3 PEERING THROUGH THE HAZE: DETECTING CARTEL SIGNS IN BRAZIL'S LPG RESALE MARKET[1]

Enxergando através da neblina: detectando sinais de cartel no mercado de revenda de GLP do Brasil

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STRUCTURED ABSTRACT

Objective: the aim of this article was to detect economic signs of cartel in the resale of LPG in the Brazilian cities of Campina Grande-PB, Caruaru-PE, Jaboatão dos Guararapes-PE, and Recife-PE; the first market condemned by the Administrative Council for Economic Defense (Cade).

Method: we used a filter suggested in Bolotova, Connor and Miller (2008) that consists of estimating an ARCH model and its generalization, a Generalized Autoregressive Conditional Heteroskedasticity (GARCH), to test the hypothesis that, during the cartel period, the average price is higher and its variance lower.

Conclusions: we showed that the average LPG price increased and the variance decreased during the cartel period in all cities we analyzed. We also corroborate the efficiency of the method, as the hypothesis of economic signs of cartel was not rejected for Campina Grande-PB.

Keywords: economic signs of cartel; economic filters; LPG resale market; collusion.

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RESUMO ESTRUTURADO

Objetivo: o objetivo deste artigo foi detectar indícios econômicos de cartel na revenda de GLP nas cidades brasileiras de Campina Grande-PB, Caruaru-PE, Jaboatão dos Guararapes-PE e Recife-PE; o primeiro mercado condenado pelo Conselho Administrativo de Defesa Econômica (Cade).

Método: utilizamos um filtro sugerido em Bolotova, Connor e Miller (2008) que consiste em estimar um modelo ARCH e sua generalização, a heterocedasticidade condicional autorregressiva generalizada (GARCH), para testar a hipótese de que, durante o período de cartel, o preço médio é maior e sua variância menor.

Conclusões: mostramos que o preço médio do GLP aumentou e a variância diminuiu durante o período de cartel em todas as cidades analisadas. Também corroboramos a eficiência do método, pois a hipótese de indícios econômicos de cartel não foi rejeitada para Campina Grande-PB.

Palavras-chave: indícios econômicos de cartel; filtros econômicos; mercado de revenda de GLP; conluio.

JEL codes: L4; L40; L41.

1 INTRODUCTION

In several countries, the antitrust law presumes that the cartel is harmful to consumers, as it promotes an increase in prices, reduces the supply of products on the market, their quality and competition between companies. For this reason, cartels are considered illegal acts per se by several jurisdictions (Malan; Resende, 2022). For Hovenkamp (2011), the overchange, the difference between the price of a product practiced in a cartelized environment and the one that should be charged if sold in a competitive market, is the main effect of the cartel. The results of empirical research carried out by Connor (2007), for example, showed that cartels generate, on average, an overchange of 25%.

Due to the social welfare losses generated by this anti-competitive conduct, the detection of cartels represents one of the most important tasks for competition authorities around the world, in addition to being one of their greatest challenges. As highlighted by Abrantes-Metz, Bajari and Murphy (2010), despite the absolute success of leniency programs, some cartels still remain undetected. Members of the collusion, fearing detection, often take steps to conceal their actions. Thus, due to the difficulties faced, antitrust agencies have sought alternative approaches to identify cartelized conducts. According to Abrantes-Metz and Bajari (2010), one of the alternative tools used is the economic filter for cartel detection.

For Abrantes-Metz and Bajari (2010), economic cartel filters seek to identify atypical or unlikely patterns in markets in competitive equilibrium. Abrantes-Metz, Bajari and Murphy (2010) point out that the use of modern statistical methodologies enables the discovery of conspiracies based on the anomalous patterns they generate in the data. Harrington Jr. (2008) adds that the application of filters

makes it possible to detect suspected collusive behavior, although it does not provide conclusive evidence of this conduct. In summary, they produce indirect proof, based on the use of economic data, to verify possible occurrences of cartels, in order to channel the action of the control agencies to possible cases of such an illicit act.

In this context, in recent years, there has been an expansion of studies that include the application of statistical methods, known in the literature as economic cartel filters, to detect the pattern of price behavior that prevails in markets where collusive anticompetitive conduct is practiced. According to Connor (2005), since the mid-1990s, several empirical studies have been motivated by discoveries of international cartels and sanctions established by antitrust agencies around the world. Bolotova, Connor and Miller (2008) highlighted that, in the past decades, researchers in the area of industrial organization have used available data and new econometric techniques to study cartels and test hypotheses based on theoretical literature.

Given the importance of economic cartel filters as an alternative tool for detecting cartels, the aim of this article was to spot the economic signs of cartel in the resale of Liquefied Petroleum Gas (LPG) in Campina Grande-PB, (a market recently condemned by Cade[5-6]), and Caruaru-PE, Jaboatão dos Guararapes-PE, and Recife-PE, (previously in the Administrative Proceeding (AP) 08700.003067/2009-67[7]). Therefore, we conduct an ex-post evaluation of the filter suggested by Bolotova, Connor, and Miller (2008), thus verifying its efficiency, based on its application for the resale of LPG in Campina Grande-PB, a market recently convicted of forming a cartel by the Brazilian antitrust agency. In other words, we seek to ascertain whether the results obtained are not subject to rejection of the cartel hypothesis, when the practice was detected by Cade.

In sum, we believe that the results found in this study show a behavior pattern in LPG resale prices consistent with what prevails in cartelized markets. In other words, we expect that the hypothesis raised in Bolotova, Connor and Miller (2008) that the average price is higher and its variance lower, during the cartel period, is not rejected. The acceptance of this hypothesis, for the results of Campina Grande-PB, makes it possible to corroborate the efficiency of the application of this methodology for the resale of LPG, as it shows that the detection of economic signs of cartel for this market is not subject to type II error (false negative). Abrantes-Metz and Bajari (2010) observe that, for a robust economic assessment of cartel economic evidence, the tests must have strong statistical power and minimize the number of false positives and negatives.

This study makes two significant contributions to the existing literature. Firstly, it employs an economic cartel detection filter, which has been little explored through this methodology in the Brazilian context. Secondly, the study's findings on a market already condemned by the Brazilian antitrust agency have the potential to validate the economic cartel filter proposed by Bolotova, Connor, and Miller (2008) in the Brazilian LPG market.

5 All Cade's cases mentioned in this article can be consulted at the following link: https://tinyurl.com/y7obr4z5.

6 The next section presents a historical summary regarding the Administrative Proceeding (AP) 08700.003067/2009-67.

7 Initially, in the Administrative Proceeding 08700.003067/2009-67, the investigation into the formation of cartels, in distribution and resale, in cities of the Ipojuca area was mentioned. This area comprises 408 municipalities although the price survey carried out by the National Petroleum Agency (ANP) involves only 31 municipalities. In addition, of these, 6 of them have at least 15 resale stations in operation: Caruaru-PE, Jaboatão dos Guararapes-PE, Recife-PE, Olinda-PE, Campina Grande-PB, and João Pessoa-PB. In this article, a priori, the analyses would be carried out for these 6 municipalities, however, Olinda-PE and João Pessoa-PB were excluded because the previous volatility test of the LPG price series showed that both municipalities did not have ARCH effect in these markets.

This study is divided into five sections, in addition to this introduction. In the second, a characterization of the structure and conduct of the LPG resale is described and a historical summary of the case involving the AP 08700.003067/2009-67 is shown. In the third, a brief theoretical approach on cartel economic filters is presented. In the fourth, the methodology is exposed. In the fifth, the results and discussion are presented and, in the sixth section, our concluding remarks.

2 LPG RESALE: STRUCTURE, CONDUCT, AND SUMMARY OF THE AP

The LPG is highly representative in the consumption basket of the Brazilian population, as it is the most used source of energy in cooking food. The northeastern region of Brazil, where the municipalities of Campina Grande-PB, Caruaru-PE, Jaboatão dos Guararapes-PE, and Recife-PE are located, represents the second largest LPG consumer market in the country, with 25% of national consumption, second only to the southeast region, which consumed 43% of LPG in 2020 (Sindigás, 2021). In 2020, the national demand for this product was 13.68 million m3, with 80.6% of this volume destined for domestic consumption (Empresa de Pesquisa Energética - EPE, 2021). In view of this, the practice of abusive LPG prices denotes a topic of considerable importance for society and object of monitoring by the antitrust authorities, due to the negative impacts generated on the social well-being. Colomer and Vernersbach (2022) point out that the final price of the LPG is the sum of the production/import value, taxes and distribution and resale margins. Therefore, it reflects to some extent the structure and competition dynamics of each stage of the Brazilian LPG industry.

In this section, we present a brief characterization of the LPG resale in Brazil, highlighting the structure and conduct of companies operating in this market segment. Next, a historical summary of the AP 08700.003067/2009-67, which involves the investigation into the cartel case, object of analysis of this study. Given that the focus of this article is the reseller market, which supplies homes, the bottled LPG with a capacity of 13 kilograms, that is, 13 kg cylinders or P-13 is considered the relevant product market, as defined by Cade. Cylinders with a capacity of P20 to P90 are part of the bulk market, which serves consumers who demand greater volumes of gas, such as commercial clients, small and medium-sized companies and, above all, the food, metallurgical and steel industries. In this case, it is the distributors that sell and deliver the LPG directly to the final consumer.

The LPG production chain is long and complex, made up of producers, importers, distributors and resellers. The last stage, the focus of this article, is responsible for the acquisition, storage, transport, and commercialization of the product in transportable containers. Resellers can be linked to a single distributor, using its brand, or independent, purchasing the product from more than one distributor. In this case, the distributors' brands cannot be displayed (Lodi; Bicalho, 2022).

The market structure of the LPG resale in Brazil is comprised of thousands of companies, most of which are small. According to Sindigás (2021), in 2020, there were 61,610 thousand authorized LPG dealers in the country, supplying 91% of Brazilian families. However, despite the fact that the Brazilian reseller market is atomized, for analyses of concentration acts and anticompetitive conducts involving the resale of LPG, Cade delimits the municipality as a relevant geographic market. For this reason, the number of resellers decreases considerably when compared to the national market. More recently, in the northeast region of the country, there exist nearly 12,707 authorized LPG resale points. Specifically, in the states of Paraíba and Pernambuco, the number of resellers reaches 1,080 and 1,604,

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respectively. In Campina Grande-PB, for instance, a relevant geographic market convicted of forming a cartel, there are 86 registered resellers (ANP, 2023).

The resale of LPG has characteristics that favor the adoption of cartel behavior, as it offers a homogeneous and essential product, in which there are no close substitutes, the cost structure is similar, there are regulatory barriers to entry, active action by unions and associations, and price advertising. In view of this, even in municipalities where there is a large number of dealerships operating, cartels may form as agents can make stable agreements, with the participation of unions or distributors that implement effective coordination, monitoring and punishment mechanisms.

Specifically, it appears in the documents of the AP 08700.003067/2009-67, that dealerships in the city of Campina Grande-PB and surroundings adopted cartel-like behavior with the support of employees of distributors and the Union of Fuel and Petroleum Derivatives Dealers of the interior of Paraíba – Sindirev. According to the information reported in Technical Note no. 66, because of the complexity of the LPG commercialization logistics chain, with its resale composed of a high number of agents and points of sale, a sophisticated monitoring and retaliation system was adopted against LPG resellers or subordinate employees who disrespected the agreements of price fixing and division of the reseller market.

Regarding the AP 08700.003067/2009-67, the case began in 2009, with a representation from the ANP and, later, investigations were initiated by the Federal Police and the Public Prosecution Service of several states of the Northeast region. The Federal Police, in partnership with the Secretariat of Economic Law of the Ministry of Justice (SDE/MJ) and the Public Prosecutor's Office of the state of Paraíba, launched the "Operação Chama Azul" or Blue Flame Operation in March 2010, when several search, seizure and temporary arrest warrants in several states. After the filing of the criminal action, before the Justice of Paraíba, Cade obtained the sharing of the evidence related to the alleged anticompetitive practices, which included telephone interceptions and documents seized in the offices of the investigated companies.

According to the findings of the investigation, the accused organized themselves to restrict competition through price fixing, division of product distribution and resale markets. Cade concluded that the dealers exchanged commercially sensitive information to promote the artificial regulation of the LPG market and facilitate the maintenance of the alleged cartels. The evidence presented in the lawsuit revealed that the cartel reached the resale of LPG in Paraíba and, also, reached the distribution market of several Northeastern states. In this context, the companies Nacional Gás Butano Distribuidora, Revendedora de Gás da Paraíba, and Frazão Distribuidora de Gás were convicted, in August 2022, of forming a cartel in the LPG distribution and resale market.

3 THEORETICAL CONSIDERATIONS ON ECONOMIC FILTERS FOR CARTEL DETECTION

This section seeks to present a general theoretical view of economic cartel filters used to identify the behavior pattern of companies that operate in markets where this anticompetitive conduct is likely to occur. As the literature on the subject is dense, especially the international one, the focus in this section is to lay out a brief theoretical foundation associated with the empirical model used in this article, as a tool for detecting economic signs of cartel.

Cartels are considered one of the most harmful anticompetitive conducts to society, as there are no efficiency gains associated with this practice. Furthermore, the secret nature of the agreements makes their detection and investigation a major challenge. According to Cuiabano et al. (2014), due to the difficulties faced by antitrust authorities in obtaining clear proof regarding a cartel, economic filters can offer additional evidence for the existence of a possible conspiracy. In addition, the use of filtering techniques can help antitrust authorities to initiate investigations in markets where there are still no formal complaints.

In recent years, there has been significant progress in the development of tools capable of detecting economic signs of cartel in sectors where this conduct is likely to occur. Silveira et al. (2021) highlighted that the literature on economic cartel filters has been growing considerably and the study of Bolotova, Connor and Miller (2008) represents one of the most notable contributions to the literature. One of the advantages of the model used by these authors is that it only demands the price series of the product commercialized in the stage of the productive chain investigated. Thus, it makes it possible to carry out the analysis in the absence of information regarding costs, for example, relying solely on the prices charged by distributors.

In their study, the authors used a price volatility model, with the introduction of a dummy variable, during the cartel period, aiming to detect the effect of the conspiracy, known or hypothetical, on the prices of citric acid and lysine markets in the United States, from 1990 to 1997, and from 1990 to 1996, respectively. The authors sought to test the hypothesis that average prices, during the cartel period, are comparatively higher than in the pre- and post-conspiracy periods and that the price variance, during the collusion, is lower than in other periods. Their results confirmed the hypothesis of higher price and lower variance, during the conspiracy period, for the lysine market. However, it was not possible to corroborate a lower variance for the citric acid market.

Another notable contribution to the literature, which is based on a hypothesis similar to that adopted in Bolotova, Connor and Miller (2008), with a different technique, however, is the article developed by Abrantes-Metz et al. (2006). These authors investigated economic evidence of cartel at 279 gas stations in Louisville, United States, from 1996 to 2002. To do so, they used a filter to detect economic evidence of cartels, based on the variation coefficient of prices over time, defined by the ratio between the *standard* deviation and the average price. Their results suggested that the variation in price was comparatively smaller during the period of the cartel, and, after the discovery of the cartel, excluding the transition from collusion to non-collusion, there was an increase in price variance.

Harrington Jr. and Chen (2006) also assume that when companies are involved in a cartel, average prices increase and their variance decreases. Thus, the behavior of cartel participants is divided into two stages. In the first, there is a gradual increase in prices, that does not follow the oscillations in costs, maintaining the growth trend. This increase must appear to be a natural increase and therefore allow the justification that the increase in prices occurred due to intrinsic market conditions. In the second stage, prices are stabilized, as, after reaching the collusive equilibrium point, firms readjust them proportionally to cost variations. Nevertheless, prices fluctuate less than costs when compared to the competitive market.

There are two types of economic filters for detecting cartel evidence, structural and behavioral. The former seeks to identify markets that have characteristics considered conducive to collusive behavior. In this case, cartels probably occur in sectors where the number of companies is relatively

small, the products offered are homogeneous and the demand is more stable. The behavioral approach, however, aims to verify the means by which companies coordinate and the result of such a coordination (Harrington Jr., 2008). According to the Organization for Economic Cooperation and Development (OECD) (2013), behavioral filters attempt to identify patterns of unusual and unexplained behavior that may indicate that a cartel is active. Aaltio (2019) stresses that neither approach provides a definitive answer on the cartelized conduct of companies, but the behavioral one is more satisfactory in terms of causality.

Although there exist several methods to empirically investigate cartels, behavioral economic filters, based on price dynamics, allow us to obtain consistent indications regarding this conduct. Price is an accessible variable, because of its interaction with the consumer and is frequently revealed so that negotiations take place. In the short term, it is sensitive to agents' behavioral changes. Moreover, for cartel members, it is difficult to determine quantity as a cooperation aim, since, unless the company is willing to provide its sales and production figures to cartel participants, this information is difficult to access. In this context, price is the control variable within the cartel and, consequently, an element conducive to filtering (Harrington Jr., 2008).

Regarding the identification of collusion, Harrington Jr. (2008) points out that behavioral economic filters can be applied using the screening and verification techniques. In the first, the filter evaluates the possible conspiracy before it is detected while in the second, it analyzes the economic conspiracy during its existence, that is, cases confirmed by the antitrust agency.

In short, the theoretical and empirical findings in the literature allow us to try and spot different pricing patterns associated with the existence of economic signs of a cartel[8]. However, as emphasized in Froeb et al. (2015), in economics there is still no universal methodology that makes it possible to detect it. On the other hand, Harrington Jr. (2006) points out that economic analyses can play a significant role in detecting cartels, stimulating political discussions and academic research.

4 METHODOLOGY

To achieve the aim of this study, firstly, we estimated the ARCH model for a cartel case in the resale of LPG, recently condemned by Cade, referring to the AP 08700.003067/2009-67. Our findings enabled us to determine the effectiveness of the economic filter in detecting indicators of cartel behavior. After that, we applied the methodology to other relevant geographic markets that were previously mentioned in the AP. In all cases, we intended to verify whether the average LPG prices practiced in those municipalities were higher and their variance lower during the cartel period, thus suggesting economic signs of a cartel.

8 The following features represent price markers for detecting cartels in the literature: i) Very low price variances are indicative of a stable cartel; ii) High and inconstant variances over time would be associated with cartels with punitive measures; iii) Non-linear price variations to cost adjustments, in particular, the drop in upstream prices not being passed on in the same proportion or with the same timeliness as the increase in costs; iv) Pricing parameters in relation to costs are different in collusive and competitive markets, which can result in relatively higher profit margins in cartel sectors (Carrijo, 2019).

a Price volatility model according to the approach in Bolotova, Connor and Miller (2008)

There are various filtering methodologies in the literature that allow for the detection of economic signs of a cartel. However, in the context of this study, we apply the filter introduced by Bolotova, Connor, and Miller (2008) as it is adequate to test whether there was an increase in the average price of LPG and a decrease in its variance during the cartel period, as stated in the AP 08700.003067/2009-67. Additionally, this method is suitable because it only requires the price series of the product commercialized in the investigated production chain stage. Therefore, the method proposed by Bolotova, Connor, and Miller (2008) enables us to conduct an investigation in the absence of information on costs, such as the prices charged by distributors. In this section, we present the price volatility model proposed in Bolotova, Connor, and Miller (2008).

The methodology applied by these authors consists of estimating an ARCH model and its generalization, a Generalized Autoregressive Conditional Heteroskedasticity (GARCH), to test the hypothesis that, during the cartel period, the average price is higher and its variance lower.

Formally, the ARCH model allows us to model the conditional variance of the series, simultaneously, with the mean (Hamilton, 1994). Assuming that the conditional variance is not constant, we estimated an AR(m) process using the square of the estimated residual, as shown in equation (1):

$$\hat{u}_t^2 = \alpha_0 + \alpha_1 \hat{u}_{t-1}^2 + \cdots + \alpha_m \hat{u}_{t-m}^2 + v_t \quad (1)$$

where $\boldsymbol{v_t}$ is a new "white noise", with $E(v_t)=0$ and $E(v_t, v_s)=\lambda^2$, for all $t = s$, and 0 otherwise.

Equation (1) is an ARCH process of order m, denoted by $u_t \sim ARCH(m)$. Thus, the linear projection of the squared error of the prediction of Y_t, from the previous q squared predicted errors, is defined by:

$$\hat{E}(\hat{u}_t^2 | u_{t-1}^2, u_{t-2}^2) = \alpha_0 + \alpha_1 \hat{u}_{t-1}^2 + \alpha_2 \hat{u}_{t-2}^2 \ldots + \alpha_q \hat{u}_{t-m}^2 + v_t \quad (2)$$

The GARCH model, proposed by Bollerslev (1996), denotes an extension of the ARCH model and allows the use of a larger lag structure, aiming to capture impacts that possibly occurred in the past. Furthermore, it can be used to describe volatility with fewer parameters than ARCH. Formally, the GARCH variance equation is represented by:

$$h_t = \alpha_0 + \delta_1 h_{t-1} + \delta_2 h_{t-2} + \cdots + \delta_r h_{t-r} + \alpha_1 u_{t-1}^2 + \cdots + \alpha_m u_{t-m}^2 \quad (3)$$

where $u_t=\sqrt{h_t}$ and v_t is independent and identically distributed (iid) with zero mean and unitary variance. The sufficient condition of stationarity (regularity) requires $k > 0$, $\delta i \geq 0$ for all $i \leq r$, $\alpha j \geq 0$ for all $j \leq m$ and $\sum^r_t \delta_t + \sum^m_{t=1} \alpha_t \leq 1$. The calculation of the sequence of conditional variances $\{ht\}$ for t = 1...T requires its pre-sample values. Typically, they are calculated as a sample mean of the squared predicted residuals for each pre-sample observation in the T-sequence (Bollerslev, 1996; Hamilton, 1994).

Bolotova, Connor and Miller (2008) used a specification of the volatility models, ARCH and GARCH, which includes a cartel dummy variable in the mean and variance equations, as well as a

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variable of an interaction between the lagged price and the cartel dummy. The sum of the coefficient of the cartel dummy variable of the average equation and the coefficient of the interaction variable quantifies the increase in the LPG resale price during the period in which the dealers maintained the cartelized conduct.

In this article, we estimated an ARCH model, according to the econometric specification used by Bolotova, Connor and Miller (2008). The cartel dummy variable equaled 1, for the cartel period from January 2008 to March 2010, and zero otherwise.

For the mean equation, we expected the coefficient of the cartel dummy variable to show a positive and statistically significant coefficient, suggesting that, during the cartel period, there was an increase in the price of LPG in the municipalities analyzed. On the other hand, in the variance equation, we expected a negative and statistically significant coefficient, showing a decrease in price variability.

b Data

In this article, weekly data on average LPG prices[9] practiced in resale in the cities of Campina Grande-PB, Caruaru-PE, Jaboatão dos Guararapes-PE, and Recife-PE, from May 2004 to May 2020 were used. These data come from the database of the ANP - Price Survey website

The full period of analysis was chosen due to data availability. The time cut for the occurrence of the cartel, from January 2008 to March 2010, was defined according to the information cited in the documents of the AP 08700.003067/2009-67. The price volatility models as well as other tests were estimated in Eviews 10.

5 RESULTS

The detection of cartels has been one of the most relevant and challenging tasks for antitrust agencies around the world. Even with the advancement and success of leniency programs, some cartels still go undetected. According to Galindo (2018), the illegality of cartels makes them highly confidential, which makes it difficult to prove their existence. Due to the difficulties faced, economic cartel filters can be used as an alternative tool for detecting economic evidence of this anticompetitive conduct.

The limitations faced by antitrust agencies to spot and punish cartels also reflects, to a certain extent, a research problem in the field of Industrial Economics. In view of this, researches with applications for the detection of economic signs of a cartel have been gaining relevance in the international and national literature. Silveira et al. (2021) observe that, in recent decades, problems to detect cartels have led to a new relevant field of research.

In this context, this study aimed to try and identify the economic signs of cartel in the resale of LPG in Campina Grande-PB, a market recently condemned by Cade, and in Caruaru-PE, Jaboatão dos Guararapes-PE, and Recife-PE. These cities were mentioned previously in the AP 08700.003067/2009-67, which was instituted to investigate the resale and distribution of LPG in the northeast region of Brazil.

9 A limitation of this research relates to the use of municipal data on average weekly LPG resale prices, released by the ANP, which provide information that may include LPG prices practiced by resellers that, eventually, did not participate in the collusion.

In Brazil, the distribution and resale of LPG have been the object of investigations into the formation of cartels by competition antitrust agencies, because of the number of complaints about suspected practice of such a conduct. In recent years, there has been a significant increase in LPG prices in several municipalities in the country. Specifically, with regard to the relevant geographic markets under analysis, the upward trend in LPG resale prices from May 2004 to May 2020 can be observed in graphs 1A, 3A, 5A and 7A (see appendix). It is noteworthy that the increase in the price of this product is a topic of particular importance for society because of the implications that abusive pricing practices have on social well-being. For this reason, it is important to analyze the behavior pattern of the prices practiced in these markets to verify whether they are consistent with the one that prevails in cartelized settings.

Finally, in the next section, we present the econometric results obtained by estimating the price volatility model, which allowed testing the hypothesis raised in Bolotova, Connor and Miller (2008). This hypothesis verifies whether the average LPG resale prices in the municipalities we analyze increased and if their variances decreased during the cartel period. Additionally, the estimated model also allows us to obtain a quantification of the increase in prices, in the markets where this pattern of behavior was observed.

a Detection of economic signs of cartel based on the approach of Bolotova, Connor and Miller (2008)

This section presents the results of applying the ARCH price volatility model with the introduction of the cartel dummy variable in the mean and variance equations, as well as the insertion of the interaction variable, the LPG lagged price and the cartel dummy variable, in the LPG reseller market in the cities of Campina Grande-PB, Caruaru-PE, Jaboatão dos Guararapes-PE, and Recife-PE.

First, the Augmented Dickey-Fuller (ADF) unit root test was applied and the results showed that the series of LPG resale prices, in the first difference, were stationary, (see Table 1A in appendix). To verify whether these series were likely to be modeled through the price volatility model, we performed the ARCH test. The results suggested rejection of the null hypothesis; therefore, the series presented statistical evidence of conditional variance (see Table 2A in appendix). To obtain consistent estimates, we used the first difference of the LPG resale price series.

Table 1 reports the results of the ARCH price volatility model estimated for the resale of LPG in Campina Grande-PB, Caruaru-PE, Jaboatão dos Guararapes-PE, and Recife-PE from May 2004 to March 2020.

Table 1 – Results of the ARCH price volatility model estimated for the mean and variance of resale LPG prices in Campina Grande-PB, Caruaru-PE, Jaboatão dos Guararapes-PE, and Recife-PE

	Campina Grande-PB	Caruaru-PE	Jaboatão dos Guararapes-PE	Recife-PE
Mean equation				
Cartel dummy	**3.03648*** **	**4.91922*** **	**0.82085*** **	**0.63771** **
Standard error	0.40114	1.10969	0.26873	0.30056
PR(-1)* Cartel dummy	**-0.08783*** **	**-0.14648*** **	**-0.02265*** **	**-0.01714***
Standard error	0.01233	0.03416	0.00811	0.01001
AR(1)	-0.31032***	0.02001NS	-0.59329***	-0.53279***
Standard error	0.04915	0.05996	0.02690	0.02530
Variance equation				
Intercept	0.26119***	0.94499***	0.45413***	0.62508***
Standard error	0.00245	0.00818	0.01168	0.00729
Residual (-1)2	0.29197***	-0.00605***	0.90399***	0.64957***
Standard error	0.03836	0.00001	0.08020	0.05749
Cartel dummy	**-0.12861*** **	**-0.63224*** **	**-0.11005*** **	**-0.35540*** **
Standard error	0.01249	0.02048	0.03585	0.02387

Note: ***, **, and * indicates statistical significance at the 1%, 5%, and 10% level, respectively. NS denotes statistically not different from zero.

Source: Research results.

The results showed that most estimated coefficients were statistically significant and showed signs consistent with the assumptions of the model of Bolotova, Connor and Miller (2008).

The cartel dummy variable, inserted in the average equations of the municipalities we analyzed, was positive and statistically significant, suggesting that, from January 2008 to March 2010, the average LPG resale price, during the cartel period, was relatively higher than than the average of LPG prices, in the period in which it did not occur. The sum of the coefficient of the cartel dummy variable and the coefficient of the interaction variable reflects the increase in the LPG price during the cartel period. Therefore, increases in LPG resale prices were R$ 2.95 in Campina Grande-PB; R$ 4.77 in Caruaru-PE; R$ 0.82 in Jaboatão dos Guararapes-PE, and R$ 0.62 in Recife-PE.

Regarding the variance equations, the estimated coefficients for the cartel dummy were all negative and statistically different from zero, showing that, during the cartel period, there was less volatility in LPG prices. In other words, there was a greater alignment of LPG resale prices in all the municipalities we evaluated.

Our results allow us to observe that during the cartel period the average LPG resale prices, in the analyzed municipalities, increased and their variances decreased. Thus, the application of this filter made it possible to obtain estimates of the behavior pattern of LPG resale prices, in these municipalities, consistent with that prevailing in markets where stable cartels exist. Specifically, the results obtained for Campina Grande-PB corroborate the efficiency of applying the filter for analysis of LPG resale prices, as this municipality has been recently condemned by Cade. In other words, the application of the filter

to detect economic signs of a cartel was not subject to type II error (false negative).

According to the information reported in the AP 08700.003067/2009-67, the resellers Frazão Distribuidora, Gás do Brasil, and Gás da Paraíba were condemned in the LPG resale market, as there was evidence that the price increases practiced in the resale of LPG were due to the formation of a cartel. Also, in the records of this AP, there are strong indications that the Sindirev coordinated periodic meetings to exert influence over LPG resellers in Campina Grande-PB and region. The LPG distributors also affected the adoption of uniform commercial conduct between competitors, facilitating price fixing agreements and the exchange of commercially sensitive information. In addition, the distributors were responsible for taking action against resellers who deviated from the price alignment conduct, and for monitoring the behavior of other market agents (Cade, 2022).

In sum, the behavioral filter, used in this article, showed that there are economic signs of a cartel in the cities of Campina Grande-PB, Caruaru-PE, Jaboatão dos Guararapes-PE, and Recife-PE. The application of this method, for a market condemned by Cade, corroborates the model of Bolotova, Connor and Miller (2008) for the analysis of economic signs of cartel in the resale of LPG. Moreover, the filter detected a pattern of price behavior consistent with that prevailing in stable cartels, in cities that were not condemned, but mentioned, in the aforementioned AP.

We expect that the results of this study can encourage and guide future analyses of this nature, for other relevant geographic markets as well as for different segments of the petroleum derivatives production chain, with similar characteristics to those of the LPG market. Also, our results emphasize that the Brazilian antitrust agency remains attentive to the conduct of LPG resellers.

6 CONCLUDING REMARKS

The social welfare losses resulting from cartel behavior make detecting cartels one of the most important tasks for antitrust agencies. Nonetheless, many times, it has also been one of its biggest challenges. Consequently, because of the difficulties faced, economic cartel filters emerge as alternative tools to investigate the behavior pattern of companies that may be involved in a cartel.

In view of the pertinence of using filters for the investigation of economic evidence of cartel, this article aimed to detect economic signs of cartel in the resale of LPG in Campina Grande-PB, Caruaru-PE, Jaboatão dos Guararapes-PE, and Recife-PE, the first market recently condemned by Cade.

To achieve the aim of this study, we applied an ARCH price volatility model with a cartel dummy variable in the mean and variance equations, as well as the interaction variable, the LPG lagged price and the cartel dummy, in the LPG reseller market of the cities under analysis.

Our findings indicated that the coefficients for the cartel dummy variable included in the mean equations for all municipalities were both positive and statistically significant. This indicates that from January 2008 to March 2010 the average LPG resale price was relatively higher in the cartel period than during the non-cartel period. Regarding the increase in prices, during the cartel period, we found that Caruaru-PE had the highest increase in average LPG prices, R$ 4.77; followed by Campina Grande-PB, R$2.95; Jaboatão dos Guararapes-PE, R$0.82; and Recife-PE, R$ 0.62.

Our analysis of the variance equations revealed that the estimated coefficients for the cartel dummy variable were consistently negative and statistically significant. This suggests that during the

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cartel period, there was less variability in LPG prices, resulting in greater alignment of resale prices across all municipalities included in our study.

Therefore, we conclude from the application of the filter, that there are economic signs of cartel in the analyzed cities. Our application of this method to a market that has been sanctioned by Cade confirmed the economic indicators of cartel behavior in the LPG resale sector. This suggests that the use of the filter to detect such behavior in this market is unlikely to result in type II error (false negative). Furthermore, our analysis revealed a consistent pattern of pricing behavior in cities that were not subject to sanctions but were included in the AP.

In short, given the harmful effects associated with cartel-like conduct, we expect that the Brazilian antitrust agency remains attentive to the behavior of LPG resellers. We note that even in cities where the number of participants is sufficiently high, the formation of a cartel can be guaranteed by effective coordination, monitoring, and punishing mechanisms for misconduct. In addition, unions and distributors can act to influence the formation and maintenance of the cartel.

Moreover, the findings of this study could serve as a basis for future research on similar segments of the petroleum derivatives production chain in other relevant geographic markets, building upon the characteristics observed in the LPG market.

REFERENCES

AALTIO, Aapo. **Competition or collusion?** Screening the Finnish road maintenance Market. 2019. Master's thesis (MSc in Finance and Economics) - Hanken School of Economics, Helsinki, 2019. Available at: https://tinyurl.com/276pvwkr. Retrieved: May 2, 2023.

ABRANTES-METZ, Rosa M.; BAJARI, Patrick. Screen for Conspiracies and their Multiple Applications. **Competition Policy International**, *[s. l.]*, v. 6, n. 2, p. 129-144, 2010. Available at: https://tinyurl.com/ynwfg75n. Retrieved: May 2, 2023.

ABRANTES-METZ, Rosa M.; BAJARI, Patrick; MURPHY, Joe. Antitrust Screening: Making Compliance Programs Robust. **SSRN**, *[s. l.]*, 2010. Available at: https://dx.doi.org/10.2139/ssrn.1648948. Retrieved: May 2, 2023.

ABRANTES-METZ, Rosa M.; FROEB, Luke M.; GEWEKE, John; TAYLOR, Christopher T. A variance screen for collusion. **International Journal of Industrial Organization**, [s. l], v. 24, n. 3, p. 467-486, 2006. Available at: https://doi.org/10.1016/j.ijindorg.2005.10.003. Retrieved: Jul 20, 2023.

AGÊNCIA NACIONAL DE PETRÓLEO, GÁS NATURAL E BIOCOMBUSTÍVEIS (ANP). **Painel dinâmico:** Processo cadastral de revendas de combustíveis e de GLP. Agência Nacional do Petróleo, Gás Natural e Biocombustíveis: Rio de Janeiro, 2023. Available at: https://tinyurl.com/2d67eod7. Retrieved: Jul 21, 2023.

BOLLERSLEV, Tim. Generalize Autoregressive Conditional Heteroskedasticity **Journal of Econometrics**, *[s. l.]*, v. 31, n. 3, p. 307-327, 1986. Available at: https://doi.org/10.1016/0304-4076(86)90063-1. Retrieved: Dec 9, 2022.

BOLOTOVA, Yuliya; CONNOR, John M.; MILLER, Douglas J. The impact of collusion on price behavior: empirical results from two recent cases. **International Journal of Industrial Organization**, *[s. l.]*, v. 26, n. 6, p. 1290-1307, 2008. Available at: https://doi.org/10.1016/j.ijindorg.2007.12.008. Retrieved: Jul 12, 2023.

CARRIJO, Gustavo Dantas. **Análise estatística dos preços de combustíveis para auxílio na detecção de cartéis no setor de distribuição.** 2019. Thesis (MBA in Governance and Regulation Control in Infrastructure) - Escola Nacional de Administração Pública, Brasília, 2019. Available at: https://tinyurl.com/237wg2l7. Retrieved: Jun 30, 2023.

CONNOR, John M. Collusion and price dispersion. **Applied Economics Letters**, *[s. l.]*, v. 12, n. 6, p. 335-338, 2005. Available at: https://doi.org/10.1080/13504850500068061. Retrieved: Jun 30, 2023.

CONNOR, John M. Price-Fixing Overcharges: Legal and Economic Evidence. **Research in Law and Economics**, *[s. l.]*, v. 22, p. 59-153, 2007. Available at: http://dx.doi.org/10.1016/S0193-5895(06)22004-9. Retrieved: May 4, 2023.

CONSELHO ADMINISTRATIVO DE DEFESA ECONÔMICA (Cade). Cade condena cartel no mercado de distribuição e revenda de gás de cozinha no Nordeste. **Conselho Administrativo de Defesa Econômica**, Brasília, 19 out. 2022. Available at: https://tinyurl.com/28s4ymky. Retrieved on: Feb 7, 2023.

CUIABANO, Simone; LEANDRO, Tainá; OLIVEIRA, Glauco; BOGOSSIAN, Paula. Filtrando cartéis: a contribuição da literatura econômica na identificação de comportamentos colusivos. **Revista de Defesa da Concorrência**, Brasília, v. 2, n. 2, p. 43-63, 2014. Available at: https://tinyurl.com/2ctnnyza. Retrieved: Dec 22, 2023.

COLOMER, Marcelo; VERNERSBACH, Aldren. Comportamento dos preços do GLP no Brasil: uma análise nacional e regional. In: PINTO JUNIOR, Helder; COLOMER, Marcelo (ed.). **Mercados de combustíveis e GLP, questões de regulação setorial e de concorrência**. Rio de Janeiro: Sindigás. 2022. p. 185-216.

EMPRESA DE PESQUISA ENERGÉTICA (EPE). **Balanço Energético Nacional 2021.** Rio de Janeiro: Empresa de Pesquisa Energética, 2021. Available at: https://tinyurl.com/27kfz8uz. Retrieved: Feb 7, 2023.

FROEB, Luke; SIBLEY, David; DOANE, Michael; PINTO, Brijesh. Screening for collusion as a problem of inference. In: BLAIR, Roger; SOKOL, Daniel (ed.). **The Oxford Handbook of International Antitrust Economics II**. Oxford: Oxford University Press, 2015. p. 523-553.

GALINDO, Carmen García. **Essays on cartels and competition policy**. 2018. Doctoral dissertation (DSc in Economics) - European University Institute, Florence, 2018. Availble at: https://tinyurl.com/2cpozo3a. Retrieved: Feb 8, 2023.

HAMILTON, James. **Time Series Analysis**. New Jersey: Princeton University Press. 1994.

HARRINGTON JR., Joseph E. Behavioral screening and the detection of cartels. In: EU COMPETITION LAW AND POLICY WORKSHOP, 2006, Florence. **Proceedings** [...]. Florence: European University Institute, 2006. Available at: https://tinyurl.com/25otyfcg. Retrieved on: Aug 23, 2024.

HARRINGTON JR., Joseph E. Detecting cartels. In: BUCCIROSSI, Paolo (ed.). **Handbook in Antitrust Economics**. Cambridge: MIT Press. 2008. p. 213-258.

HARRINGTON JR., Joseph E.; CHEN, Joe. Cartel pricing dynamics with cost variability and endogenous buyer detection. **International Journal of Industrial Organization**, *[s. l.]*, v. 24, n. 6, p. 1185-1212, 2006. Available at: http://dx.doi.org/10.1016/j.ijindorg.2006.04.012. Retrieved on: Jan 25, 2023.

HOVENKAMP, Herbert J. **Quantification of Harm in Private Antitrust Actions in the United States**. Philadelphia: University of Pennsylvania, 2011. Available at: https://tinyurl.com/2de9ljhn. Retrieved on: Jan 17, 2023.

LODI, Carlos Felipe; BICALHO, Lucia Navegantes. Padrão de concorrência e estruturas dos mercados regionais de GLP. In: PINTO JUNIOR, Helder; COLOMER, Marcelo (org.). **Mercados de combustíveis e GLP, questões de regulação setorial e de concorrência**. Rio de Janeiro: Sindigás, 2022. p. 114-126. Available at: https://tinyurl.com/2492b9gy. Retrieved on: Jan 17, 2023.

MALAN, Fabiane Fernandes Hanones; RESENDE, Guilherme Mendes. **Estimação de sobrepreço em cartéis:** o caso do cartel de combustíveis na região metropolitana de Belo Horizonte-MG: Documento de Trabalho nº 007/2022. Brasília: **Conselho Administrativo de Defesa Econômica**, 2022. Available at: https://tinyurl.com/28jwna6z. Retrieved on: Jan 16, 2023.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD). **Ex-officio cartel investigations and the use of screens to detect cartels.** Paris: Organisation for Economic Co-operation and Development, 2013. (Series Roundtables on Competition Policy, 147). Available at: https://tinyurl.com/2aqdhbjk. Retrieved on: Feb 10, 2023.

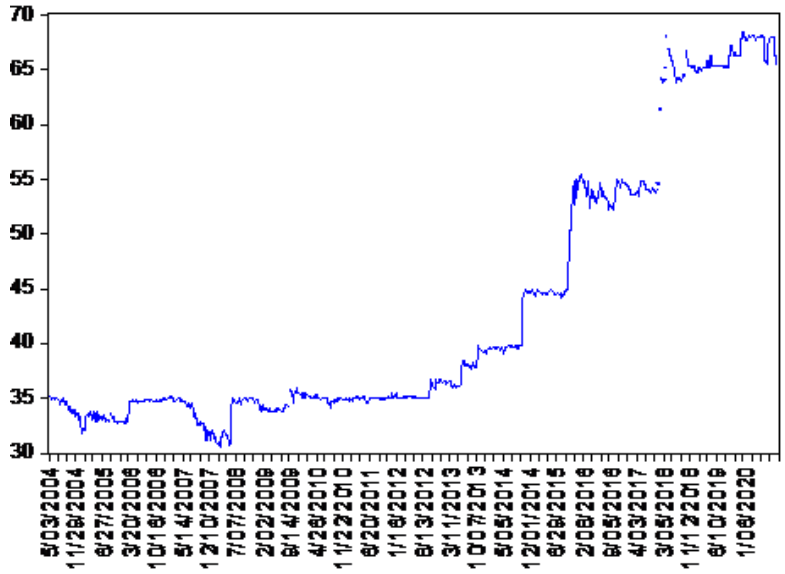
SILVEIRA, Douglas; VASCONCELOS, Silvinha; BOGOSSIAN, Paula; NETO, Joaquim. Cartel Screening in the Brazilian Fuel Retail Market. **Economia**, Niterói, v. 22, n. 1, p. 53-70, 2021. Available at: https://doi.org/10.1016/j.econ.2021.01.001. Retrieved on: Jan 10, 2023.

SINDIGÁS. **Panorama do Setor de GLP em Movimento**. Rio de Janeiro: Sindigás, 2021. Available at: https://tinyurl.com/2ct64pv9. Retrieved on: Aug 22, 2023.

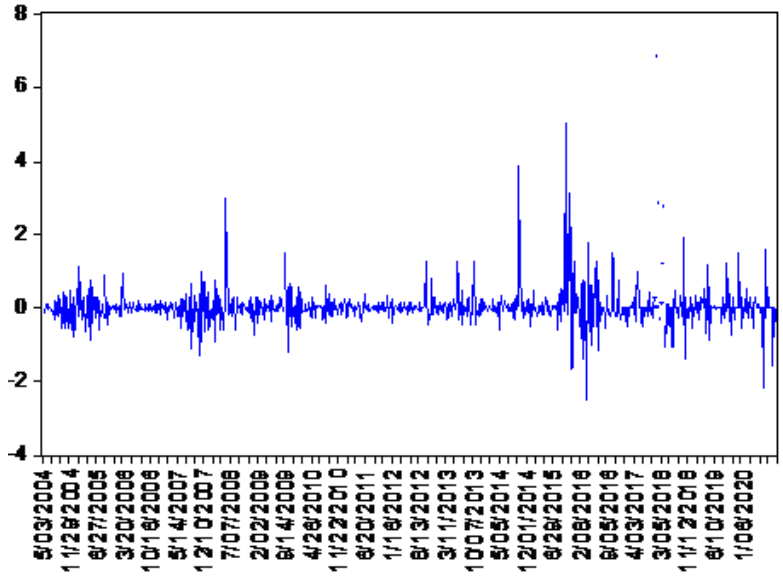
APPENDIX

Campina Grande - PB

Graph 1A – LPG price

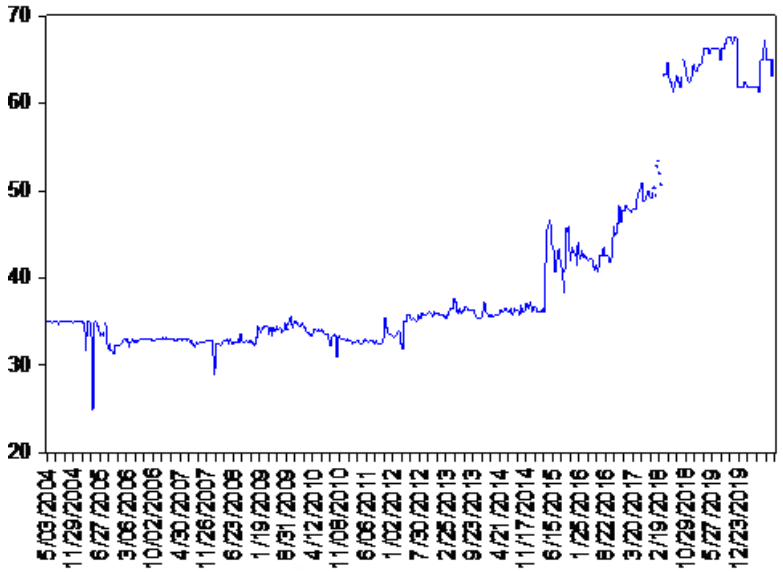


Graph 2A – First difference of LPG price

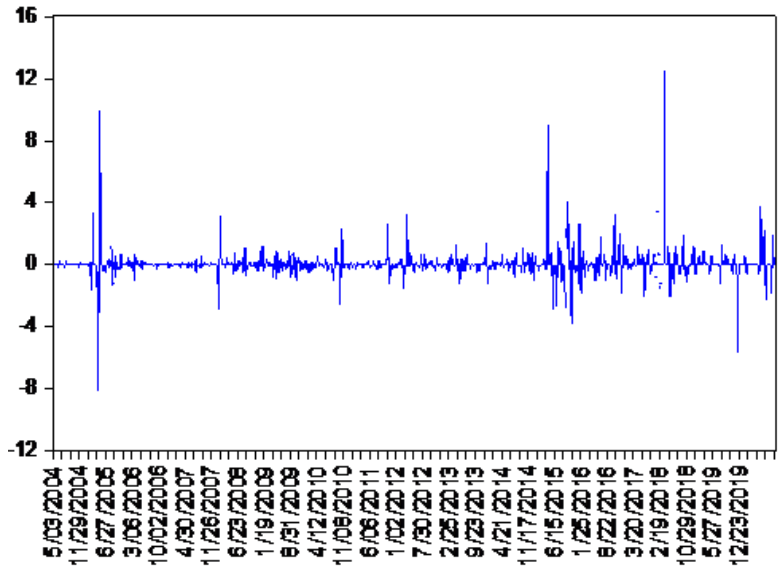


Caruaru – PE

Graph 3A – LPG price

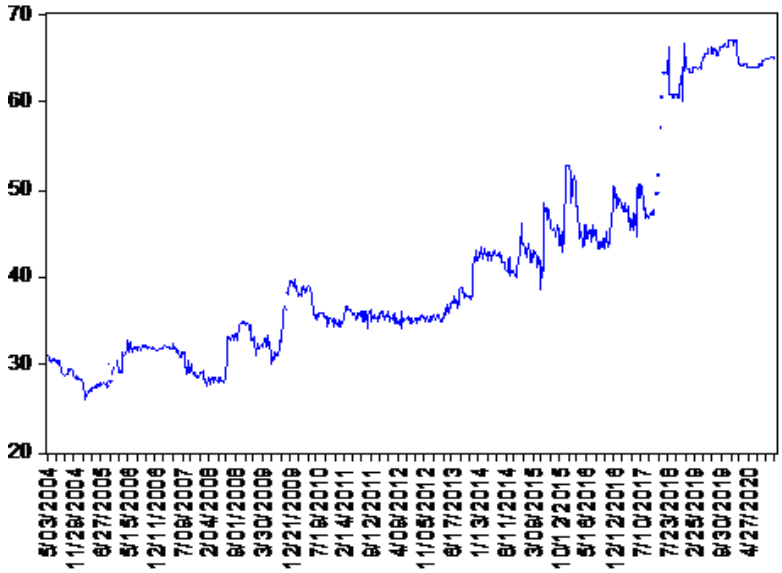


Graph 4A – First difference of LPG price

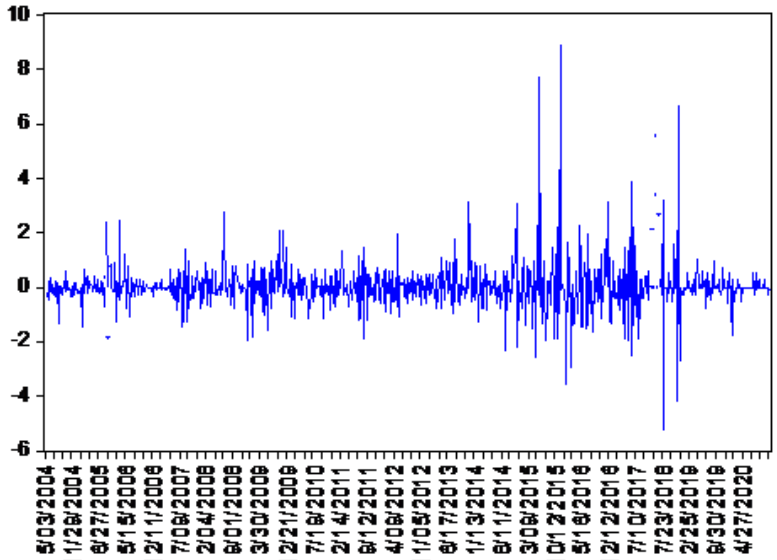


Jaboatão dos Guararapes – PE

Graph 5A – LPG price

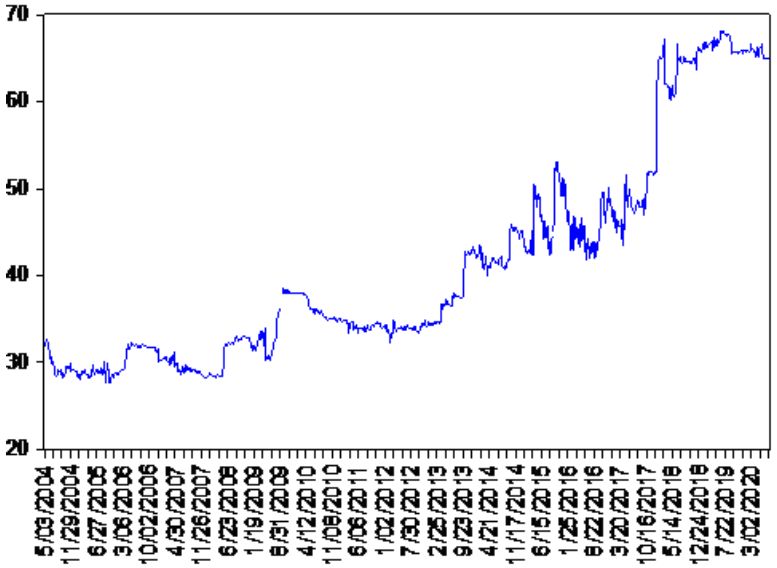


Graph 6A – First difference of LPG price

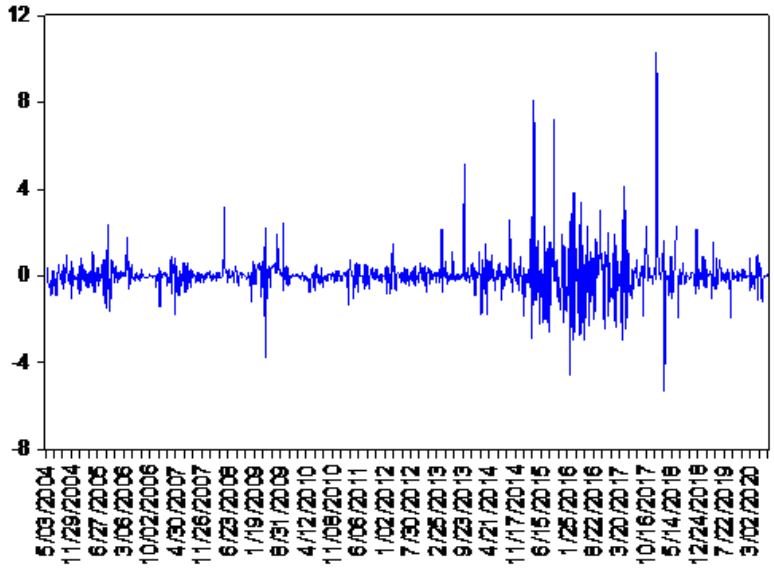


Recife - PE

Graph 7A – LPG price



Graph 8A – First difference of LPG price



Source: Research results.

Table 1A – Unit root test (ADF) in the series of LPG prices charged by resellers in Campina Grande-PB, Caruaru-PE, Jaboatão dos Guararapes-PE, and Recife-PE

Variable	Test statistic	Probability
PRCampina Grande	-1.832898	0.6879
Δ PRCampina Grande	-18.49327	0.0000
PRCaruaru	-1.789599	0.7092
ΔPRCaruaru	-24.75071	0.0000
PRJaboatão dos Guararapes	-2.481758	0.3372
Δ PRJaboatão dos Guararapes	-32.75392	0.0000
PRRecife	-2.468093	0.3441
ΔPRRecife	-37.04887	0.0000

Source: Research results.

Table 2A – Heteroskedasticity test (ARCH effect) on the first difference of the LPG price series practiced by resellers in Campina Grande-PB, Caruaru-PE, Jaboatão dos Guararapes-PE, and Recife-PE

Variable	Test statistic	Probability
Δ PRCampina Grande	5.270288	0.0053
ΔPRCaruaru	8.934143	0.0001
Δ PRJaboatão dos Guararapes	3.677579	0.0257
ΔPRRecife	2.382070	0.0930

Source: Research results.

Table 3A – Serial correlation test of the residuals on the first difference of the LPG price series practiced by resellers in Campina Grande-PB, Caruaru-PE, Jaboatão dos Guararapes-PE, and Recife-PE

Variable	Test statistic	Probability
Δ PRCampina Grande	16.1710	0.0000
ΔPRCaruaru	16.9331	0.0000
Δ PRJaboatão dos Guararapes	9.2465	0.0001
ΔPRRecife	28.0926	0.0000

Source: Research results.