering all products sold by the two privatized refining plants. They also sell liquefied petroleum gas, naphtha, and aviation kerosene. Hence, the welfare loss could be more significant if they also practice similar pricing policies in those markets. Second, there is a possible impact on

neighboring markets, with higher end-user prices affecting consumers contiguous to the most affected states. Third, higher energy prices indirectly influence various other prices in the economy. Therefore, accounting for this indirect effect would lead to higher welfare losses. Consequently, *our second policy recommendation* advocates expanding the scope of our study to assess the broader impact of privatization sales on the Brazilian economy.

As our focus was on end-user prices, we cannot guarantee that the new owners of RLAM and REMAN absorbed the entire consumer welfare loss. It is possible, for example, that Petrobras was charging subsidized prices in those states, and current prices only reflect the end of those subsidies. What we can assert is that consumers in Bahia and Amazonas experienced a loss of welfare. It would be valuable to conduct a similar analysis as we did here, shedding light on refining and other intermediate prices to understand the situation comprehensively.

While preparing this work, we used ChatGPT 3.5 and Grammarly AI to enhance the clarity, coherence, and correctness of the content. After utilizing these tools, we reviewed and edited the content as needed. We take full responsibility for the accuracy and quality of the publication.

References

ANP (2021), 'Anuário estatístico brasileiro do petróleo, gás natural e biocombustíveis 2021 – Agência Nacional do Petróleo, Gás natural e Biocombustíveis'. https://www.gov.br/anp/pt-br/centrais-de-conteudo/publicacoes/anuario-estatistico-brasileiro-do-petroleo-gas-natural-e-biocombustiveis.

ANP (2022), 'Anuário estatístico brasileiro do petróleo, gás natural e biocombustíveis – Agência Nacional do Petróleo, Gás Natural e Biocombustíveis'. https://www.gov.br/anp/pt-br/centrais-de-conteudo/publicacoes/anuario-estatistico/arquivos-anuario-estatistico-2022/anuario-2022.pdf.

ANP (2023), *Sistema de Levantamento de Preços (SLP) da Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP)*. URL https://www.gov.br/anp/pt-br/centrais-de-conteudo/dados-abertos/serie-historica-de-precos-de-combustiveis.

Arnold, D. (2022), 'The impact of privatization of state-owned enterprises on workers', *American Economic Journal: Applied Economics* **14**(4), 343–380.

Bandekar, A. (2021), 'Using pgfplots to make economic graphs in latex'. https://towardsdatascience.com/using-pgfplots-to-make-economic-graphs-in-latex-bcdc8e27c0eb.

Berry, S. T. & Haile, P. A. (2021), Foundations of demand estimation, *in* 'Handbook of industrial organization', Vol. 4, Elsevier, pp. 1–62.

Bortolotti, B. & Siniscalco, D. (2004), 'The challenges of privatization: an international analysis'.

Brada, J. C. (1996), 'Privatization is transition—or is it?', *Journal of economic perspectives* **10**(2), 67–86.

Bradburd, R. (1995), 'Privatization of natural monopoly public enterprises: the regulation issue', *Review of Industrial Organization* **10**, 247–267.

Bridgman, B., Gomes, V. & Teixeira, A. (2011), 'Threatening to increase productivity: evidence from brazil's oil industry', *World development* **39**(8), 1372–1385.

Cabral, M. A. M. (2020), 'Abuse of dominant position and cease-and-desist agreements: risks to brazilian competition policy arising from the atypical case of petrobras' refineries', *GRUR International* **69**(7), 706–726.

CADE (2019), 'Despacho presidÊncia número 100/2019 – Conselho Administrativo de Defesa Econômica'. https://sei.cade.gov.br/sei/modulos/pesquisa/md_pesq_documento_consulta_externa.php?DZ2uWeaYicbuRZEFhBt-n3BfPLlu9u7akQAh8mpB9yMTzB1tqizUyoJl6oNlJp9CnvosvmPIFLJmZLdBe04B3yNungj.

CADE (2022*a*), 'Despacho decisório nº 5/2022/gab3/cade – Conselho Administrativo de Defesa Econômica'. https://static.poder360.com.br/2022/05/SEI_CADE-1067342-Despacho-Deciso%CC%81rio.pdf.

CADE (2022*b*), 'Mercado de distribuição e varejo de combustíveis líquidos – Conselho Administrativo de Defesa Econômica'. https://cdn.cade.gov.br/Portal/centrais-de-conteudo/publicacoes/estudos-economicos/cadernos-do-cade/Caderno_Mercados-de-distribuicao-e-varejo-de-combustiveis-liquidos.pdf.

Callaway, B. & Sant'Anna, P. H. (2021), 'Difference-in-differences with multiple time periods', *Journal of econometrics* **225**(2), 200–230.

Cardoso, L. C. B. & Bittencourt, M. V. L. (2013), 'Mensuração das elasticidades-preço da demanda, cruzada e renda no mercado de etanol brasileiro: um estudo usando painéis cointegrados', *Revista de Economia e Sociologia Rural* **51**, 765–784.

Cardoso, L. C., Bittencourt, M. V., Litt, W. H. & Irwin, E. G. (2019), 'Biofuels policies and fuel demand elasticities in brazil', *Energy policy* **128**, 296–305.

CNPE (2019), 'Conselho nacional de polÍtica energÉtica – cnpe resoluÇÃo n 9, de 9 de maio de 2019.', *CONSELHO NACIONAL DE POLÍTICA ENERGÉTICA*. URL hhttps://www.gov.br/mme/pt-br/assuntos/conselhos-e-comites/cnpe/resolucoes-do-cnpe/2019.

Cunningham, S. (2021), *Causal Inference: The Mixtape*, Yale University Press.

Dargay, J. M. & Goodwin, P. (1995), 'Evaluation of consumer surplus with dynamic demand', *Journal of Transport Economics and Policy* pp. 179–193.

De Freitas, L. C. & Kaneko, S. (2011), 'Ethanol demand under the flex-fuel technology regime in brazil', *Energy Economics* **33**(6), 1146–1154.

Egami, N. & Yamauchi, S. (2023), 'Using multiple pretreatment periods to improve difference-in-differences and staggered adoption designs', *Political Analysis* **31**(2), 195–212.

Estache, A., Gomez-Lobo, A. & Leipziger, D. (2001), 'Utilities privatization and the poor: lessons and evidence from latin america', *World Development* **29**(7), 1179–1198.

Gardner, J., Thakral, N., T. Tˆo, L. & Yap, L. (2023), 'Two-stage differences in differences', *Mimeo*.

Griebeler da Motta, L. & Pastore, R. (2022), 'Challenges to divestitures in the brazilian refining market', *Available at SSRN 4151046*.

Hausman, J. A. & Newey, W. K. (1995), 'Nonparametric estimation of exact consumers surplus and deadweight loss', *Econometrica: Journal of the Econometric Society* pp. 1445–1476.

IBGE (2023*a*), *Estimativas da População – Instituto Brasileiro de Geografia e Estatística*. URL https://www.ibge.gov.br/estatisticas/sociais/populacao/9103-estimativas-de-populacao.html?=&t=downloads.

IBGE (2023*b*), *IBGE divulga o rendimento domiciliar per capita e o Coeficiente de Desequilíbrio Regional de 2022*. URL https://agenciadenoticias.ibge.gov.br/agencia-sala-de-imprensa/2013-agencia-de-noticias/releases/37023-ibge-divulga-o-rendimento-domiciliar-per-capita-e-o-coeficiente-de-desequili~:text=Em%202022%2C%20o%20rendimento%20nominal,e%20CDR%20de%200%2C68.

Junior, D. S. (2013), 'Impacts of biodiesel on the brazilian fuel market', *Energy economics* **36**, 666–675.

Laguna, N. M. (2004), 'Oil policies and privatization strategies in mexico: implications for the petrochemical sector and its production spaces', *Energy Policy* **32**(18), 2035–2047.

Megginson, W. L. & Netter, J. M. (2001), 'From state to market: A survey of empirical studies on privatization', *Journal of economic literature* **39**(2), 321–389.

Mendes, G., Santos, L., Mariz, L. & Portugal, M. (2018), 'Desinvestimentos e abertura do setor de refino no brasil'. https://repositorio.ipea.gov.br/bitstream/11058/8699/1/td_2411.pdf.

Meyer, A. & Pac, G. (2013), 'Environmental performance of state-owned and privatized eastern european energy utilities', *Energy Economics* **36**, 205–214.

MME (2017), 'Combustível brasil: Setor de combustíveis biocombustíveis e demais derivados do petróleo. maio, 2017.', *Ministério de Minas e Energia*. URL https://www.gov.br/mme/pt-br/assuntos/secretarias/petroleo-gas-natural-e-biocombustiveis/abastece-brasil/combustivel-brasil/ct-cb/20171207RelatrioCTCB.pdf.

Muller, R. B. & Rego, E. E. (2021), 'Privatization of electricity distribution in brazil: Long-term effects on service quality and financial indicators', *Energy policy* **159**, 112602.

Ordonez, R. & Rosa, B. (2018), 'Análise: Manutenção do monopólio no refino gera entrave a preços mais competitivos dos combustíveis', *O Globo*. URL https://oglobo.globo.com/economia/analise-manutencao-do-monopolio-no-refino-gera-entrave-precos-mais-competitivos-dos

Petrobras (2016), 'Adotamos nova política de preços de diesel e gasolina', *Fatos e Dados - Petrobras*. URL https://petrobras.com.br/fatos-e-dados/adotamos-nova-politica-de-precos-de-diesel-e-gasolina.htm.

Petrobras (2023), 'Petrobras sobre estratégia comercial de diesel e gasolina', *Comunicados ao Mercado*. URL https://api.mziq.com/mzfilemanager/v2/d/25fdf098-34f5-4608-b7fa-17d60b2de47d/ecfc4c78-c016-bd34-bdc6-9aeb2850a013?origin=1.

Rojas, H. C. & Leite, B. E. (2018), 'Refino de petróleo no brasil: Desafios históricos e reposicionamento do setor', *Revista Brasileira de Direito do Petróleo, Gás e Energia* **5**(1), 20–32.

Roth, J., Sant'Anna, P. H., Bilinski, A. & Poe, J. (2023), 'What's trending in difference-in-differences? a synthesis of the recent econometrics literature', *Journal of Econometrics*.

Santos, G. F. (2013), 'Fuel demand in brazil in a dynamic panel data approach', *Energy Economics* **36**, 229–240.

Silvestre, B., Hall, J., Matos, S. & Figueira, L. A. (2010), 'Privatization of electricity distribution in the northeast of brazil: The good, the bad, the ugly or the naïve?', *Energy Policy* **38**(11), 7001–7013.

Spulber, N. & Sabbaghi, A. (2012), *Economics of water resources: from regulation to privatization*, Vol. 13, Springer Science & Business Media.

Tavares, M. E. E., Szklo, A. S., Machado, G. V., Schaeffer, R., Mariano, J. B. & Sala, J. F. (2006), 'Oil refining expansion criteria for brazil', *Energy policy* **34**(17), 3027–3040.

Vickers, J. & Yarrow, G. (1991), 'Economic perspectives on privatization', *Journal of economic perspectives* **5**(2), 111–132.

Viscusi, W. K., Harrington Jr, J. E. & Sappington, D. E. (2018), *Economics of regulation and antitrust*, MIT press.

Wolf, C. (2009), 'Does ownership matter? the performance and efficiency of state oil vs. private oil (1987–2006)', *Energy Policy* **37**(7), 2642–2652.

Wooldridge, J. M. (2021), 'Two-way fixed effects, the two-way mundlak regression, and difference-in-differences estimators', *Available at SSRN 3906345*.

Appendix

Summary Statistics

Table 4: Summary statistics for three data sets: gasoline, diesel and ethanol market – gas station level

Variable	N	Mean	St. Dev.	Min	Max
Panel A – Gasoline					
Price	2,441,683	4.900	0.886	2.870	8.990
Latitute	2,441,683	−20.679	6.144	−32.035	2.824
Longitude	2,441,683	−48.126	5.043	−72.676	−38.222
Capital	2,441,683	0.200	0.400	0	1
Treated	2,441,683	0.010	0.099	0	1
Month	2,441,683	5.767	3.163	1	12
Year	2,441,683	2,019.757	1.527	2018	2023
Panel B – Diesel					
Price	1,267,164	4.022	1.026	2.453	8.999
Latitude	1,267,164	−20.150	6.398	−32.035	2.824
Longitude	1,267,164	−48.676	5.511	−72.676	−38.222
Capital	1,267,164	0.121	0.326	0	1
Treated	1,267,164	0.009	0.092	0	1
Month	1,267,164	5.766	3.132	1	12
Year	1,267,164	2,019.546	1.426	2018	2023
Panel C – Ethanol					
Price	2,112,180	3.577	0.912	1.799	7.980
Latitude	2,112,180	−20.888	4.958	−32.035	2.824
Longitude	2,112,180	−47.606	4.573	−72.676	−38.222
Capital	2,112,180	0.196	0.397	0	1
Treated	2,112,180	0.009	0.097	0	1
Month	2,112,180	5.838	3.168	1	12
Year	2,112,180	2,019.661	1.443	2018	2023

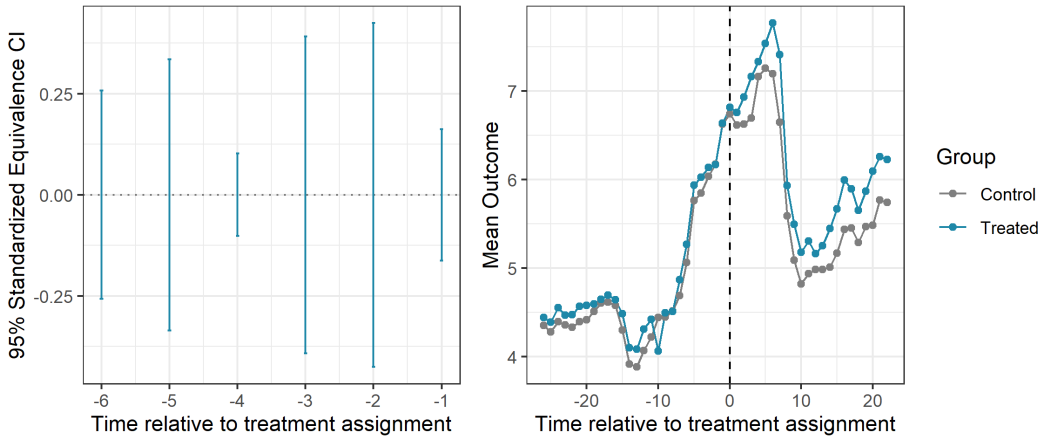
Notes: The data used in this table is from ANP (2023). The variable *Capital* indicated whether the gas station is located in a state capital. All prices are expressed in Brazilian Real (BRL) in nominal terms.

Parallel Trends

We employed estimators derived from Gardner et al. (2023) and Wooldridge (2021), both relying on the conditional parallel trends assumption. To validate this assumption, we conducted tests using the framework outlined by Egami & Yamauchi (2023). The outcomes for the gasoline, diesel, and ethanol markets are depicted in the following three figures, revealing an absence of pre-trends across all three markets. The following figures are estimates based on Equation 7.

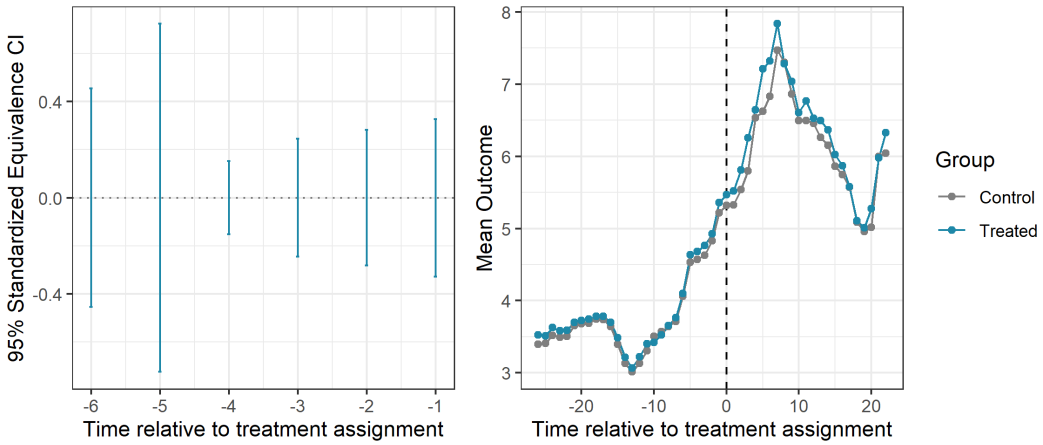
$$P_{it}^{f} = \alpha + \sum_{\tau=-q}^{-1} \beta_{\tau} T_{i\tau} + \sum_{\tau=0}^{m} \beta_{\tau} T_{i\tau} + \gamma X_{it}^{'} + \delta_{i} + \theta_{t} + \varepsilon_{it} \tag{7}$$

Figure 5: Gasoline: Pre-trends and pre- and post-privatization outcomes



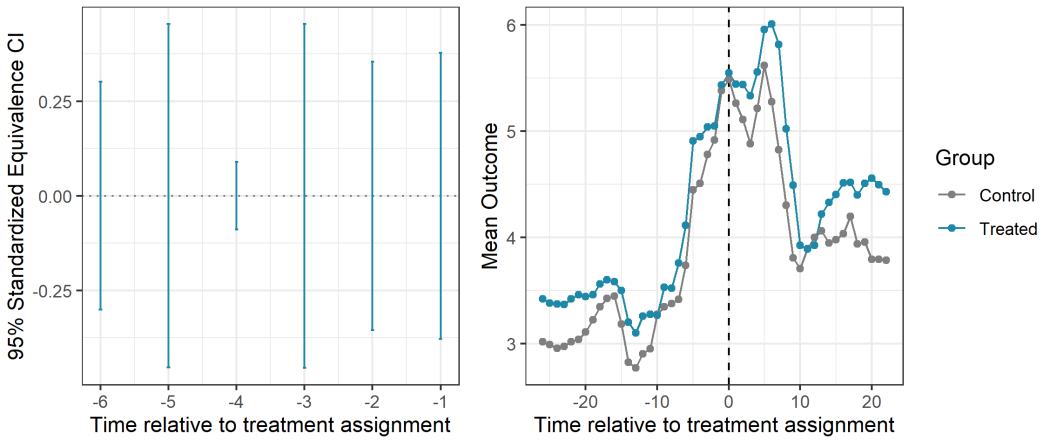
Notes: These graphs are constructed using codes from Egami & Yamauchi (2023). The left side displays confidence intervals for pre-trends until six months before privatization. On the right side, outcomes for the treated group (gas stations in Bahia and Amazonas) are compared with the control group (gas stations in all other states, excluding those in the North and Northeast regions). The mean outcome is in nominal BRL.

Figure 6: Diesel: Pre-trends and pre- and post-privatization outcomes



Notes: These graphs are constructed using codes from Egami & Yamauchi (2023). The left side displays confidence intervals for pre-trends until six months before privatization. On the right side, outcomes for the treated group (gas stations in Bahia and Amazonas) are compared with the control group (gas stations in all other states, excluding those in the North and Northeast regions). The mean outcome is in nominal BRL.

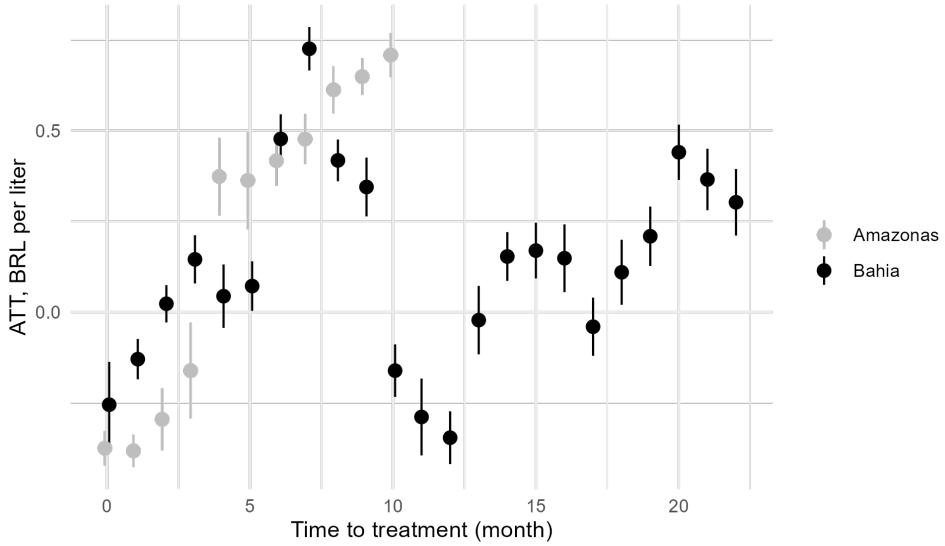
Figure 7: Ethanol: Pre-trends and pre- and post-privatization outcomes



Notes: These graphs are constructed using codes from Egami & Yamauchi (2023). The left side displays confidence intervals for pre-trends until six months before privatization. On the right side, outcomes for the treated group (gas stations in Bahia and Amazonas) are compared with the control group (gas stations in all other states, excluding those in the North and Northeast regions). The mean outcome is in nominal BRL.

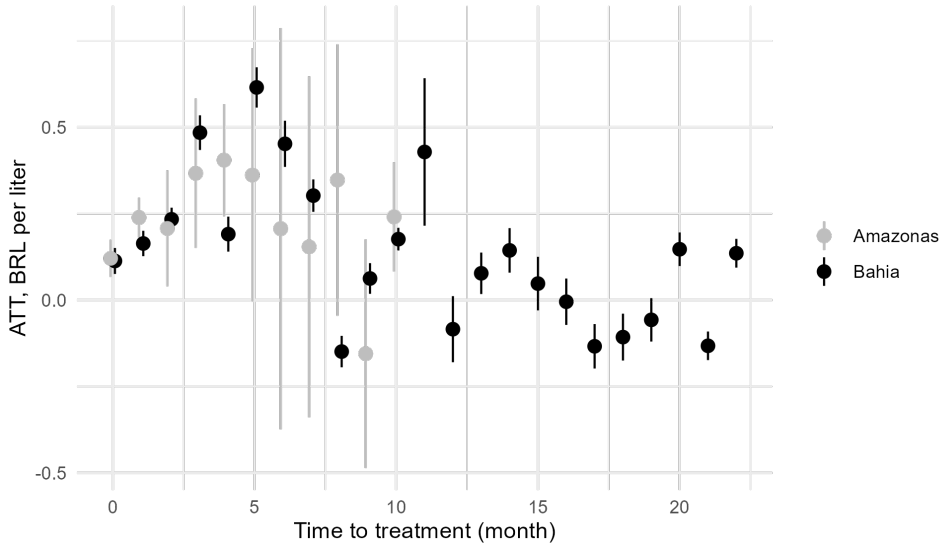
5.1 Other Figures

Figure 8: Ethanol overpricing across time and cohorts (Wooldridge, 2021)



Notes: The points are the Average Treatment Effect (ATT) of privatization sales for consumers in Bahia and Amazonas over successive months post-privatization. Bars show the confidence intervals at the 95 percent level. We used Wooldridge (2021) estimator. Amazonas have fewer observations due to the one-year lag in privatizing their refinery compared to Bahia's refinery.

Figure 9: Diesel overpricing across time and cohorts (Wooldridge, 2021)



Notes: The points are the Average Treatment Effect (ATT) of privatization sales for consumers in Bahia and Amazonas over successive months post-privatization. Bars show the confidence intervals at the 95 percent level. We used Wooldridge (2021) estimator. Amazonas have fewer observations due to the one-year lag in privatizing their refinery compared to Bahia's refinery.