CARTEL DAMAGE EVALUATION: A CASE STUDY OF THE LIQUEFIED PETROLEUM GAS SECTOR IN PARÁ, BRAZIL

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Abstract

Collusive practices carried out by cartels have proven to be extremely harmful to economic efficiency and social welfare. Cartel detection and damage evaluation have become a priority among antitrust agencies around the world. However, both are challenging tasks. In particular, economists and regulators have different views on how to define cartel damage and on the most appropriate methodology to estimate it. This paper aims at comparing the performance of different damage evaluation methodologies applied to the liquefied petroleum gas cartel in Pará state, Brazil. Cartel damages were estimated by a multivariate regression method and by a difference-in-differences approach. Our results suggest that estimated damages are sensitive to the chosen methodology, with estimated price overcharge ranging from 10% to 17%.

Keywords: antitrust, cartel, damage evaluation

JEL classification: L41

Resumo

As práticas colusivas utilizadas pelos cartéis são extremamente prejudiciais à eficiência econômica e ao bem-estar social. A detecção de cartéis e a avaliação de seus danos tornaram-se uma prioridade das agências antitruste em todo o mundo. No entanto, estas duas práticas encontram uma série de desafios. Em particular, os economistas e reguladores divergem tanto na definição do conceito de dano quanto na metodologia de seu cálculo. Este artigo tem por objetivo avaliar o desempenho de diferentes metodologias de cálculo de dano a partir do caso do cartel de gás liquefeito de petróleo no estado do Pará.Os danos foram calculados através dos métodos de regressão multivariada e de diferenças-em-diferenças. Os resultados sugerem que os danos estimados são sensíveis à metodologia escolhida, com os sobrepeços estimados variando entre 10% e 17%.

Palavras-chave: defesa da concorrência, cartel, avaliação de danos.

Classificação JEL: L41

Área ANPEC: 08 – Microeconomia, Métodos Quantitativos e Finanças

1. Introduction

Collusive practices used by cartels have proven to be extremely harmful to economic efficiency and social welfare. The act of two or more competing firms to coordinate decisions allows them to earn higher profits than they would have in a competitive environment. By forming a cartel, firms aim at maximizing their joint profits. In such cases, the colluding firms may exercise market power by increasing price above marginal costs and consequently decreasing supply below the competitive equilibrium (Davis and Garcés, 2010). Not only does this decreases total welfare generated by the market, but it also allows cartel firms to appropriate most of the consumer surplus.

Detecting these kind of practices has become a priority within antitrust agencies around the world. Most countries have created laws that prohibit firms from coordinating with their competitors in order to decrease competition. However, detecting collusion is not so straightforward as one might think. According to Harrington (2004), there are two general ways of detecting a cartel: observing the means by which firms coordinate and observing its final result. It is a very data-intensive and time-consuming process since it involves estimating a competitive benchmark and comparing it to the behavior of the suspected infringers.

In addition, since colluding is highly lucrative when successful, it is attractive for firms to engage in the practice when they see an opportunity. In a study performed by Ivaldi et al. (2016), on average, competition authorities do not recuperate excess profits gained by cartel members, even in developed countries. Therefore, regulators try to find effective ways to punish companies so that the costs of colluding outweighs its benefits. These punishments usually come in the form of fines or compensation payments that are calculated based on the estimated damages caused by the colluding firm. However, imposing a penalty that is too high can have a contrary effect, undermining the firm's ability to be an efficient market player, hindering the main objective of bringing the economy back to fair competition. Therefore, antitrust agencies must balance these two objectives.

A lot of controversy has surfaced concerning the role of the antitrust agency in calculating the estimated damages. Some experts argue that the sole role for an antitrust agency is to implement a fine to punish the infringers. Others argue that in order to set an appropriate fine, regulators must be able to calculate the estimated damage cause by the collusion.

Calculating damages caused by a cartel is an important step in the direction of establishing an appropriate level of compensation to award the plaintiff or estimating the illegal profits obtained by the cartelized industry so to impose a fine. The nature of damages calculation will depend on the legal framework in place; each country have different provisions as regarding to who can bring a claim and to what kind of damages may be vindicated[1]. It will also depend on the type of data that is available and the time and human resource constraints in each case. When selecting a suitable approach to calculate estimated damages, analysts will have to aim for a method that can lead to accurate results without hindering practicality and at the same time taking into consideration the legal constraints, such as information asymmetry and burden of proof.
This paper aims at comparing the performance of different damage evaluation methodologies applied to the liquefied petroleum gas distribution market in Pará state, Brazil. Cartel damages were estimated by a multivariate regression method and by a difference-in-differences approach. Our results suggest that estimated damages are sensitive to the chosen methodology, with estimated price overcharge ranging from 10% to 17%.

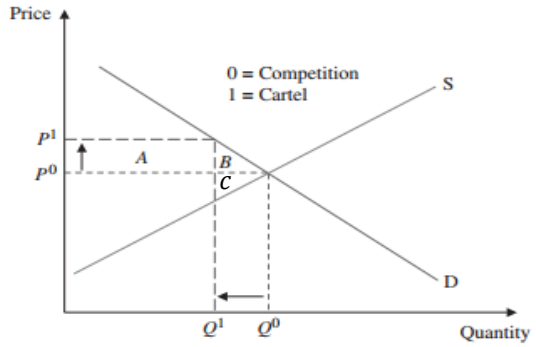
[1] Clark, E. et al, "Study on the Conditions of Claims for Damages in Case of Infringement of EC Competition Rules: Analysis of Economic Models for the Calculation of Damages." Ashurt, 2004.

The paper is organized in the following way. After this introduction, the second section discusses the microeconomic foundations of cartel damage evaluation.

1. *Cartel damage evaluation: microeconomic foundations*

We consider a situation where the cartelized good is sold directly to the final consumer. Cartel damages can be calculated by estimating the difference between the price actually practiced during the cartel and the price that would have been charged if the cartel hadn't existed - the so-called "counterfactual". On Figure 1 we have price represented by the vertical y-axis and quantity by the horizontal x-axis. The graph shows the observed prices and quantities implemented by the cartel, p^1 and Q^1, and the estimated counterfactual prices and quantities, p^0 and Q^0 that would have been observed had there not been a cartel.

Figure 1: Cartel Damage



Source: Davis and Garcés (2010)

The areas of rectangles A and B represent the total estimated damage incurred by consumers. Rectangle A represents the transfer of consumer surplus to the producer additional profits and B the deadweight loss from goods that would have been sold at p^0 but are no longer sold at p^1. Equation 1 illustrates the rent transfer from the consumer to the producer:

$$A = (p^1 - p^0) \times Q^1 \qquad (1)$$

The term (p^1 - p^0) in equation 1 refers to the "price overcharge": consumers will pay p^1 instead of p^0 and purchase quantity Q^1 instead of Q^0. In other words, consumers are charged a higher price than they would have been under competition and have a lower quantity available in the market. By adding the two areas, you get the total damage to consumer from the cartel. Triangle C, on the other hand, represents the deadweight loss to the producer, or what it could have sold at p^0 but didn't at p^1.

Deadweight loss is inefficient because it restricts the output available in the economy and pushes out of the market potential consumers, who would be willing to purchase the good at the price interval [p^0, p^1]. The producer also suffers with the deadweight loss, however, since the transfer in consumer surplus to the producer (area A) is always larger than the deadweight loss to the supplier (area C), the cartel is still worthwhile for them. While the deadweight loss is considered a problem by antitrust authorities, it is rarely included in the damage calculations due to the difficulty of accurately measuring it. In order to calculate the total amount of deadweight loss, one has to estimate five elements caused by the infringement: (i) the market output with the violation; (ii) the amount of the overcharge; (iii) what the market output would have been in a violation-free world; (iv) the price that would have been charged had there not been the violation; (v) the

shape of the demand curve between (i) and (iii) (Leslie, 2006). In particular, items (iv) and (v) pose a seriously challenge, since they require the analyst to estimate the elasticity of demand.

Some scholars argue that trebling actual damages may serve as a surrogate measure to actually calculating the deadweight loss[2]. Others argue that if antitrust violators are not held accountable for the deadweight loss their actions inflict on consumers and the market, the damages owed would be an insufficient deterrent[3].

Determining which concepts should be incorporated in the process of calculating the damages is essential. The first and foremost step requires that the antitrust authority defines the concept of "damages". The anticompetitive price overcharge has frequently been key for computing damages claims, but simply using overcharge to quantify damage might seriously underestimate the true damage caused by a cartel. Looking solely at the overcharge to the direct customer of the cartel does not take into consideration the deadweight loss and ignores the loss of total welfare. The calculation could also become more complex if one considers the potential dynamic effects. These effects might increase damages if a competitive environment could have contributed positively to technological advances. On the other hand, it could mitigate damages if the higher profits earned by the cartelized firms contributed to higher investments in R&D[4].

Since these effects are far too complex to be measured, they are usually ignored by the empirical literature when calculating damages. For the purposes of this study, we will exclude the deadweight loss from the damages calculation.

2. Empirical Methods in Cartel Damage Evaluation

When deciding on which approach will best be suited to estimate the damages, analyst face trade-offs that have to be taken into consideration during the empirical economic analysis. While some trade-offs are related to the economic methodology itself, others concern the legal constraints, such as the burden of proof, that will define the economic approach.

The first and main concern when calculating the counterfactual in cartel cases is to be as accurate and close to the truth as possible. In order to get there, experts have to balance the trade-off between accuracy and practicality[5]. Quantifying the effects of a collusive conduct requires the creation of a counterfactual scenario, where you try to estimate what the prices would have been if there had been no cartel. The closer to the real world a model gets the more complex it becomes. In statistical terms, accuracy can be defined as being correct on average and precise. Being correct on average is not the same as being close to the truth; you could be greatly over or underestimating the true value of the damages in one case and still be statistically correct on average. This is why one also has to consider the precision of the calculation, or how close to the truth is the estimate. Note that it is better to have a biased and precise estimate than to have an unbiased but imprecise one. The more economic assumptions that is employed in the calculation the more precise the estimation will be. However, if the assumptions are incorrect, you will obtain biased results.

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[2] The employment of trebling in place of actually calculating the damages caused by the deadweight loss is still a very controversial issue among scholars. While some argue that trebling damages can mitigate the effect of DWL, others argue that it does not, since it still excludes consumers that were forced out of the market. In addition, they argue that since many collusion cases are settled, trebling doesn't even take place so it does not provide full compensation for the higher prices consumers who continued to buy the product had to pay (Leslie 2006)

[3] Leslie, C.R., "Antitrust damages and deadweight loss," The Antitrust Bulletin, 51(3), pp. 521-567, 2006.

[4] A studied performed by Andrea Günster, Mathijs van Dijk and Martin Carree concluded that in general cartels hinder innovation by decreasing investments in R&D because there is lower incentives to invest in new products and technologies. However, in some rare cases, higher profits could contribute to R&D investments.

[5] This discussion of accuracy and practicality is based on European Commission (2011).

This leads us to the concept of practicality. The damage calculation process should be conducted within a reasonable timeframe and with the available resources. Antitrust authorities experience time constraints and have a limited amount of manpower that can be allocated to a specific project. Therefore, it is very important that the company makes the necessary information readily available to the authorities or economic analyst. Another key factor that helps ensure practicality is proper data submission and presentation style. Economists must provide the raw data and any adjustments made to the data and the statistical method used to derive your results so that a second expert can easily verify the results. This also facilitates the comprehension of the methodology and results by judges and lawyers. The expert must be prepared to explain the logic behind the chosen method, so the more practical the approach the easier it is to explain. The choice between accuracy and practicality will vary on a case-by-case basis and will be highly influenced on the data available. Sometimes, it will not be possible to obtain an accurate empirical estimate within a reasonable timeframe or with the available resources. In such cases, it is up to the legal system to determine how to proceed.

Finding a reasonable balance between accuracy and practicality affects how each expert tailors his economic analysis. It includes the decision of which data to use and which ones to leave out, the number of variables and which method to employ. Working with data submitted by parties involved in the investigation will most likely lead to more accurate estimations. However, working with public data not only shortens the data collection period, but also makes you less susceptible to data manipulation and allows for cross-firm comparisons.

The number of variables to include in your analysis is also key to achieving unbiased and accurate results. Although it is important to control for factors that affect price, including all demand and cost shifters, not only leads to an intensive data collection process but also may reduce the accuracy of the estimates. If the variables are highly correlated and the individual impact of each variable is not of interest in the analysis, it would be enough to include only the representative variables and control for the combined effect. On the other hand, omitting an important variable will lead to biased estimates.

Finally, in many jurisdictions, empirical economic evidence is not sufficient to prove a misconduct in cartel cases. Investigators are required to present evidence of explicit communication between infringing firms in order to meet the legal standard of proof. In Brazil, although rare, it is possible to prosecute and condemn a cartel even when there are no concrete evidence of exchanges between colluding firms. In some few cases it has been enough to be able to demonstrate economic indicators of a collusion, however in these cases the burden of proof were much higher. The burden of proof for proving a collusive conduct is also higher when quantifying damages but that also varies among jurisdictions. Once the antitrust authority has been able to achieve the required standard of proof, the burden of proof shifts to the defendant, who will then have to prove that the authority's assertions are wrong. When legal standards are higher, experts might be required to present more accurate results, which may lead them to rely on more than one empirical approach. This brings us back to the trade-off of practicality and accuracy.

2.1 The Multivariate "Before and After" Approach

A simple approach in quantifying price overcharge is to compute the difference between the cartel price and the perfect competitive price. The multivariate approach closely follows this idea by estimating a reduced form regression of the price level on a dummy indicating the cartel period and on demand and cost shifters that control for various exogenous influences on price. It is important to note that econometric analysis does not prove causality but it seeks to establish statistically significant relationship between the dependent variable and the other explanatory variables.

Generally speaking, the estimated regression has the following specification

$$p_t = \gamma D_t + x_t\beta + \varepsilon_t \quad (2)$$

where
p_t: price level at period t
x_t: vector of demand and cost shifters
D_t : dummy variable indicating the cartel period (D = 1 if cartel was active in period t; D = 0 otherwise)

Our parameter of interest is γ, which may be interpreted as the estimated price overcharge during the cartel period. If the coefficient γ is positive and statistically significant, we have some evidence on the existence of a cartel.

Overall, the before and after models are practical and lead to sufficiently accurate results without requiring too much data or human resources. However, differently from the structural model that we are going to see further ahead, it ignores the deadweight loss from the calculation so that damages would be equal to the estimated overcharge.

3.2 Yardstick and the Difference-in-Differences Methodology

When dealing with a cartel that has not been stable throughout its existence or when supply and demand conditions fluctuated in a significant way along the years, a better way to estimate the counterfactual price is to use the yardstick approach. This method quantifies damages by comparing the collusive prices with the ones that were practiced in other competitive but comparable markets. It can be considered an extension to the multivariate before and after time-series approach by adding a cross-sectional dimension in the comparison. This method is challenging because the two products must be similar in terms of demand, costs and market structure and should at least be from the same country so that institutional shocks are similar. Furthermore, there is no guarantee that the benchmark chosen is cartel-free or unbiased.

One can also unify the before and after approach with the yardstick approach into a single framework known as the difference-in-difference. The difference-in-difference approach is an econometric method that uses panel data to run cross-sectional data from different periods and markets, which increase the validity of the results. If you have relevant data on various regions (some that are affected by the cartel and some that are not), the difference-in-difference method will allow you to compare the differences in both markets.

The purpose of implementing this approach is to evaluate the impact of a treatment on an outcome Y across different groups. In this case, we will be dealing with two groups: one that has received treatment denominated T=1, and another that does not receive the treatment, T=0, which will be our control group. The analysis will be performed in two periods where t=0 indicates the pre-treatment period, and t=1, indicates the post-treatment period. Each individual or group will have two notations, one pre-treatment and one post-treatment. To simplify, let us have $\bar{Y}_0^T$ and $\bar{Y}_1^T$ as the sample averages of the outcome for the treatment group before and after treatment, respectively, and $\bar{Y}_0^C$ and $\bar{Y}_1^C$ the sample averages for the control group.

The outcome Y_i can be modeled as:

$$Y_i = \alpha + \beta T_i + \gamma t_i + \delta(T_i * t_i) + \varepsilon_i \quad (3)$$

The coefficients α, β, γ, δ are unknown parameters representing:
α = constant term
β = treatment group specific effect
γ = time trend common to control and treatment groups
δ = true effect of treatment

The difference-in-difference estimator is defined as the difference in average outcome in the treatment group before and after treatment *minus* the difference in average outcome in the control group before and after treatment.

$$\hat{\delta}_{DD} = \bar{Y}_1^T - \bar{Y}_0^T - (\bar{Y}_1^C - \bar{Y}_0^C) \quad (4)$$

Given the unbiased estimator assumption, if we take the expectation of the $\hat{\delta}_{DD}$ estimator we get:

$$\begin{aligned} \hat{\delta}_{DD} &= E[\bar{Y}_1^T] - E[\bar{Y}_0^T] - (E[\bar{Y}_1^C] - E[\bar{Y}_0^C]) \quad (5) \\ &= \alpha + \beta + \gamma + \delta - (\alpha + \beta) - (\alpha + \gamma - \gamma) \\ &= (\gamma + \delta) - \gamma \\ &= \delta \quad (6) \end{aligned}$$

The estimator in Equation 5 is basically taking the average difference in outcome Y_i for the pre and post-treatment period in the treatment group and subtracting the average difference for the pre and post-treatment period for the control group.

However, like with any other model, the difference-in-difference approach also has its downsides. Two assumptions must hold in order to guarantee an unbiased difference-in-difference estimators: i) there must be a common trend between prices from the control group and the treatment group in the periods before the shock, i.e. treatment and control groups should be expected to follow similar factor processes prior to the treatment period; and ii) treatment and control groups should not, on average, experience differential shocks in the post-treatment period. If any of these assumptions do not hold, then there is no guarantee that the DD estimator is unbiased. A second caveat is related to the control group formation. Finding a relevant and accurate benchmark, that has similar characteristics to the market in question without having been affected by a cartel is not an easy task.

3.3 Cost-plus Approach

The Cost-based Approach uses financial information of an industry or company to calculate the counterfactual price using a bottom-up analysis. The analyst will take the relevant production costs and add a reasonable profit margin that could have emerged in an otherwise competitive market. Typically, the average costs will be calculated based on accounting data or information available from management reports.

However, it is a somewhat challenging method to employ. First, calculating an appropriate profit margin to add to the average unit cost of production can be quite difficult in practice. Also, since in most cases the accounting costs do not reflect actual economic costs it becomes extremely difficult for investigators to calculate a robust cost estimates. In addition, some may consider this method an oversimplification of the factors that affect price in a cartel-free world - it assumes that competitive costs and price-cost margin are constant when the cartel is in place (Clark et al., 2004).

It is also a method with high data requirement and is time consuming. However, it could be a good proxy for a counterfactual when dealing with companies in markets where there is a constant relationship between price and cost.

3.4 Structural Models and Market Simulation

Contrary to the yardstick, a comparator-based model, the structural model relies on a simulated-base benchmark to calculate damage. The Simulation method, also known as the "Oligopoly Model Method," as described by Clark et al (2004), aims at calculating the relevant market data on costs, price, quantities, and profits in a collusion-free world. It uses economic models based on industrial organization theory to predict the effect of the shock on prices and output. It is worth highlighting that this approach is the only one discussed in this paper that has the capacity of measuring the deadweight loss.

The economic analyst will build an economic equilibrium model to determine prices, quantities, costs and marginal costs in a cartelized industry. Once assumptions are specified and the model is laid out, the prices that would have been under competition can be calculated and compared to those practiced during the cartel. This model also assumes an oligopolistic behavior, so it is important to decide whether you are dealing with a Bertrand or Cournot competition. This method requires information on costs, market structure and demand and a profound understanding of the market.

Even though it has an unique capacity of capturing a parcel of the damage that cannot be measured by the other models, it is a much more complicated and time consuming method. It is highly sensitive to the assumptions made about cost and demand parameters and how they affect prices. Also, since it is a data-intensive method it is sensitive to changes in its settings and parameter values. Damage quantification based on simulation methods might be closest to real-world competitive market outcomes, since they do not rely on cost data provided by defendant and are very transparent for outsiders. However, not only does it present the largest challenges for economists with regard to the high level of market knowledge that is required, it also faces difficulties in being validated in court as an appropriate damage calculation method. Since it is a more complex method that involves strong assumptions on a "would be" demand, it tend to be more vulnerable towards courts. Judges and other non-experts may face some difficulty in interpreting the results and the model specifications, therefore economists have to be very educated with this kind of model-building and have to prepare good documentation for its replication (Doose, 2013).

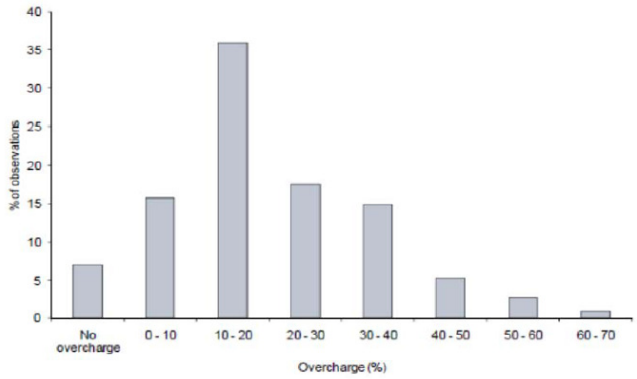
3.5 Comparing Methodological Approaches

In order to ensure the robustness of the estimates, practitioners generally apply various methodologies to assess cartel damage. In general, different methods applied to identical cartel episodes did not result in significantly different estimates.

Connor and Lande (2008) concluded that the multivariate before and after approach usually provided overcharges estimates that were higher than other econometric models applied to the same cartel episode. One possible reason for such result is that analysts using the Before and After Method may have failed to adjust for all competitive factors that influence the competitive benchmark price. The Cost-based and Yardstick approaches yielded even higher overcharge estimates. One explanation for these higher estimates is that using cost or profits fail to fully account for all competitive industry cost. In the Yardstick approach cases, analysts may have underestimated quality differences between the products.

For practicality purposes, many countries recur to more straightforward methods when determining cartel damage in cases of relatively minor economic importance. A simple method relies on results from previous cartel cases. This method takes into account the average overcharge observed in past known cartels and apply it to any current case. There is an increasing number of data on overcharge estimation available in cartel cases which allows us to estimate the average overcharges. Connor and Lande (2008) reviewed 674 cartel damage cases. They found that the majority of detected cartels have an estimated overcharge between 10% to 20% (Figure 2). The empirical evidence of existing overcharge estimations suggests a high variation of overcharges across various cases, highlighting the need for case specific estimates. Given the high variation and the lack of precision of this method in determining the actual overcharge in any given case, not all jurisdictions admit it as an adequate measure of effective damage.

Figure 2: Historical overcharge estimations



2: Connor and Lande (2008) as reported in Oxera and Komninos (2009)

The United States Sentencing Guidelines established an overcharge estimate of 10 percent of the total volume of commerce. Compared to the figures in Figure 2, one can verify that the fines applied by the US antitrust agency on cartels were not nearly enough to hinder the practice. Later, the agency doubled that amount in order to incorporate deadweight loss and other previously neglected damages.

3. Empirical application: liquefied petroleum gas cartel in Pará, Brazil

In March 2005, the Federação Nacional de Revendedores de Gás Liquefeito de Petróleo ("Fergas"), made a complaint to CADE about potential anticompetitive practices being carried out by the three mains gas distributors in the state of Pará: Tropigás, Minasgás and Parágas.

In December 2016, CADE sentenced the company Parágas Distribuidora Ltda. for the formation of an illegal cartel in the liquefied petroleum gas distribution market.[6] According to the leading opinion, the evidence in the case files showed that Parágas was guilty of implementing a price fixing scheme with its competitors. Furthermore, the firm was found guilty of creating vertical restrictions, such as fixing retail prices, refusing to supply the LPG to retailers from other distributors, for requiring its retailers to sign exclusivity agreements, and finally for selling the LPG to unauthorized retailers, as means to enforce the collusion.

[6] According to the case files, all three companies in the cartel were found guilty of collusion. However, Tropigas and Minasgas entered into a leniency agreement and settled with CADE and were therefore not tried together with Parágas.

Despite the consensus on the guilt, a harsh controversy ecloded concerning damage evaluation. The CADE advisor responsible for the leading opinion, Ms. Cristiane Alkmin, interpreted that in order to apply an appropriate fine to the colluding firm, the best approach was to calculate the estimated overcharge and undue gains for the firm. She suggested that, "when pecuniary sanctions are not a function of the damage caused to society, one can make the mistake of charging beyond or below the 'appropriate penalty' for that damage that was caused to society.[7]" If the fines paid by the infringing firms are restricted to the price overcharge, the damage to society will not be fully repaired. The advantage gained through an illicit act is lower than the welfare loss, since it disregards the deadweight loss. However, in her opinion, calculating damages, even if just an estimate, can serve as a reference for the establishment of the fine.
In the LPG case, the variables for cartel duration, quantity sold, and the price fixed by the cartel were available in the evidence collected. The counterfactual price was to be calculated by a chosen method for damage estimation. For this case, she chose the difference-in-difference approach. The damage calculation will be a proxy of the sum of the undue gains by the participating firms in the cartel during its duration.

The relevant market considered for the calculation was the LPG distribution in the state of Pará. The selected period for the cartel was from February 2003 to April 2005 and the non-cartel period was August 2001 through January 2003. For the control group, she used two criteria for selection. In the first group, she selected the states that showed the most competitive prices, taking the average LPG price in each state and comparing it to the HHI. As she observed, the more companies acting in that market, the lower was the average price of the state. The chosen states were: RJ, AL, SP, and MG. For the second control group, she selected all the states in Brazil where there had been no cartel condemnations during the period.

However, her methods were scrutinized by another voting member, Mr. Marcio Oliveira. Although both advisors agreed on the fact that the companies were guilty of cartel formation, Mr. Oliveira disagreed with some of the premises of the model applied in the calculation as well as with the chosen method for setting the fine.
First, he interprets that it is not CADE's role to recover damages but in fact to establish a penalty for these anticompetitive practices. When relying solely in overcharges to calculate the penalty, one is not taking into consideration other undue advantages gained from the collusion, such as the exclusion of a potential competitor from the market. In addition, one cannot guarantee that all overcharges will eventually become an undue gain to the company; part of the increase in the equilibrium price may be due to shocks that would have affected the market regardless of the cartel. In Baker (1989), he elaborated on the difficulty of identifying cartel formation when there is an environment of uncertainty concerning price. Simply calculating estimated overcharges does not allow you to differentiate undue gains from natural market fluctuations. Therefore, Mr. Oliveira argued that a better method would be to take an average of the overcharges result from multiple approaches, so to avoid under or oversetting the fine.

Furthermore, Mr. Oliveira showed concerns on Ms. Alkmin's choice for the control group. He stated that it is impossible to know for a fact whether a specific state was a good counterfactual for the estimate, since even if there was no cartel condemned in the chosen states during the period of the study, it does not guarantee that no cartel was in place. This is a common criticism to the difference-in-difference method; although there are some steps that can be taken to secure a control group with benchmarks that have not be affected by the shock, it is impossible to know for sure.

[7] CADE Administrative Process 08012.006043/2008-37 - Vote 0255038

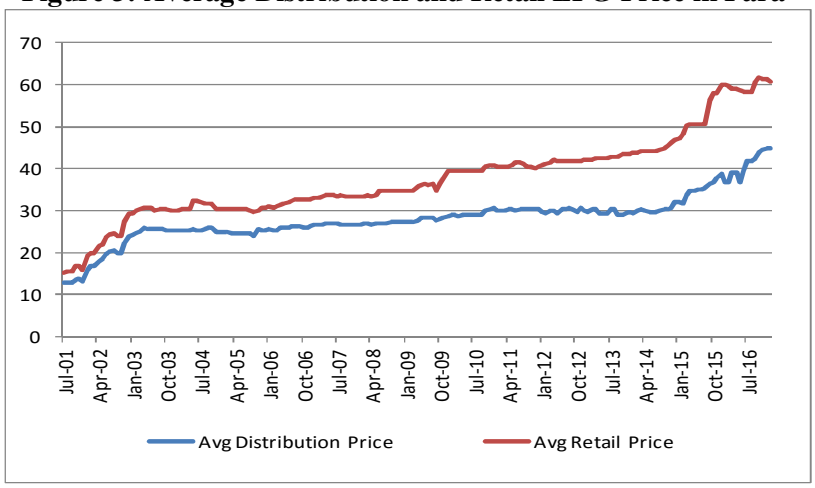
4.1 Empirical Analysis

In this section, we revisit Ms. Alkmin's calculations in order to provide more robustness to the results. First, besides using the difference-in-difference method as the only means of calculation as was done by the CADE, we added a second model to estimate the damage. We start the damage evaluation with a multivariate before and after approach and then move on to the difference-in-difference to corroborate our results.

To mitigate the concerns raised by Mr. Oliveira on the validity of the benchmark for the difference-in-difference model, the states chosen for the control group were selected with more scrutiny. In addition to choosing states based on their market competitiveness, like was done by CADE, we also tested for a common tendency in those states to avoid using a control group that had factors influencing price that were absent in the treatment state. This allows us to test for the common trend hypothesis in the difference-in-difference method and to increase the robustness of our results.

In order to estimate the damage caused by the LPG cartel in Pará we used the information available in the discovery process as well as data collected from public sources. The dates established for the cartel period were the same ones used by CADE in their damage calculations, February 2003 to April 2005. Analyzing the cartel in the same time interval as CADE allows for the comparison of our results with the ones obtained by Ms. Alkmin. We used the ANP[8] portal to obtain monthly data for the distribution and retail price of LPG sold in pressure canisters (P-13) in each state from July 2001 to December 2016. Figure 6, illustrates the behavior of the two price series. Although there are evidences of price fixing at the retail level (a demand by the distributors themselves),[9] it was chosen to use the series for distribution price, where there are concrete evidence of a price fixing scheme.

Figure 3: Average Distribution and Retail LPG Price in Pará



Source: Data collected from ANP

Besides LPG distribution price, proxies for demand shifters were used as independent variables to control for exogenous factors that could affect the dependent variable and potentially mislead the final conclusions on the effect of the cartel. For such, were used LPG consumption, provided by the ANP, income and industrial production, collected from IPEA Data and IBGE, respectively.

[8] Agência Nacional de Petróleo - Brazilian Oil and Gas Agency

[9] In the discovery process, retailers claimed that distributors would determine the prices that should be practiced with the final consumer.

For LPG apparent consumption, data was only available from 2007 to 2016, in Kilogram units. Therefore, LPG distribution sales was collected from the ANP website and used as a proxy for consumption from 2000 to 2006. Additionally, a dummy variable was created to indicate the periods in which the cartel was active.

Unfortunately, data on cost shifters were not publicly available and they were not included in our empirical analysis. In the case of the LPG distribution market, the main cost variable that could potentially affect price would be the transportation cost, which constitutes of over 50% of the total cost of the product[10]. This raises a couple of problems: first, the cost is a determinant of LPG prices and therefore our regression estimates may be plagued by omitted variable bias. This may create endogeneity issues in both the before and after multivariate analysis and the difference-in-difference approaches. This should not be a problem in the difference-in-difference method if the unobserved cost shifters vary in similar way across cartelized and non-cartelized markets. If the cost structure is similar, than they would cancel out when calculating the differences. However, it may become a problem for the difference-in-difference approach if cost structure of the LPG distributors in Pará are different than those in the control group. Second, lack of cost information prevents us from employing structural methods such as the cost-plus or simulation approaches. Therefore, in this study we will work with an implicit assumption that the transportation costs for LPG firms vary in a similar way across treatment and control groups markets.

4.1.1 Estimation results

Table 1 presents the regression results for the multivariate regression specifications. Analyzing the coefficient on the cartel dummy, it is possible to conclude that LPG distribution prices were between 10% to 13% higher while the cartel was active. Not only were the cartel dummy coefficients statistically significant but they also showed little variation given the different regression specifications, corroborating the robustness of the price overcharge estimate.

Table 1: Regression results – multivariate specification

Damage Estimation Dependent Variable: Log Distribution Price				
	1	2	3	4
Log Income	0.131*	0.0163	0.0174	-0.0352
	[.0515]	[.0633]	[.0632]	[.0544]
Industrial Production	0.0086***	.0075***	.0075***	.0034***
	[.00044]	[.00055]	[.00057]	0.00071
Cartel Period	.132***	0.127***	.1302***	.1015***
	[.0162]	[.0159]	[.0158]	[.014]
Consumption		0.00000758**		
		[2.54e-06]		
Log Consumption			.2029**	-.2525**
			[.0683]	[.0821]
Trend				.0027***
				[.000345]
Constant	1.561***	2.305***	-0.842	7.155***
	[.3595]	[.4307]	[.8821]	[1.264]
N	168	168	168	168
R^2	0.8073	0.8172	0.8171	0.8677
F	228.97	182.21	182.11	212.57

* p < 0.05, ** p < 0.01, *** p < 0.001

[10] http://www.petrobras.com.br/pt/produtos-e-servicos/composicao-de-precos/gas-liquefeito-de-petroleo-glp/

Following Ivaldi et al. (2016) and Levenstein, Suslow and Oswald (2003)[11], it was considered sales affected by the collusive practice in order to calculate the cartel's excess profits derived from the price overcharge.[12] Total LPG sales throughout the cartel period was of R$ 7,722,887,257 amounting damages to something in between R$ 783,873,056 to R$ 1,016,331,963.[13]

However, the multivariate before and after methodology can be somewhat limited when estimating damages since it only analyzes the market in Pará, where the cartel was instated. In order to have a more reliable estimate for the damages, it is important to compare the affected market with a market that has been operating cartel free. The difference-in-difference method, takes into consideration cartel-free markets that can be used as a counterfactual for the analysis.

In order to apply the difference-in-difference approach to estimate cartel damage, one must first identify the treatment and control groups, as well as the period the cartel was active. In addition, the analyst has to determine the method and model specifications. It is important to point out that the choice of control group was an important element of discussion between CADE advisors in their opinion. As previously mentioned, the difference-in-difference method requires two basic assumptions: i) the markets for the control group must not be affected by the cartel; and that ii) the prices in the different markets must follow a common trend. These groups should have similar characteristics, except for the price shock. The treatment group, in this case, will be the state of Pará and the endogenous variable the LPG distribution price. The period of the cartel considered will be from February 2003 to March 2005 (27 months), the same period used by CADE to calculate the damage.[14] The data collected for the control group was retrieved from the same sources used to collect the data for the state of Pará: ANP, IPEA Data, IBGE.

In order to satisfy the first requirement for the difference-in-difference method, the first objective was to select states where there had been no cartel activity in the market in question during the period being studied. However, knowing for a fact that a market is cartel free is nearly impossible. Just because no cartels had been condemned during that period, it does not mean that there was no cartel. Due to the difficulty of detecting cartels, it is possible that a cartel could be operating in any given state without the knowledge of the authorities. Therefore, the states which demonstrated to have a lower market concentration based on the Herfindahl Index (HHI) were the main focus of the analysis. The HHI was calculated for all the states in Brazil in 2007[15] and in 2016. Although this method does not eliminate the danger of using a state where a cartel was active but unknown, it is a way to mitigate these risks. Based on the HHI, the states of São Paulo, Pernambuco, Santa Catarina and Paraná were the only four states which presented a HHI below 0.25 in 2007 and maintained a similar level of competitiveness in 2016. Therefore, they were selected as our potential control group.

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[11] Ivaldi, M. et al, "Cartel Damages to the Economy: An Assessment for Developing Countries," Competition Law Enforcement in the BRICS and in Developing Countries. Switzerland Springer, 2016. pp. 103-133

[12] The value for total LPG sales in the distribution level was arrived at by multiplying the LPG sales from February 2003 to April 2005 with the respective monthly LPG distribution price. To arrive at the damages, we used a variation of Equation 1, but in percentage, where $A = (p^1-p^0) \times Q^1$ or the total sales multiplied by the $\gamma = (p^1-p^0)/p^0$, in this case 10% to 13%.

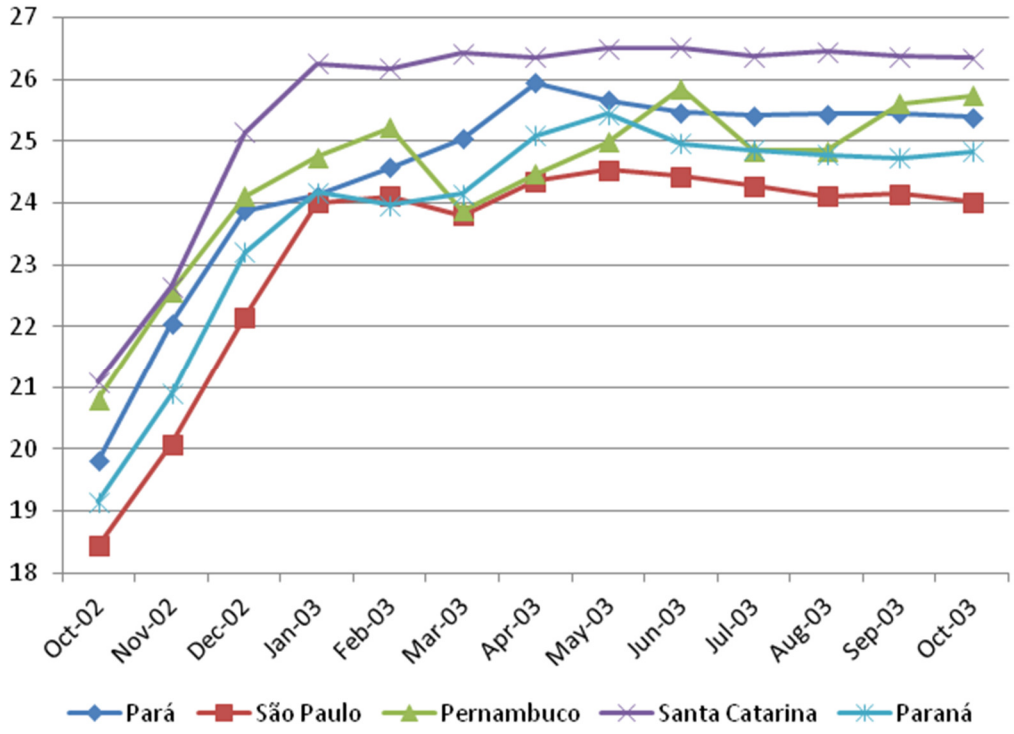
[13] LPG sales are described in the values of 2005, when the cartel ended. If we update these values up to December 2016 using the IPCA, LPG sales would have been R$ 14,929,176,194 in today's terms. That would equal damages in between R$ 1.5 - R$ 1.9 billions.

[14] In order to determine the estimated period for the cartel activity, CADE used evidence collected during the investigation, including recordings from company employees and other documents that indicated a February as the most probable date for the beginning of the cartel and March 2005 as its dissolution.

[15] The year of 2007 was the earliest data available for LPG consumption. As mentioned earlier, for the years between 2000 to 2006, a proxy was used.

To satisfy the second condition for the difference-in-difference model, the prices for the state of Pará and the control group were tested for a common trend. The first analysis consisted of a visual inspection of the LPG distribution prices in both the treatment and control groups.
In Figure 4, it is possible to see that Pará's price curve becomes steeper than that of the other states around March 2003. Although there is an upward trend in price among all the states, it seems that the increase in Pará around the period of the beginning of the cartel was more significant than in the others state of the control group.

Figure 4: LPG Distribution Prices



Source: ANP.

In addition, a more formal trend test was performed in order to confirm the conclusions from the visual inspection. Table 2 shows the outputs for the global common trend test conducted with the control group. We will focus on the second regression, which takes into consideration the fixed effects. The idea of the common tendency test using fixed effects is that it allows for the control of non-observable variables that do not change throughout time.

In table 2, the variable "trend" represents the average time trend for Pará state. The second column shows that the cross-term trend coefficients for São Paulo and Pernambuco are not statistically significant, which means that there is evidence of a common trend for these states. In other words, the trend in these states do not diverge from Pará "trend". The coefficients for Santa Catarina and Paraná, on the other hand, strongly suggest the contrary, which means that some shock other than the cartel is making the trend in these states diverge from the one in Pará. This leads us to reconsider them as a good benchmark for the control group.

Table 2: Global Common Trend Test

	Common Trend	
	1	2
Trend	0.0908***	0.0907***
	[0.0028]	[0028]
Trend x SP	0.0168***	-0.0182
	0.0041	[.0683]
Trend x PE	0.0190***	0.0957
	[0.0041]	[.0683]
Trend x SC	0.0095*	0.2726***
	[0.0041]	[.0683]
Trend x PR	0.0088*	-0.2667***
	[0.0041]	[.0683]
Trend Sq x SP	-0.0000332***	-0.00000356
	[0.000007]	[.00006]
Trend Sq x PE	-0.0000346***	-0.0000992
	[0.000007]	[.00006]
Trend Sq x SC	-0.00000852	-0.0002302***
	[0.000007]	[.00006]
Trend Sq x PR	-0.0000148*	0.0002176***
		[.00006]
SP		-22.58
		[20.11]
PE		-22.58
		[20.11]
SC		-77.38***
		[20.11]
PR		80.97***
		[20.11]
Constant	-25.61***	-25.55***
	[1.66]	[1.65]
N	935	935
R^2	0.8309	0.8367
F	504.91	362.94

* p < 0.05, ** p < 0.01, *** p < 0.001

Lastly, a local common trend test, which allows for the treatment variable to interact with time dummies, was carried out. The objective of this test was to create interactions of time dummies and the treatment indicator for the first two pre-treatment periods and two post-treatment periods. After creating the pre and post-treatment dummies, the following model was regressed:

$$y_{it} = \lambda_{it} + \delta_{it} + \beta_{-1}D_{it} + \beta_{-2}D_{it} + \beta_{-1}D_{it} + \beta_1 D_{it} + \beta_2 D_{it} + \varepsilon_{it} \quad (5)$$

where y is the outcome for state *i* at time *t* and λ and δ are state and time fixed effects.

In order to validate the difference-in-difference assumption, the pre-treatment dummies should be the same for both the control and treatment groups, which means that they should not be statistically significant. In addition, the post-treatment coefficients, β_{+1} and β_{+2}, should be positive and statistically significant. The intuition here is that prices should follow a common trend in the pre-treatment period and diverge after the shock in the post-treatment period.

Table 3 shows the results of the local common trend test. Column 1 includes all four states in the control group throughout the entire period, July 2001 through December 2016. Column 2 shortens the time frame of the analysis to a short period before and after the beginning to the cartel, that is January 2002 through December 2003.[16] The reason for decreasing the range period being analyzed was to avoid capturing any other shocks that might have taken place in the LPG distribution price besides the cartel in the post-treatment period. Columns 3 and 4 follow the same considerations as Columns 1 and 2, respectively, but only include São Paulo and Pernambuco in the control group.

Table 3: Local Common Trend Test

	Common Trend			
	1	2	3	4
Trend	0.0803***	0.3452***	0.0764***	0.3837***
	[0.0013]	[0.0170]	[0.0018]	[0.0218]
SP	-1.7163***	-0.1163	-1.7227***	-0.1279
	[0.2235]	[0.3898]	[0.239]	[0.3869]
PE	-.92683***	0.6964		0.6849
	[0.2235]	[0.3898]		[0.3869]
SC	2.6851***	2.403***		
	[0.2235]	[0.3898]		
PR	0.0585	0.9112*		
	[0.2235]	[0.3898]		
Dec-02	1.9969	2.1828	1.6923	2.1905
	[2.1571]	[1.3192]	[2.3085]	[1.3092]
Jan-03	2.1702	2.0912	1.87	2.0604
	[2.1571]	[1.3192]	[2.3084]	[1.3093]
Mar-03	2.9273	2.3185	2.6344	2.2108
	[2.1571]	[1.32]	[2.3082]	[1.3106]
Apr-03	3.7493	2.8756*	3.4603	2.7294*
	[2.1569]	[1.3207]	[2.3081]	[1.3118]
Constant	-19.50***	-156.11***	-17.18***	-175.93***
	[0.79]	[8.77]	[1.09]	[11.24]
N	935	120	561	72
R^2	0.8207	0.8146	0.7697	0.8392
F	470.45	53.72	264.02	47.73

* p < 0.05, ** p < 0.01, *** p < 0.001

[16] Remembering that according to the evidence collected by CADE, the beginning of the cartel was dated in February 2003 and its dissolution was considered to have taken place in April 2005. Therefore, I chose to consider a period one year before its beginning and 10 months after. Columns 2 and 4 of the local common trend test does not consider the entire period of the cartel.

Based on the results for Column 1, we reject the null hypothesis at a 90% confidence level for the month of April 2003, but not at 95%. This seems to be saying that the price increase of the cartel started to pick up at around the month of April and not in February when the cartel was actually instated. Moreover, in the joint significance test for the months of December 2002 and March 2003, we do not reject the null hypothesis, $\beta_{-1} = \beta_{-2} = 0$, reinforcing the conclusions from the previous tests that there is in a common tendency between the treatment and control groups before the cartel shock. However, for the post treatment joint significant test, $\beta_1 = \beta_2 = 0$, we reject the null hypothesis, proving that there was in fact a shock in that period.

The joint significance tests performed for the data in Columns 2 and 4 showed similar results. We do not reject the null hypothesis for the pre-treatment period at a 5% significance level but reject it for the post-treatment period. These results validate our common trend test. Given the two common trend test, our control group will be restricted to Pernambuco and São Paulo.

The results for the difference-in-difference regression can be found in Table 4. We will focus on the results from Columns 3 and 4, which includes only São Paulo and Pernambuco in the control group. Column 3 included the data from the period between July 2001 to December 2016. Its output shows an overprice of 16.96% in LPG distribution price during the cartel, awarding the cartel participants an extra gain of almost R$ 1.3 billion[17].

In Column 4 we restricted the period of the analysis from February 2002 to December 2003, for the same reason we did in the local common tendency test: to avoid shocks other than the cartel overprice from influencing our results. As we can see from the output in Column 4, the overprice was similar to that in Column 3, however slightly smaller. The results indicated that the cartel was operating with prices 15.97% higher than it would have in perfect competition, amounting to over R$ 1.2 billion in undue gains.[18] It is important to highlight that the price overcharge result in the model in which the control group included only Pernambuco and São Paulo was almost two and a half times larger than it was in the model including all four states (6.76%). This could indicate that there probably were other shocks influencing the LPG distribution prices in the two states we excluded from the analysis.

As we can see from the results, the price overcharge calculated by the difference-in-difference method utilizing a more restricted and scrutinized control group gave us a value much larger than what was estimated by Ms. Alkmin in her calculations for the CADE. However, it was consistent with the conclusions arrived by Connor and Lande in their study in which they calculated the modal average overcharges in between 10 to 20 percent. This shows how the difference-in-difference model can be sensitive to the choice of a control group; restricting the control group may have a significant influence on the results.

[17] The formulas used to arrive at the damages and price overcharge in percentage were, respectively: $\beta_3 \sum_{i=1}^{M} Q_i$ and $\frac{\beta_3}{P_{1,t}}$ where $P_{1,t}$ was the average LPG distribution price in January 2003.

[18] Updating the damages up to December 2016 using the IPCA, we arrive at damages amount in between R$ 2.2 to R$ 2.4 billions.

Table 4: Difference-in-Differences Regression

Difference-in-Differences				
	1	2	3	4
PA	-55.23***	103.96***	-5.906***	-0.476
	[1.04]	[23.52]	[0.665]	[1.32]
SP	-39.60***	77.51***	8.85**	9.56*
	[1.53]	[17.01]	[2.87]	[4.76]
PE	-28.41***	52.29***		
	[0.563]	[11.82]		
SC	-10.95***	30.43***		
	[0.395]	[6.24]		
Trend	-0.073***	0.142***	-0.0035**	0.0057**
	[0.001]	[0.031]	[0.001]	[0.002]
Industrial Production	0.014**	-0.04	-0.083***	0.052**
	[0.005]	[0.026]	[0.009]	[0.017]
LPG Consumption	-2.72E-08*	6.76E-09	-1.02E-07	-7.53E-08*
	[1.09E-08]	[3.32E-08]	[2.01E-08]	[3.22E-08]
Treated x Cartel Dummy	1.63***	2.81**	4.09***	3.85***
	[0.346]	[0.871]	[0.792]	[0.902]
Constant	93.34***	-67.96**	46.01***	33.63***
	[0.989]	[23.62]	[0.992]	[1.91]
N	856	115	856	115
R^2	0.8669	0.5187	0.2894	0.3863
F	689.36	14.28	57.62	11.33

* p < 0.05, ** p < 0.01, *** p < 0.001

Conclusion

Quantifying cartel damages has been gaining momentum among antitrust authorities around the world, Brazil included. Even though there have been major discussions on the role of a competition agency, more specifically on whether it has jurisdiction to calculate estimated damages or not, it seems that more and more agencies been bringing it upon them to do so. Given the several different methodologies available for that purpose, analysts face the difficult task of choosing the most appropriate approach for calculation while at the same time finding balance between accuracy and practicality. As discussed along this paper, some methods are able to return more accurate results but they also require more data and assumptions and are much more time consuming. On the other hand, there are other methods, such as before and after approaches and difference-in-difference methods, used in this paper to estimate damages, that are more practical and less data intensive but gives less accurate results.

The objective of this paper was to select among the existing methods, one that could give us accurate results in a timely manner. The Multivariate Before and After method indicated an overcharge of between 10% to 13% in the distribution prices of LPG in Pará. The difference-in-difference model estimated an overcharge of something in between 15.97% to 16.96%. These results are consistent with the study performed by Connor and Lande (2008) where they calculated the mode of overcharges in between 10 to 20 percent. Also, the results obtained in our study were higher than the one obtained by Ms. Alkmin in her difference-in-difference application: 4% to 8.2%.

Even though the results from this study seem to be consistent with average overcharges found in the academic literature and with the results calculated by CADE, there are always improvements that can be made to refine the calculations even further. First, we could adopt the synthetic control method in the difference-in-difference estimation to improve the results. The synthetic control method builds on the difference-in-difference model to evaluate the causal effects of shocks. It makes two essential changes to the model: i) it allows for time-varying individual-specific heterogeneity; and ii) takes a serious, data driven approach to forming counterfactuals. It basically uses longitudinal data to build a weighted average of non-treated units that best reproduces the characteristics of the treated unit over time, prior to the treatment.[19] This approach relaxes the previous hypothesis that the benchmark market should not be affected by the shock and that there must be a common tendency between the treatment and control groups in the pre-treatment period. Therefore, it allows us to forgo the common tendency tests that were performed in this study. However, like all other methods, it comes at a cost: its computational time far exceeds that of the difference-in-difference estimation, leading us back to the practicality versus accuracy issue.

In addition, it would be important that in future studies we find available data on cost shifters, mainly transportation costs, so to enable us to calculate the deadweight loss using the structural models. This would allow for the construction of a supply and demand structural model that could potentially calculate the impact of the total loss of welfare to society. Although it requires a large data base, it is the model that best simulates the "real world".

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