6

ESTIMATING THE OVERCHARGE OF THE LIQUEFIED PETROLEUM GAS CARTEL IN BRAZIL'S FEDERAL DISTRICT: EVIDENCE FROM BEFORE-AND-AFTER AND DIFFERENCE-IN-DIFFERENCES APPROACHES[1]

Estimando o sobrepreço no cartel de gás liquefeito de petróleo do Distrito Federal: evidências dos métodos Before-and-After e Diferenças-em-Diferenças

Rodrigo Gonçalves da Silva[2]
Instituto Brasileiro de Ensino, Desenvolvimento e Pesquisa (IDP) – Brasília/DF, Brasil
Lílian Santos Marques Severino[3]
Conselho Administrativo de Defesa Econômica (Cade) – Brasília/DF, Brasil
Felipe Resende Oliveira[4]
Conselho Administrativo de Defesa Econômica (Cade) – Brasília/DF, Brasil

1 **Editor responsável:** Prof. Dr. Victor Oliveira Fernandes, Conselho Administrativo de Defesa Econômica (Cade), Brasília, DF, Brasil.
Lattes: http://lattes.cnpq.br/5250274768971874. **ORCID:** https://orcid.org/0000-0001-5431-4142.
Recebido em: 14/07/2025 **Aceito em:** 21/11/2025 **Publicado em:** 10/12/2025

2 Graduado em Economia pelo Instituto Brasileiro de Ensino, Desenvolvimento e Pesquisa (IDP).
E-mail: rodrigogoncalvessilva80@gmail.com **Lattes:** http://lattes.cnpq.br/7321238674253005.
ORCID: https://orcid.org/0009-0003-4704-748X

3 Economista-Chefe no Departamento de Estudos Econômicos do Conselho Administrativo de Defesa Econômica (Cade) e Professora no IDP. Doutora em Economia pela Universidade Católica de Brasília.
E-mail: lilian.severino@cade.gov.br. **Lattes:** http://lattes.cnpq.br/1147563699948673.
ORCID: https://orcid.org/0000-0003-2833-9367.

4 Atua no Departamento de Estudos Econômicos do Conselho Administrativo de Defesa Econômica (Cade). Doutor em Economia pela Universidade Federal de Pernambuco.
E-mail: felipe.resende@cade.gov.br. **Lattes:** http://lattes.cnpq.br/5724942282637254.
ORCID: https://orcid.org/0000-0002-2258-3572

SILVA, Rodrigo Gonçalves da; SEVERINO, Lílian Santos Marques; OLIVEIRA, Felipe Resende. Estimating the overcharge of the liquefied petroleum gas cartel in Brazil's Federal District: evidence from Before-and-After and Difference-in-Differences approaches. **Revista de Defesa da Concorrência**, Brasília, v. 13, n. 2, p. 140-159, 2025.

https://doi.org/10.52896/rdc.v13i2.1955

STRUCTURED ABSTRACT

Context: the liquefied petroleum gas (LPG) distribution and retail market in Brazil's Federal District engaged in collusive practices that raised prices and triggered an investigation by the Administrative Council for Economic Defense (Cade), culminating in the cartel's conviction in 2023.

Objective: estimate the overcharge attributable to the LPG cartel and demonstrate the relevance of Cade's intervention in restoring competition and consumer welfare.

Method: combined application of the "*Before and After*" and Difference-in-Differences (DID) approaches, comparing prices before, during, and after the collusive conduct to isolate the cartel's causal effect on prices.

Conclusions: The estimates obtained from the "*Before and After*" methodology indicate overcharges ranging from 2.82% to 5.94%, while the Difference-in-Differences model shows values between 3.73% and 4.56%. Considering the most comprehensive specification, which includes time fixed effects and standard errors clustered by neighborhood, the estimated effect loses statistical significance, suggesting that part of the price variation may be explained by common spatial and temporal factors. Overall, the results indicate that, although there is no robust evidence of a price increase directly attributable to the cartel, CADE's intervention was relevant in dismantling the coordinated conduct and preserving market competition, thereby promoting a more competitive and stable environment for price formation.

Keywords: cartel; LPG; Cade; overpricing.

RESUMO ESTRUTURADO

Contexto: o mercado de distribuição e revenda de gás liquefeito de petróleo (GLP) no Distrito Federal apresentou práticas colusivas que elevaram preços e motivaram a investigação do Conselho Administrativo de Defesa Econômica (Cade), culminando na condenação do cartel em 2023.

Objetivo: estimar o sobrepreço atribuído ao cartel de GLP e demonstrar a relevância da intervenção do Cade para restabelecer a concorrência e o bem-estar dos consumidores.

Método: emprego combinado das abordagens "*Before and After*" e Diferenças-em-Diferenças (DID) para comparar preços antes, durante e depois da conduta colusiva, isolando o efeito causal do cartel sobre os preços.

Conclusões: as estimativas obtidas pela metodologia "*Before and After*" indicam sobrepreços variando entre 2,82% e 5,94%, enquanto o modelo de Diferença em Diferenças apresenta valores entre 3,73% e 4,56%. Considerando a especificação mais abrangente, que inclui efeitos fixos de tempo e erros-padrão agrupados por bairro, o efeito estimado perde significância estatística, sugerindo que parte da variação dos preços pode ser explicada por fatores espaciais e temporais comuns. De modo geral, os resultados indicam que, embora não haja evidência robusta de um aumento de preços diretamente atribuível ao cartel, a intervenção do Cade foi relevante para desarticular a conduta coordenada e preservar a concorrência no mercado, promovendo um ambiente de formação de preços mais competitivo e estável.

Palavras-chave: cartel; GLP: Cade; sobrepreço.

Classificação JEL: L41; K21; C21; L95.

INTRODUCTION

In economics, a cartel is a collusive agreement among firms in the same industry, typically competitors, whose goal is to fix prices, control the market, and maximize profits (Levenstein; Suslow, 2006). Such practices are anti-competitive and illegal because they manipulate the supply of goods and services and reduce consumer choice.

Cartels significantly raise consumer prices, as shown by a meta-analysis by Connor and Bolotova (2006) covering cartels across a broad range of sectors and countries over 125 years, which finds average overcharges of around 25%. Such increases erode purchasing power and undermine living standards. Moreover, by prioritizing the maintenance of joint market control over competing on quality or innovation, these anti-competitive alliances discourage investment in new technologies and limit the variety of products available to consumers.

Meta-analysis by Connor and Bolotova (2006), covering cartels across a wide range of industries and countries over 125 years, finds that cartels raise consumer prices by an average of 25%. Such increases erode purchasing power and undermine living standards. Moreover, by prioritizing joint market control over competition on quality or innovation, these anti-competitive alliances discourage investment in new technologies and limit the variety of products available to consumers.

The Conselho Administrativo de Defesa Econômica (Cade) is Brazil's antitrust authority responsible for safeguarding free competition in the economy. Under Law No. 12.529/2011, which created the Sistema Brasileiro de Defesa da Concorrência (SBDC), Cade has three principal mandates: (i) a repressive role, which empowers the authority to investigate and adjudicate infringements of economic order; (ii) a preventive role, which obliges it to review merger transactions and monitor market dynamics; and (iii) an educational role, aimed at informing the public about practices that may harm competition and at expanding knowledge of antitrust legislation among consumers and market participants (Brasil, 2011).

Cartel conduct is defined in the SBDC, specifically in Article 36, paragraph 3. Under this provision, the following practices, when carried out in concert with competitors, constitute infringements of the economic order: (i) fixing or manipulating the prices of goods or services, (ii) limiting the production or commercialization of a given quantity of goods or services, and (iii) dividing markets or allocating customers (Brasil, 2011).

These practices are subject to monetary sanctions that include: (i) a fine ranging from 0.1% to 20% of the company's gross revenue; (ii) for individuals or legal entities that do not engage in entrepreneurial activity, a fine between R$ 50,000.00 and R$ 2,000,000,000.00; and (iii) for company officers, a fine of 1% to 20% of that imposed on the firm, as provided in Article 37 of the same law (Brasil, 2011). Beyond these financial penalties, criminal liability also applies: under Law No. 8.137/1990,

Article 4, offenders are subject to imprisonment from two to five years and a fine (Brasil, 1990).

This study aims to estimate the overcharge imposed by the cartel and to assess its financial impact on consumers by examining Administrative Proceeding No. 08012.006043/2008-37[5] and applying a difference-in-differences model. The collusive agreement operated in the distribution and retail markets for liquefied petroleum gas (LPG) in the Distrito Federal, its surrounding area, and other localities in Brazil's Center-West region.

This study aims to estimate the cartel's overcharge and assess its financial impact on consumers by analyzing Administrative Proceeding No. 08012.006043/2008-37 and applying two models: before and after and difference in differences. The collusive agreement affected the LPG distribution and retail markets in the Federal District, its surrounding areas, and other locations in Brazil's Central-West region.

Liquefied Petroleum Gas (LPG), commonly known as cooking gas, is widely used by households for food preparation, water heating, and space heating, and it also serves various industrial applications. Produced as a by-product of petroleum refining, LPG in Brazil is generated mainly by Petrobras, the country's largest oil company. After production, Petrobras sells the LPG to distribution firms, which then supply the product to end consumers.

According to Alves and Tiergarten (2008), LPG, a petroleum derivative, plays a pivotal role as an energy source in industrial, commercial, and residential sectors. Obtained as a by-product of oil refining, this fuel - commonly called cooking gas - is widely used by households for food preparation, water heating, and space heating, as well as in numerous industrial processes. In Brazil, LPG production is predominantly concentrated at Petrobras, the leading company in the sector, which sells the product to distribution firms responsible for making it available to final consumers.

According to Cade[6], the investigation into the alleged LPG cartel in the Federal District began with a complaint against the Sindicato das Empresas Transportadoras e Revendedoras Varejistas de Gás Liquefeito de Petróleo do Distrito Federal (Sindvargas) and its then president, who were suspected of convening meetings in May 2008 to coordinate increases in LPG prices charged to final consumers.

Following a preliminary inquiry requested by the Ministério Público do Distrito Federal e Territórios (MPDFT), the Departamento de Proteção e Defesa Econômica (DPDE) of the former Secretaria de Direito Econômico (SDE) concluded that there was strong evidence of cartel formation in the LPG retail market in the Federal District during the period from December 2007 to april 2010.

Based on this evidence, in April 2010 the Polícia Civil do Distrito Federal (PCDF), with support from the then SDE, launched "Operação Júpiter." Search and seizure warrants were executed at various locations in the Federal District and in Goiânia, Goiás, to collect evidence of the alleged cartel. According to Cade[7], the LPG distributors under investigation had formed a classic cartel by agreeing to fix prices and to divide among themselves the LPG distribution and retail markets in the Federal District and surrounding areas, as well as in the municipalities of Barra do Garças, Mato Grosso; Posse, Goiás; and Uruaçu, Goiás, which were supplied by distributor facilities headquartered in Brasília.

5 All Cade's public proceedings mentioned in this article can be found at: https://x.gd/ONDMz.

6 Nota Técnica n° 13/2015/CGAA6/SGA2/SG/CADE.

7 Parecer jurídico nº 5/2020/CGEP/PFE-CADE-CADE/PGF/AGU no processo nº 08012.006043/2008-37.

According to Cade[8], the distributors involved in the cartel refused to sell to retailers supplied by other companies, threatened retaliation against those who marketed cylinders from multiple sources, and divided customer portfolios among themselves. The retailers, in turn, acted as monitors of the cartel's price schedule, imposing sanctions on any member that failed to comply. Because these practices combined horizontal coordination among competitors with vertical restrictions across different levels of the supply chain, the scheme was classified as a mixed cartel.

According to the Certidão de Julgamento of the 219th Ordinary Session[9], on September 13, 2023, Cade condemned 27 legal entities, including LPG retailers and distributors, and 19 individuals for cartel practices and violations of the economic order, imposing total fines exceeding R$ 26 million (Cade, 2023).

The study assesses the benefits that Cade's enforcement generates for society, underscoring the importance of tackling cartels that restrict competition and impose costs on consumers. It is structured into six sections. Following this introduction, which situates the topic, Section 2 provides a synthesis of the national and international literature on cartel overcharge estimates. Section 3 sets out the methodological approach, while Section 4 describes the data set and the relevant descriptive statistics. Section 5 presents and discusses the empirical overcharge results. Section 6 closes the study with the main conclusions.

2 LITERATURE REVIEW

The effects of collusion on competitive conditions vary according to market size, the number of participating firms, and the structure of the agreement. In competitive markets, each firm independently adjusts prices and quantities to maximize its own performance (Tito, 2018). In cartelized markets, however, companies coordinate to raise prices and reduce the supply of goods and services, thereby increasing their joint profits. While such behavior benefits the participating firms, it harms consumers, who face higher prices, fewer choices, and potentially lower product quality.

In economics, a monopoly arises when a single firm exerts exclusive control over the supply of a good or service, thereby setting the market price. When cartelized firms coordinate effectively to maximize their collective profits, the resulting equilibrium price and quantity approach those of a monopoly, with a higher price and a lower output compared with a competitive market (Stigler, 1964).

Tito (2018) argues that in a competitive market firms produce until price equals marginal cost, whereas a monopoly or a successful cartel raises the price until marginal revenue equals marginal cost. This strategy reduces the volume of sales compared with the competitive outcome and increases the price charged, transferring to the cartelists the surplus that, under free competition, would belong to consumers. In addition, the lower output generates a deadweight loss, representing a welfare loss captured by neither consumers nor producers.

Considering that markup is the difference between a product's selling price and its marginal cost, in conditions of perfect competition this margin is zero because price equals marginal cost. In cartelized markets, however, firms coordinate to raise the price above cost, mimicking a monopoly and imposing a supra-competitive markup to increase their profits

8 Parecer jurídico nº 5/2020/CGEP/PFE-CADE-CADE/PGF/AGU no processo nº 08012.006043/2008-37.

9 Certidão de Julgamento da 219° Sessão Ordinária, Processo Administrativo nº 08012.006043/2008-37.

https://doi.org/10.52896/rdc.v13i2.1955

(Domowitz; Hubbard; Petersen, 1986).

Some studies have quantified the impacts and, in particular, the overcharges imposed by certain cartels, with research appearing in both international and national literature. Internationally, Eruktu and Hildebrand (2010) examined the fuel station cartel operating in several local markets in Quebec, Canada. The authors employed the difference-in-differences method and found that gasoline prices fell by 1.75 cents per litre after the public announcement of the investigation. They also concluded that the cartel had inflicted damages exceeding US$ 2 million over the previous year.

Laitenberger and Smuda (2015) estimated the damages suffered by German consumers as a result of a detergent cartel that operated from 2002 to 2005 across eight European countries. The authors applied both before-and-after and difference-in-differences methodologies and found average overcharges ranging from 6.7% to 6.9%, corresponding to consumer losses of approximately € 13.2 million between July 2004 and March 2005.

Govinda, Khumalo and Mkhwanazi (2014) examined the impact of the South African cement cartel following the intervention of the national competition authority. Using an econometric approach, the authors estimated overcharges between 7.5% and 9.7% during the cartel period relative to the post-intervention phase. They further quantified the consumer savings derived from the antitrust action between 2010 and 2013, estimating benefits of R 4.5 billion to R 5.8 billion (approximately USD 425 million to USD 547 million).

In the Brazilian context, Lucinda and Seixas (2016) estimated the consumer harm caused by the so-called "Peroxide Cartel," which operated from 1995 to 2004. Their study aimed to assess Cade's effectiveness in preventing cartel behavior. To quantify the damages, the authors employed three distinct methodologies: time-series analysis, difference-in-differences, and structural models. They found average overcharges of approximately 15.5% and 22%, depending on whether the cartel's end was assumed to be January 2004 or February 2004, respectively, with each methodology yielding about 9.3% overcharge. The authors also calculated per-ton losses of R$ 162.20 and R$ 114.50 for those two end-dates. Across all three approaches, the estimated total damages were of the same order of magnitude as the fines imposed, leading to the conclusion that full compensation of consumer losses would require fines at least as large as those applied.

Afonso and Féres (2017) analyzed the LPG cartel that operated between February 2003 and April 2005 in the state of Pará. The study employed two methodologies. The before-and-after approach yielded estimated overcharges between 10% and 13%, while the difference-in-differences method indicated overcharges ranging from 15.97% to 16.96%. Based on these figures, the authors calculated total damages of approximately R$ 1 billion under the before-and-after model and R$ 1.2 billion under the difference-in-differences approach.

The study conducted by Fernandes and Jesus Júnior (2023) identifies empirical evidence of cartelization in the LPG retail market in the municipalities of Nova Andradina and Dourados (MS) between May 2004 and August 2020. The authors estimated ARCH, GARCH, and T-GARCH models, introducing a cartel dummy, and found that during the investigated period there was an increase in the average LPG price and a reduction in the standard deviation, indicating lower volatility and greater price alignment, a pattern typical of cartels. Although no reduction in variance was observed in Dourados, the coefficients of variation showed greater price convergence during the possible cartel period. These results strengthen the econometric literature on the detection of anticompetitive

behavior in markets that have been relatively underexplored in Brazil.

Motta and Resende (2020) assessed the benefits generated by Cade's intervention against the fuel cartel that operated in the Federal District. The study is based on the Organisation for Economic Co-operation and Development (OECD) methodology, which considers three variables: (i) the revenue of the affected market, drawing on data available in the administrative case files, (ii) the cartel's duration, for which scenarios of varying longevity are tested, and (iii) the overcharge imposed by the cartel, estimated using a difference-in-differences approach with multiple counterfactual sets and a synthetic control method. The authors estimated that the benefits of Cade's action ranged from R$ 206 million to R$ 358 million for gasoline consumers in the Federal District under the assumption that the cartel would have lasted only one year without the agency's intervention. Assuming a hypothetical six-year duration, the benefits increased to between R$ 1.24 billion and R$ 2.15 billion.

Resende, Motta, and Lima (2019) assessed the benefit generated by dismantling the crushed-stone cartel that operated in the São Paulo metropolitan area. Following the OECD framework, which was also applied in the Federal District fuel cartel case, the authors relied on three key variables: (i) the affected market's revenue, drawn from the case files; (ii) the cartel's duration, for which several longevity scenarios were tested; and (iii) the overcharge, estimated with a difference-in-differences approach using alternative counterfactual groups. They found that the overcharge ranged from 6.12% to 10.69%, and that the benefits from ending the cartel, assuming a six-year horizon, lay between R$ 348.60 million and R$ 608.91 million.

Resende and Malan (2024) estimated the overcharge generated by the fuel cartel in the Belo Horizonte, Minas Gerais, area using several difference-in-differences specifications. Across all models the authors found an average overcharge of about R$ 0.0119 per liter, or 0.52%, for gasoline and roughly R$ 0.0211 per liter, or 1.53%, for ethanol. They also observed an increase in retail margins throughout the cartel period, amounting to R$ 0.0162 per liter, or 8.52%, for gasoline and R$ 0.0204 per liter, or 15.4%, for ethanol. In addition, the study estimated the harm to third parties from the cartel, considering only regular gasoline and the volume sold, and calculated a loss of approximately R$ 5,260,086.00. Based on the average overcharge in the gasoline margin, the cartelists unlawfully obtained about R$ 7,160,790.00 during the collusive period.

3 METHODOLOGY

This section presents the empirical design used to measure the overcharge imposed by the LPG cartel in the Federal District and surrounding areas. It first details the before-and-after approach, which compares the price trajectory before, during, and after the antitrust intervention, and outlines the theoretical and econometric models employed to isolate the cartel's effect. Next, it describes the difference-in-differences strategy, which contrasts the behavior of retailers involved in the cartel (treatment group) with that of non-involved retailers (control group) while accounting for common supply and demand shocks. For each method, the variables of interest, the additional controls, the counterfactual definition, the cartel's operating period, and the set of sanctioned firms are specified.

3.1 Before and After

As an initial approach, this study employs the before and after method, which is widely used to measure the effect of an intervention on a given variable or group of interest. The technique involves comparing the trajectory of the variable in the period before the intervention with that observed afterwards, thereby isolating changes attributable solely to the intervention. In this work, the procedure is applied to estimate the impact of the cartel on LPG prices, following the practice established in cartel overcharge assessments in the specialized literature (Connor; Bolotova, 2006).

To operationalize the before-and-after approach in the case of the LPG cartel in the Federal District, we compare average product prices across three distinct time windows. The pre-cartel period spans January 2004 through November 2007, the cartel period extends from December 2007 through the launch of Operação Júpiter in April 2010 according to Cade documentation, and the post-intervention horizon covers May 2010 through December 2013. We compile the historical price series for each interval and estimate the average changes between them in order to identify artificial increases during the collusion and any subsequent normalization. The resulting difference thus constitutes a measure of the overcharge imposed on consumers and the corresponding economic damage. The estimated model, which forms the theoretical framework of this investigation, is formalized in equation (1) below.

$$log(PriceLPG_t) = \alpha + \beta_1 Cartel_t + \beta_2 log(BRENT_t) + \beta_3 \log(\mathrm{ICMS}_t) + \beta_4 \log(GDP_t) + \varepsilon_t \quad (1)$$

In equation (1), $\mathrm{Price}GLP_t$ denotes the average LPG price in the Federal District at time *t*; α is the intercept; β_1 captures the cartel's effect on that price; $Cartel_t$ is a dummy variable equal to 1 during the collusion period and 0 otherwise; a variável BRENT_t enters as a control for global oil supply and demand shocks that could bias the estimated cartel effect; $ICMS_t$ controls for the state tax on the circulation of goods and services (Imposto sobre Circulação de Mercadorias e Serviços), which according to the study Formação de Preço do Gás Liquefeito de Petróleo no Mercado Brasileiro (EPE, 2024) accounts on average for 16.1% of the final price; however, because the ICMS rate in the Federal District remained essentially stable at around 12% throughout the sample, its limited variation constrains its explanatory power; GDP_t is included to capture macroeconomic demand swings that may affect LPG prices; and finally ε_t represents the error term.

3.2 Difference-in-Differences Model

To estimate the overcharge, this study employs the difference-in-differences (DID) method. According to Vitale and Carrieri (2016), the DID estimator compares two elements: first, the average change in the treated market before and after the intervention; second, the average change in the control market over the same time span. The technique therefore combines a cross-sectional dimension, which contrasts treated and untreated markets, with a temporal dimension, which compares periods before and after the intervention. The mathematical formulation of the procedure follows the presentation in Domingues (2017).

Box 1 – Mathematical representation of the DID model

Group	Before	After	After - Before
Control	A	B	B – A
Treatment	C	D	D – C
Treatment – Control	C – A	D – B	(D - C) - (B - A)

Source: Domingues (2017).

The DID estimator gauges the impact of an intervention by comparing the trajectory of a treated group with that of a control group not exposed to the shock. By contrasting each group's variation before and after the event, the method reconstructs the path that the treated market would have followed in the absence of the cartel. The validity of this approach hinges on selecting an appropriate control market, meaning one whose differences from the treated market remain stable over time, whose prices react similarly to supply and demand shocks, and whose behavior was not influenced by the antitrust decision, as recommended by Vitale and Carrieri (2016). The econometric specification adopted for the difference-in-differences approach is formalized in Equation (2).

$$log(PriceLPG_{i,t}) = \alpha + \beta_1 DID_{i,t} + \mu_{neighborhood(i)} + \theta_{municipality(i)} + \tau_t + \varepsilon_{i,t} \quad (2)$$

In this specification, $log(PreçoGLP_{i,t})$ corresponds to the natural logarithm of the price charged by retailer i in period t; α denotes the intercept; $\beta_1 DID_{i,t}$ represents the interaction between the cartelist retailer dummy and the cartel-period dummy, taking the value one when the price comes from a Cade-condemned establishment during the collusion and zero otherwise; $\mu_{neighborhood(i)}$ and $\theta_{municipality(i)}$ are fixed effects capturing unobserved, time-invariant characteristics of the neighborhoods (*bairros*) and municipalities where each retailer operates, while τ_t denotes time fixed effects that control for aggregate shocks affecting all retailers simultaneously, and $\varepsilon_{i,t}$ is the idiosyncratic error term. The inclusion of these fixed effects helps isolate the cartel's impact by accounting for persistent spatial characteristics and common temporal shocks such as seasonal demand fluctuations, fuel distribution costs, or national pricing policies, thereby reducing potential bias from unobserved spatial and temporal heterogeneity.

The identification of the causal effect in the difference-in-differences framework relies on the parallel trends assumption, which states that, in the absence of the cartel, price trajectories in treated and control markets would have evolved similarly over time. As discussed by Angrist and Pischke (2009), this assumption is essential for the internal validity of quasi-experimental models and must be supported by both empirical evidence and economic reasoning. To strengthen the credibility of this assumption, the control group was selected to mirror the treated group in terms of demand conditions, income levels, and logistical costs, ensuring comparable exposure to macroeconomic shocks. In addition, robustness checks were conducted to assess the consistency of the results, including re-estimations with different sets of fixed effects at the neighborhood and municipality levels. The stability of the overcharge estimates across specifications reinforces the robustness of the findings and supports the causal interpretation of the results.

The definition of treatment and control groups in this study applies to both the before-and-after approach and the difference-in-differences method. The treatment group comprises LPG distribution and retail markets located in the Federal District and in adjacent municipalities of Goiás

where collusion was identified, covering the period from December 2007, when the collusive behavior began, to April 2010, when Operação Júpiter was launched. The control group includes LPG retailers in the same geographic area that neither participated in the cartel nor were investigated by antitrust authorities. It is assumed that these firms operated independently. Selection criteria were based on similarities in economic, demographic and infrastructural conditions so that both groups share the same market environment, with only the treatment group exposed to the cartel's influence.

According to the Certidão de Julgamento of the 219th Ordinary Session, issued in 2023, the firms that participated in the collusion and were either convicted or entered into a *Termo de Compromisso de Cessação* (TCC) are listed below (Cade, 20213).

Table 1 - Convicted firms and fines imposed

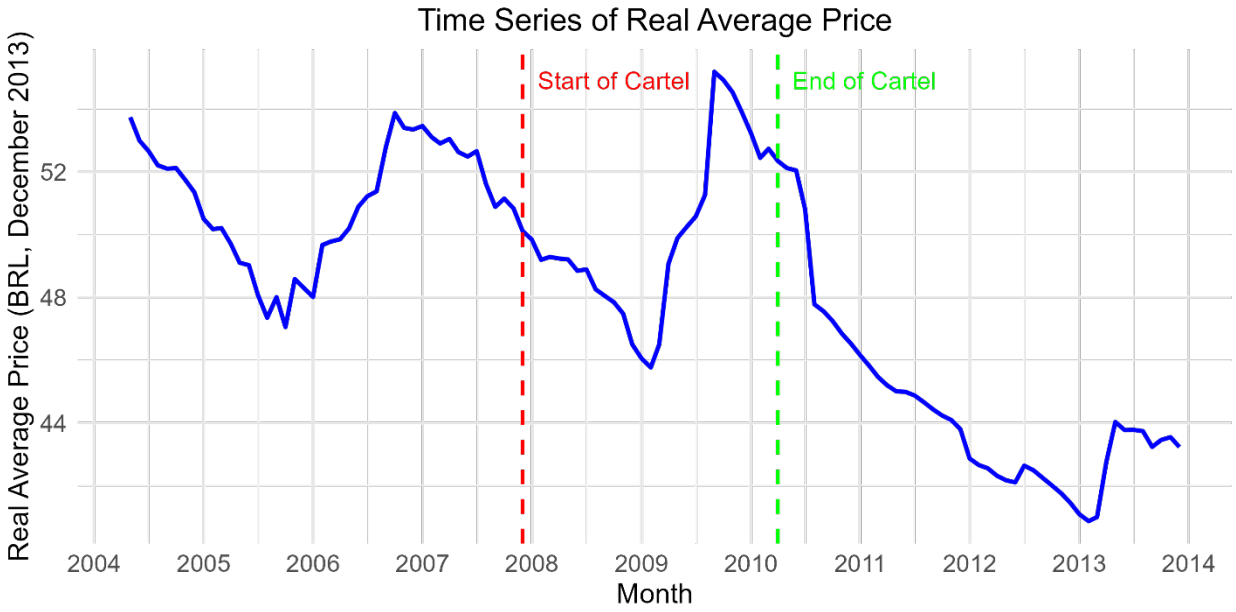
Firms	Fines / Pecuniary Contribution
Ultragás S.A.	R$ 2.154.010,86
Copagaz Distribuidora de Gás Ltda	R$ 2.200.150,64
Liquigás Distribuidora S.A.	R$ 2.917.413,76
Supergásbrás Energia Ltda.	R$ 7.390.146,29
A Casa do Gás Comércio de GLP Ltda.	R$ 77.494,58
A.S. Gás Depósito e Transporte de Gás Ltda.	R$ 1.374.988,93
Belo Gás Comercial Ltda-ME	R$ 269.972,61
Chegou o Gás Ltda ME (Biogás)	R$ 50.000,00
Chamas Comércio	R$ 207.666,93
Representação e Transporte de Gás Ltda ME	R$ 207.666,93
Copergás Distribuidora de Gás e Transporte Ltda.	R$ 89.925,74
Disk Gás do Denílson Ltda ME	R$ 50.000,00
Disk Zé Carlos do Gás Ltda (JD Comércio de Gás Ltda)	R$ 4.425,80
Ferreira & Costa Comércio de Gás Ltda-ME	R$ 75.590,93
Fogás Comércio de Gás Ltda.	R$ 50.000,00
Gasil Comércio de Gás e Transporte Ltda.	R$ 79.352,14
Goiás Gás Ltda ME	R$ 50.000,00
Guma Gaz Eireli	R$ 82.246,49
Itália Comércio de Gás Ltda-ME	R$ 616.868,07
LG Distribuidora de Gás Ltda	R$ 50.000,00
Metrogas Ltda ME	R$ 6.422,36
Natural Gás Comércio de Gás Ltda-ME	R$ 63.448,90
NGX Comércio e Transporte de Gás Ltda-ME	R$ 558.159,95
NGB (Nacional Gás Butano)	R$19.921.040,95
Ouro Gás Comércio Varejista de Gás Ltda ME	R$ 207.666,93
Pádua Comércio de Gás Ltda	R$ 254.013,50
RM Comércio de Gás Ltda-ME	R$ 192.134,30
RJ Comércio de Gás Ltda ME	R$ 182.857,92
Rodrigues & Maciel Gás Ltda EPP	R$ 268.277,31
Souza Comércio de Varejista de Gás Ltda ME	R$ 207.666,93
Unidos Depósito e Transporte de Gás Ltda.	R$ 309.531,69
TOTAL	R$40.169.141,40

Source: Cade, Administrative Proceeding 08012.006043/2008-37.[10][11]

Estimating the overcharge requires precise identification of the period during which the collusive arrangement was active. For this purpose, the documentation contained in the administrative case was reviewed. According to Cade[12], the investigation into a possible LPG cartel in the Federal District market was opened in May 2008; in July of the same year, Procon-DF conducted inspections of distributors and retailers and found price increases lacking economic justification in previous months. Later, in July 2009, the then SDE concluded that there was strong evidence of collusive conduct between December 2007 and November 2008.

In November 2009 the now-defunct SDE of the Ministry of Justice (MJ) opened a Preliminary Inquiry against certain LPG retailers on suspicion of infringing the economic order. Based on the evidence gathered, authorities launched Operação Júpiter on 30 April 2010, executing search and seizure warrants in the Federal District and in Goiânia. Accordingly, this study defines the cartel's active period as beginning in December 2007, when Cade concluded that collusion existed, and ending on 30 April 2010, the date of Operação Júpiter. Graph 1 shows the trajectory of the average LPG price in the Federal District and its surrounding areas over the period analyzed.

Graph 1 – Time series of the average LPG price



Source: ANP data. Prepared by the author[13].

10 The price records available from ANP do not include observations for Chamas Comércio and RJ Comércio de Gás Ltda. over the analysis period.

11 The companies Ultragás S.A., Copagaz Distribuidora de Gás Ltda., Liquigás Distribuidora S.A. and Supergásbrás Energia Ltda. signed TCC and made pecuniary contributions.

12 Separate Opinion – Commissioner Luiz Augusto Azevedo de Almeida Hoffman, 2023, at Processo Administrativo nº 08012.006043/2008-37 (Apartado de Acesso Restrito nº 08700.002352/2016-90).

13 The time series was compiled using the real average price deflated to December 2013 constant values.

4 DATA SOURCES

Information on the cartel's characteristics, its operating period, and the participating distribution and retail firms was obtained from public documents in Administrative Proceeding No. 08012.006043/2008-37. To estimate the overcharge, this study used price series for 13 kg LPG cylinders (LPG P13) provided by the Agência Nacional do Petróleo (ANP). The sample covers May 2004 through December 2013, thereby including three years before the cartel, three years during the collusive period, and three years after the antitrust intervention. Since the price data are reported weekly, they were aggregated to monthly averages to ensure temporal comparability in the subsequent econometric analyses.

The Brent price, a benchmark for crude oil, was obtained from Ipeadata at a daily frequency in US dollars and then aggregated to monthly averages. Next, the exchange rate was retrieved from the same source and also averaged monthly. The monthly Brent price in Brazilian reais was calculated by multiplying the average monthly barrel price in dollars by the corresponding average exchange rate.

ICMS data were also extracted from the ANP portal, which provides monthly series of average LPG prices, ICMS components, and gross distribution and retail margins. According to ANP, the ICMS amount is calculated based on the rates set by state governments. GDP data used in the analysis come from Ipeadata and are organized at a monthly frequency, which requires no additional transformation and enables more precise measurement of macroeconomic effects over time.

The following tables present descriptive statistics for the variables used to estimate the cartel overcharge. Tables 1 and 2 correspond to the before and after model, while Table 3 represents the difference in differences model.

The values of LPG, Brent, and GDP were converted to December 2013 constant prices using the National Broad Consumer Price Index. The monthly IPCA rates were obtained from the Brazilian Institute of Geography and Statistics (IBGE). The following tables present descriptive statistics for the variables employed in the overcharge estimation. Tables 2 and 3 report descriptive statistics for the before and after analysis, while Table 4 presents the corresponding descriptive statistics structured under the difference in differences framework.

Table 2 - Descriptive Statistics for the Before and After Approach - in December 2013 Brazilian Reais (LPG and Brent)

Pre-cartel			**During-cartel**		**Post-intervention**	
Variables	**LPG**	**Brent**	**LPG**	**Brent**	**LPG**	**Brent**
Mean	51,02	201,53	50,05	191,2	44,35	219,32
Standard Deviation	1,9	17,8	2,67	48,4	2,66	28,98
Minimum	47,05	167,23	45,76	128,66	40,87	162,48
Maximum	53,87	237,6	55,18	285,79	52,11	264,87

Source: ANP and Ipea data. Author's calculations.

Table 3 – Descriptive Statistics for the Before and After Approach - in December 2013 Brazilian Reais (ICMS[14] and GDP[15])

Pre-cartel			During-cartel		Post-intervention	
Variables	**ICMS**	**GDP**	**ICMS**	**GDP**	**ICMS**	**GDP**
Mean	4,12	294.107,64	4,61	355.240,95	4,98	431.492,15
Standard Deviation	0,13	233,21	0,35	203,48	0,29	233,97
Minimum	3,94	252.626,92	3,94	318.556,03	4,46	387.567,23
Maximum	4,47	341.723,84	5,2	396.413,87	5,45	473.552,50

Source: ANP and Ipea data. Author's calculations.

Tables 2 and 3 from the before and after model show that the average LPG price declined from 50.05 reais during the cartel to 44.35 reais in the subsequent period, while the Brent price rose from 191.2 reais to 219.3 reais per barrel. This inverse movement suggests that the decrease in the LPG price was not driven by international cost pressures but by the dissolution of the collusion. Brent volatility, measured by a standard deviation of 48.4 reais during the cartel, contrasts with the relative stability of LPG at 2.67 reais, reinforcing the view of artificially rigid prices. Meanwhile the average ICMS rate increased gradually from 4.12 reais to 4.98 reais but exhibited limited variation, and real GDP grew from 294 billion reais to 431 billion reais, indicating economic expansion that alone would not explain the drop in the final consumer price.

Table 4 – Descriptive Statistics for the Difference-in-Differences (in December 2013 Brazilian Reais)

Period without cartel			Cartel period	
Cartel retailers		**Non-cartel retailers**	**Cartel retailers**	**Non-cartel retailers**
Mean	48,13	47,50	50,02	49,42
Standard Deviation	5,07	5,01	4,52	3,96
Minimum	38,35	34,69	38,7	38,06
Maximum	57,54	58,29	57,5	57,86

Source: ANP. Author's calculations.

In Table 4, cartel retailers charged an average of R$ 48.13 outside the collusive period and R$ 50.02 during it, while non-cartel retailers posted prices of R$ 47.50 and R$ 49.42, respectively. The absolute gap between the two groups decreases slightly from R$ 0.63 to R$ 0.60, confirming a cartel-related premium even after accounting for common supply and demand shocks. Moreover, the standard deviation among cartel retailers falls from 5.07 to 4.52, indicating stronger price convergence within the treated group, a hallmark of collusive coordination.

RESULTS

In this section, the set of cartel overcharge estimates is presented, obtained through two distinct methodologies: before and after and difference in differences. Each approach was chosen

14 ICMS is the average cost in BRL per 13-kg cylinder, obtained by applying the specific BRL-per-kilogram rate to LPG.

15 Real GDP is expressed in millions of Brazilian reais (R$ millions), deflated to December 2013 price levels.

to capture specific aspects of the cartel's impact on LPG prices, enabling a more comprehensive and accurate analysis. The results of each modeling exercise are then detailed, with emphasis on key considerations and on comparing the performance of both methods.

Table 5 - Results of the before and after approach

	(1)	(2)	(3)	(4)	(5)
Constant	3.8603*** (0.0085)	4.9211* (0.2249)	4.5651*** (0.0911)	7.8829*** (0.3705)	8.4017*** (0.6074)
Cartel	0.0514*** (0.0170)	0.0278*** (0.0163)	0.0578*** (0.0138)	0.0500*** (0.0119)	0.0363*** (0.0120)
Log (Brent)	-	-0.1985*** (0.0420)	-	-	-0.1089*** (0.0326)
Log (ICMS-DF)	-	-	-0.4661*** (0.0601)	-	0.0578 (0.1063)
Log (GDP)	-	-	-	-0.3147*** (0.0289)	-0.3165*** (0.0608)
Observations	116	116	116	116	116
Adjusted R^2	0.0660	0.2129	0.3849	0.5388	0.5788

Source: ANP. Author's calculations. Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1. The dependent variable is the log of the LPG price.

Table 5 presents five specifications of the before and after approach, each gradually adding controls to assess the robustness of the overcharge estimate. In model (1), which includes only the Cartel dummy, the coefficient of 0.0514 implies a 5.3% increase in the real LPG price during the collusion. The inclusion of Brent in model (2) reduces this effect to 2.8% and yields a negative coefficient for log (Brent) (–0.1985), likely reflecting the lag in passing international cost changes through to domestic prices. In model (3), ICMS is added; the overcharge rises back to 5.9% but the tax coefficient appears negative, a consequence of the ICMS rate remaining essentially constant throughout the period, which results in limited informative variability and collinearity with the underlying price trend.

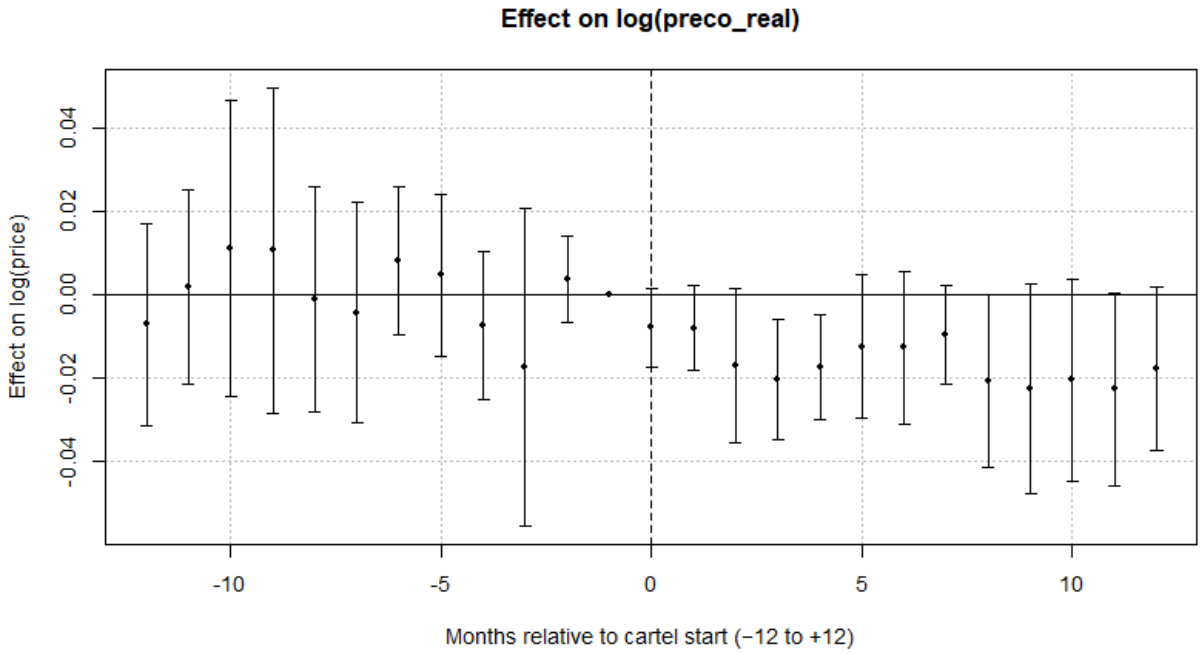
Model (4) introduces only GDP as a proxy for aggregate demand. The estimated overcharge is 5.13%, but the coefficient on log (GDP) is negative and statistically significant at –0.3147, indicating that a 1% increase in economic activity is associated with an approximate 0.31% reduction in the real LPG price, which runs counter to theoretical expectations. Finally, model (5) includes Brent, ICMS and GDP together. The coefficient on the Cartel dummy falls to 0.0363, equivalent to a 3.7% overcharge, while the adjusted R^2 rises to 0.579. In this full specification, both Brent and GDP retain negative and significant coefficients, but ICMS loses statistical significance, suggesting that international cost and macroeconomic variables capture most of the long-run price trend, whereas the nearly constant state tax adds little new explanatory power. Taken together, the five models demonstrate that, regardless of the control variables included, the collusion led to a price increase between 3% and 6%, confirming its economic relevance.

To assess the plausibility of the parallel-trends assumption, an event-study model was estimated within a DID framework. Graph 2 presents the estimated coefficients, where the horizontal axis shows the months relative to the treatment period (with zero as the reference month) and the vertical axis displays the estimated effects on the logarithm of LPG prices. The pre-treatment coefficients are small and statistically indistinguishable from zero, indicating that the price dynamics

of treated and control units evolved similarly before the intervention. This result reinforces the validity of the common-trend assumption required for causal identification. After the treatment begins, the estimated effects remain close to zero or slightly negative for a few months, suggesting the absence of an immediate price response. This pattern is consistent with the interpretation that the cartel required some time to coordinate its pricing behavior, **or may suggest** that the formal start date (December 2007) does not perfectly coincide with the moment when collusive practices began to affect the market.

Graph 1, in turn, shows the evolution of average real LPG prices between 2004 and 2014, highlighting the beginning and end of the collusive period. Prices declined shortly after December 2007, which may reflect temporary instability or market adjustments preceding the cartel's effective coordination. This behavior helps interpret the slightly negative coefficients observed in the first few months after treatment. Taken together, these patterns confirm the adequacy of the control group, which follows a trajectory similar to the treated units before the intervention and constitutes a valid counterfactual for identifying the cartel's effects on prices.

Graph 2 - Dynamic Effects of the LPG Cartel - Event-Study Estimates



Source: ANP. Author's calculations. Estimates from a TWFE model with neighborhood and month fixed effects, using only treated units. Periods beyond seven months before and after treatment are binned.

Table 6 reports four difference-in-differences[16] specifications estimated with clustered standard errors and distinct sets of fixed effects. Model (1) includes only the treatment × period interaction and clusters errors at the retailer level; the coefficient of 0.04220 implies an overcharge of 4.31%. Model (2) adds bairro fixed effects while retaining the same clustering level, causing the overcharge to fall to 3.79%. Model (3) introduces município fixed effects and clusters at the município level, raising the overcharge to 4.56%. Finally, Model (4) incorporates both bairro and município fixed

16 The analysis was conducted using the R package *fixest*.

effects, with standard errors clustered by bairro. The estimated coefficient for the treatment-period interaction is 0.0366, corresponding to an overcharge of 3.73%. Taken together, the four estimates show that accounting for different degrees of spatial heterogeneity changes the point estimate only marginally, and all specifications confirm a substantial economic impact of the cartel on LPG prices. Finally, Model (5) adds time fixed effects and keeps standard errors clustered by neighborhood, controlling for aggregate shocks and structural differences across locations. The estimated coefficient of 0.0085 is positive but not significant, indicating that, after accounting for spatial and temporal heterogeneity, the average impact of the cartel on prices is no longer statistically different from zero.

Table 6 – Results of the Difference-in-Differences Model

	(1)	(2)	(3)	(4)	(5)
Constant	3.8660***	-	-	-	-
	(0.0040)				
DID (Cartel* Time)	0.0422***	0.0372**	0.0445**	0.0366**	0.0085
	(0.0150)	(0.0146)	(0.0136)	(0.0145)	(0.0101)
Neighborhood Fixed Effect	No	Yes	No	Yes	Yes
Municipality Fixed Effect	No	No	Yes	Yes	Yes
Time Fixed Effect	No	No	No	Yes	Yes
Observations	22.786	22.692	22.786	22.692	22.692
Adjusted R^2	0.0023	0.2622	0.1004	0.2790	0.8025

Source: ANP. Author's calculations. Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1. The dependent variable is the log of the LGP price.

The overcharges estimated in this study, obtained through both the before-and-after and DID approaches, range from 3.7% to 6.0%, depending on the specification and control variables included. These magnitudes are consistent with evidence reported in several national and international cartel cases. Afonso and Féres (2017) find higher overcharges for the LPG cartel in Pará, between 10% and 17%, while Laitenberger and Smuda (2015) report similar magnitudes for the detergent cartel in Europe, with damages between 6.7% and 6.9%. Fernandes and Jesus Júnior (2023) also detect strong price alignment and reduced volatility in the LPG market of Mato Grosso do Sul, reinforcing the hypothesis that collusion tends to stabilize and raise prices. Results of intermediate magnitude were found by Resende and Malan (2024) in the fuel cartel in Belo Horizonte, with average overcharges of 0.52% for gasoline and 1.53% for ethanol, along with increased retail margins. Motta and Resende (2020), in turn, estimate significant consumer benefits resulting from Cade's intervention against the fuel cartel in the Federal District, ranging from R$ 206 million to R$ 2.15 billion, depending on the assumed duration of the conspiracy. Taken together, these studies suggest that while the magnitude of harm varies according to each market's structure and scope, the signs of coordination and overpricing are consistent, corroborating the price-increasing pattern observed in this work.

Several studies indicate that dismantling a cartel does not necessarily lead to an immediate or lasting reduction in prices. Grezzana (2016) shows that, although retail fuel prices in Brazil briefly declined following cartel investigations, the effect was short-lived and price dispersion across stations remained unchanged. Bolotova and Connor (2008), in turn, analyze the effectiveness of sanctions imposed on international cartels and conclude that, on average, penalties are smaller than the illicit

gains obtained during collusion, which limits deterrence and delays the restoration of competition. Taken together, these findings suggest that cartel-dismantling policies do not always translate into immediate consumer welfare gains, as many markets exhibit price rigidity, institutional inertia, and structural barriers that hinder a swift return to competitive conditions.

6 CONCLUDING REMARKS

This study estimated the overcharge imposed by the LPG cartel in the Federal District and its surrounding areas, which operated from 2008 to 2010 and was sanctioned by Cade in 2023. Two complementary empirical approaches were employed. The before-and-after strategy indicated overcharges between 2.82% and 5.95%, while the DID models produced estimates ranging from 3.73% to 4.56%. However, when time fixed effects were included to control for aggregate shocks and spatial heterogeneity, the estimated effect lost statistical significance, indicating that the result is not robust under more restrictive specifications, although it does not rule out the existence of a relevant economic impact. Overall, the findings highlight the importance of Cade's intervention in halting the coordinated conduct and restoring competitive conditions in the LPG market.

By combining two complementary identification strategies and exploiting rich microdata, this study contributes to the empirical literature on cartel damage estimation in emerging markets. Some methodological limitations merit attention. The first concerns the precise demarcation of the cartel's duration. An inaccurate definition of this interval can lead to under - or overestimation of the overcharge. Therefore, the study adopts the period from December 2007 to the launch of Operação Júpiter in April 2010 in order to approximate as closely as possible the cartel's actual lifespan.

Another important limitation relates to the definition and empirical validation of the control group. Although the analysis treats the Federal District as the intervention area and the surrounding regions as the control, no systematic verification was conducted to confirm that these neighboring localities remained effectively unexposed to the cartel's influence. The absence of such a check may lead to contamination ("spillover") issues if coordinated pricing practices extended to nearby municipalities. Moreover, while selecting geographically contiguous areas can ensure structural similarity, it may also introduce unwanted spatial correlation, potentially biasing causal identification. In this regard, future versions of the analysis could explore alternative approaches, such as using non-contiguous but comparable areas as a control group, applying a synthetic control method as a robustness check, or adopting propensity-score or matching-based DID strategies to better balance observable characteristics between treated and untreated units.

The second limitation stems from the quality and availability of LPG price series in Brazil. The data provided by ANP do not continuously track the same retailers over the entire sample period, which hinders precise measurement of the damages. This issue underscores the need to expand the collection and public release of microdata not only by ANP but also by other institutions in order to support more robust economic assessments.

Cade's intervention proved decisive in the highly relevant household liquefied petroleum gas market, dismantling the collusive agreement and restoring competitive conditions, with direct benefits for consumer welfare. This study contributes to the debate on cartel-imposed losses by quantifying the overcharge in an essential market. By measuring the damage caused by price

manipulation, the analysis underscores the importance of preserving competition and strengthening the role of regulatory authorities.

REFERENCES

AFONSO, Nathalie Gressler; FÉRES, José. Cartel damage evaluation: a case study of the liquefied petroleum gas sector in Pará, Brazil. *In:* ENCONTRO NACIONAL DE ECONOMIA, 45., 2017, Natal. **Anais** [...]. Niterói: Anpec, 2017. Available at: https://www.anpec.org.br/encontro/2017/submissao/files_I/i8-0295bd1f49b93d5f1c87cf78a505f303.pdf. Accessed on: Oct. 12, 2024.

ALVES, Carlos Alberto; TIERGARTEN, Michele. A relação entre varejo e distribuição na cadeia do GLP: analisando as estratégias de cooperação e de alianças. **Revista Ibero Americana de Estratégia**, v. 7, n. 2, p. 101-109, 2008. DOI: https://doi.org/10.5585/ijsm.v7i2.977. Available at: https://periodicos.uninove.br/riae/article/view/13132/6584. Accessed on: Oct. 12, 2024.

ANGRIST, Joshua David; PISCHKE, Jörn-Steffen. **Mostly Harmless Econometrics**: An Empiricist's Companion. Princeton: Princeton University Press, 2009.

BOLOTOVA, Yuliya; CONNOR, John M. Cartel sanctions: An empirical analysis. **SSRN**, 2008. DOI: https://dx.doi.org/10.2139/ssrn.1116421. Available at: https://x.gd/tqt7r. Accessed on: Oct. 12, 2024.

BRASIL. **Lei nº 12.529, de 30 de novembro de 2011**. Estrutura o Sistema Brasileiro de Defesa da Concorrência; [...] e dá outras providências. Brasília, DF: Presidência da República, 2011. Available at: https://www.planalto.gov.br/ccivil_03/_ato2011-2014/2011/lei/l12529.htm. Accessed on: June 1, 2024.

BRASIL. **Lei nº 8.137, de 27 de dezembro de 1990**. Define crimes contra a ordem tributária, econômica e contra as relações de consumo, e dá outras providências. Brasília, DF: Presidência da República, 1990. Available at: https://www.planalto.gov.br/ccivil_03/leis/l8137.htm. Accessed on: Oct. 12, 2024.

CONNOR, John M.; BOLOTOVA, Yuliya. Cartel overcharges: Survey and meta-analysis. **International Journal of Industrial Organization**, v. 24, n. 6, p. 1109-1137, 2006. DOI: https://doi.org/10.1016/j.ijindorg.2006.04.003. Available at: https://x.gd/fOoKQ. Accessed on: Oct. 12, 2024.

CONSELHO ADMINISTRATIVO DE DEFESA ECONÔMICA (Cade). **Ata da 219ª Sessão Ordinária de Julgamento**. Brasília, DF: Cade, 2023. Available at: https://x.gd/bU6KD. Accessed on: Oct. 12, 2024.

DOMINGUES, Jayna Carolina Nobre. **Análise do impacto do decreto 31.066/2012 na arrecadação do ICMS no comércio varejista e atacadista de produtos de informática**. 2017. Dissertação (Mestrado em Economia) - Universidade Federal do Ceará, Programa de Economia Profissional, Fortaleza, 2017. Available at: https://repositorio.ufc.br/bitstream/riufc/29089/1/2017_dis_jcndomingues.pdf. Accessed on: Oct. 10, 2024.

DOMOWITZ, Ian; HUBBARD, R. Glenn; PETERSEN, Bruce C. Business cycles and the relationship between concentration and price-cost margins. **The RAND Journal of Economics**, v. 17, n. 1, p. 1-17, 1986. DOI: https://doi.org/10.2307/2555624. Available at: https://x.gd/qo8vf. Accessed on: Oct. 12, 2024.

EMPRESA DE PESQUISA ENERGÉTICA (EPE). **Formação de Preço do Gás Liquefeito de Petróleo no Mercado Brasileiro**: Nota Técnica. Rio de Janeiro: Empresa de Pesquisa Energética, 2024. Available at: https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-413/topico-712/NT-EPE-DPG-SDB-2024-02_GLP_2024.05.13.pdf. Accessed on: Oct. 12, 2024.

ERUTKU, Can; HILDEBRAND, Vincent A. Conspiracy at the Pump. **The Journal of Law and Economics**, v. 53, n. 1, p. 223-237, 2010.

FERNANDES, Rosangela; JESUS JÚNIOR, Leonardo de. Indícios econômicos de cartel na revenda de GLP: o caso da operação "Laissez-Faire". **Revista de Defesa da Concorrência**, v. 11, n. 1, p. 25-46, 2023. DOI: https://doi.org/10.52896/rdc.v11i1.1022. Available at: https://x.gd/6EX4y. Accessed on: Oct. 12, 2024.

GOVINDA, Hariprasad; KHUMALO, Junior; MKHWANAZI, Siphamandla. On measuring the economic impact: savings to the consumer post cement cartel bust. *In*: ANNUAL CONFERENCE ON COMPETITION LAW, ECONOMICS AND POLICY, 8., 2014, Johannesburg. **Anais** [...]. Pretoria: The Competition Commission, 2014. Available at: http://compcom.co.za.www15.cpt4.host-h.net/wp-content/uploads/2014/09/On-measuring-the-economic-impact-savings-to-the-consumer-post-cement-cartel-burst-CC-15-Year-Conference.pdf. Accessed on: Oct. 12, 2024.

GREZZANA, Stefania. Lost In Time And Space: The Deterrence Effect Of Cartel Busts On The Retail Gasoline Market. *In*: ENCONTRO NACIONAL DE ECONOMIA, 43., 2015, Florianópolis. **Anais** [...]. Niterói: ANPEC, 2016. Available at: https://www.anpec.org.br/encontro/2015/submissao/files_I/i9-c070e8bef254632e19122e0965025f80.pdf. Accessed on: Oct. 12, 2024.

LAITENBERGER, Ulrich; SMUDA, Florian. Estimating consumer damages in cartel cases. **Journal of Competition Law & Economics**, v. 11, n. 4, p. 955-973, 2015. DOI: https://doi.org/10.1093/joclec/nhv030. Available at: https://x.gd/DaLEH. Accessed on: Oct. 21, 2024.

LEVENSTEIN, Margaret C.; SUSLOW, Valerie Y. What determines cartel success? **Journal of Economic Literature**, v. 44, n. 1, p. 43-95, 2006. Available at: https://www.jstor.org/stable/30032296. Accessed on: Oct. 21, 2024.

LUCINDA, Claudio; SEIXAS, Renato. **Prevenção Ótima de Cartéis**: o caso dos peróxidos no Brasil: Documento de Trabalho nº 02. Brasília: Conselho Administrativo de Defesa Econômica (Cade), 2016. Available at: https://x.gd/AsyeU. Accessed on: Oct. 21, 2024.

MOTTA, Lucas Varjão; RESENDE, Guilherme Mendes. **Mensurando os benefícios de combate a cartéis**: o caso do cartel de postos de combustíveis no Distrito Federal. Brasília: Conselho Administrativo de Defesa Econômica (Cade), 2020. Available at: https://x.gd/FaMjs. Accessed on: Oct. 21, 2024.

RESENDE, Guilherme Mendes; MALAN, Fabiane. Estimação de sobrepreço em cartéis: o caso do cartel de combustíveis na região metropolitana de Belo Horizonte/MG. **Revista de Defesa da Concorrência**, v. 12, n. 1, p. 55-86, 2024. DOI: https://doi.org/10.52896/rdc.v12i1.1084. Available at: https://x.gd/ciXS0. Accessed on: Oct. 13, 2024.

RESENDE, Guilherme Mendes; MOTTA, Lucas; LIMA, Ricardo. Mensurando os benefícios de combates a cartéis: o caso do cartel de britas. *In:* RESENDE, Guilherme Mendes; SACCARO JÚNIOR, Nilo Luiz; MENDONÇA, Mário Jorge (org.). **Avaliação de Políticas Públicas no Brasil**: uma análise das políticas de defesa da concorrência. Rio de Janeiro, IPEA, 2019. p. 115-147. DOI: http://dx.doi.org/10.38116/978-

65-5635-015-8cap4. Available at: https://x.gd/aQfYc. Accessed on: Oct. 13, 2024.

STIGLER, George J. A theory of oligopoly. **Journal of Political Economy**, v. 72, n. 1, p. 44-61, 1964. Available at: https://home.uchicago.edu/~vlima/courses/econ201/Stigler.pdf. Accessed on: Oct. 13, 2024.

TITO, Fabiana Ferreira de Mello. **Ensaios sobre danos de cartel**: metodologias de cálculo do sobrepreço, efeito repasse (pass-on) e multa ótima. 2018. Tese (Doutorado em Teoria Econômica) - Faculdade de Economia, Administração e Contabilidade, Universidade de São Paulo, São Paulo, 2018. DOI: 10.11606/T.12.2018.tde-21082018-150528. Available at: https://x.gd/p425s. Accessed on: Oct. 13, 2024.

VITALE, Cristiana; CARRIERI, Silvia. **Reference Guide on Ex-post Evaluation of Competition Agencies' Enforcement Decisions**. Paris: Organisation for Economic Cooperation and Development (OECD), 2016. Available at: https://www.oecd.org/content/dam/oecd/en/publications/reports/2016/04/reference-guide-on-ex-post-evaluation-of-competition-agencies-enforcement-decisions_d0990849/262476ff-en.pdf. Accessed on: Oct. 21, 2024.