THE CEMENT CARTEL AND THE OVERCHARGE CADE PREVENTED

O Cartel do Cimento e o Sobrepreço que o CADE Evitou[1]

Felipe Resende Oliveira[2]
Ricardo Carvalho de Andrade Lima[3]
Daniel Henrique Alves Reis[4]

Abstract: This study estimates the overcharge stemming from cartelization in Brazil's cement market (1994 – 2007). A Difference-in-Differences model compares cement price paths, drawn from SINAPI-IBGE, to those of comparable construction inputs (lime and steel), using the searches and seizures carried out by CADE in February 2007 as an exogenous shock. The June 2006–August 2007 window captures the cartel's immediate breakdown, yielding an average overcharge of 2.02 %. Applied to participating firms' sales volumes and updated to current values, this overcharge represents a transfer of roughly R$ 6.94 billion to cartel members. Antitrust intervention, by dismantling the cartel, generated an estimated R$ 11.8 billion in consumer savings between February 2007 and December 2022. The evidence underscores the effectiveness of CADE's actions and reinforces the need for stringent sanctions to deter anticompetitive practices that impose substantial costs on society.

Keywords: Cartel; Competition Defense; Overcharge; Difference-in-Differences.

[1]This article expresses the authors' views alone and does not necessarily reflect the official position of the Cade.

[2] Department of Economic Studies (DEE) of the Administrative Council for Economic Defense (CADE) and Professor of Economics at the Graduate Program in Economics (PPGECO), Federal University of Mato Grosso (UFMT). felipe.resende@cade.gov.br.

[3] Professor in the Graduate Program in Economics and in the Public Policy Program at the Catholic University of Brasília (UCB), and Forensic Economics Analyst at the Federal Prosecution Service (MPF). ricardocarvalho2009@gmail.com.

[4] Economist at Magalhães & Dias Advocacia. PhD in Economics from the University of São Paulo (FEA-USP), dre@magalhaesdias.com.br.

Resumo: Este estudo estima o sobrepreço decorrente da cartelização do mercado de cimento no Brasil (1994 – 2007). Utiliza-se um modelo de Diferença em Diferenças que compara a trajetória dos preços do cimento, obtidos no SINAPI-IBGE, com a de insumos similares (cal e aço), tomando as buscas e apreensões realizadas pelo Cade em fevereiro de 2007 como choque exógeno. O intervalo junho/2006-agosto/2007 captura a ruptura imediata do conluio, resultando em um sobrepreço médio de 2,02%. Aplicado ao volume de vendas das firmas participantes e atualizado monetariamente, o sobrepreço representa uma transferência de aproximadamente R$ 6,94 bilhões aos agentes cartelizados. A atuação antitruste, ao desmantelar o cartel, gerou economia estimada em R$ 11,8 bilhões para os consumidores entre fevereiro de 2007 e dezembro de 2022. As evidências encontradas destacam a eficácia das intervenções do Cade e reforçam a necessidade de sanções rigorosas para dissuadir práticas anticoncorrenciais que impõem custos elevados à sociedade.

Palavras-chave: Cartel; Defesa da Concorrência; Sobrepreço; Diferença-em-Diferenças.

1. Introduction

On 28 May 2014 the *Conselho Administrativo de Defesa Econômica* (Cade) Tribunal imposed the heaviest penalty ever recorded by Brazil's competition-law system: fines totaling R$ 3.1[5] billion on the country's six largest cement companies[6] (Votorantim Cimentos, Itabira Agroindustrial, InterCement Brasil, Holcim Brasil, Cimpor CCB e Cia de Cimento Itambé). The sectoral associations[7] ABCP, SNIC and ABESC were fined R$ 4 million, and six executives[8] were ordered to pay a combined R$ 26.1 million. Beyond the monetary sanctions, the ruling imposed administrative and financial restrictions that included entry in the National Consumer Protection Registry, suspension of fiscal incentives, bans on borrowing from

[5] Updated to January 2025, this amount equals R$ 5,616,274,307.14.
[6] The Cade signed a Cease and Desist Agreement (TCC) with Lafarge Brasil S.A.; the settlement set a contribution of R$ 43 million to the Fundo de Defesa dos Direitos Difusos.
[7] Under article 20 item I together with article 21 item II of Law 8,884 of 1994.
[8] Under article 20 items I, II and III of the same law.

state-owned banks, mandatory publication of decision extracts in major newspapers, reporting obligations to CADE and asset divestitures to reduce market concentration. The associations were barred from refusing membership to firms meeting their bylaws' requirements and from electing convicted individuals to their boards for five years. CADE also ordered sector-wide monitoring for five years to prevent recidivism.

The investigation began on 23 November 2006, when a Votorantim sales manager filed a cartel complaint with Brazil's *Secretaria de Direito Econômico* (SDE). In January 2007 the agency opened a confidential inquiry and, after confirming the evidence, secured court warrants for searches and seizures carried out from 7 to 13 February 2007. The material collected supported the launch in March of Administrative Proceeding 08012.011142/2006-79. February 2007 serves as the date marking the breakdown of anticompetitive conduct and the reference point for the Difference in Differences estimator, since cartels usually stop communicating once an investigation is announced (Harrington, 2004a). The case file reached CADE's tribunal in November 2011 and was decided in May 2014; the investigative path from SDE to CADE remained uninterrupted despite the institutional changes introduced by Law 12.529 of 2011.

Case records show that the cement cartel had been active in Brazil for decades, with documented evidence dating back to 1987[9]. In 2012 market concentration was striking: eight cement firms, seven of them defendants, accounted for about 85%[10] of national output, although shares varied across regions. Entry was further limited by the slow licensing of limestone quarries, a process that could take up to five years, illustrating the hurdles new producers faced (CADE, 2014).

---

[9] A former Votorantim employee stated that the cartel had been active since the 1960s. The case file notes that the minutes of ABESC's 88th Executive Board meeting (23 April 1987) proposed regional average price tables based on local cost structures, while the minutes of the 95th meeting (9 December 1987) reported the creation of a Standard Cost System requiring firms to send cost data to ABESC for price setting. This shows the cement cartel extended its anticompetitive coordination downstream as well as in production.

[10] SINDICATO Nacional da Indústria do Cimento, 2012. Available at: http://snic.org.br/assets/pdf/relatorio_anual/rel_anual_2012.pdf. Accessed on: March 24, 2025.

Cement is a relatively uniform commodity produced by calcining limestone with chemical additives, then forming clinker and grinding it with gypsum or other materials; Portland II, a gray variety, is the most common. Because transport becomes uneconomical beyond about three hundred to five hundred kilometers, plants are usually located close to limestone quarries, which creates regional markets. Building a new plant demands large investments in infrastructure, equipment and specialized technology, and must pass through an environmental and mineral licensing process that can last up to five years. These requirements raise major entry barriers, limit market contestability and help sustain high industrial concentration (CADE, 2019).

The sector's structure favours collusion; high logistics costs and economies of scale concentrate production in a few firms, the homogeneous product simplifies coordination, and relatively inelastic demand strengthens incumbents' market power (Ivaldi *et al.*, 2003; Harrington *et al.*, 2015). Cartels, understood as agreements that restrict competition and lift prices, typically last about five years but can dissolve quickly when cheating, new entry, or external shocks occur. Some nevertheless persist for decades because flexible organizational arrangements make them resilient (Levenstein, 2006). Antitrust investigations curtail the formation of new cartels and speed the breakup of existing ones, as shown in European evidence (Zhou, 2016) and in the Brazilian cement case reviewed by CADE, where collusion endured for many years.

The cement industry brings together factors that favour illegal agreements. High transport costs and economies of scale leave production in the hands of a few firms, while the homogeneous product makes coordination easier. A shortage of substitutes creates relatively inelastic demand, and strong entry barriers such as large upfront investment and lengthy environmental licensing limit market contestability and create an environment that encourages collusion (Ivaldi *et al.*, 2003; Harrington *et al.*, 2015).

Levenstein (2006) defines cartels as agreements in which firms curb competition, raise prices, and control market supply. While their average lifespan is roughly five years, many collapse in less than twelve months due to member cheating, new entrants, or external shocks. Others, however, can endure for decades when flexible organizational structures operate in

highly concentrated markets, as the Brazilian cement case illustrates. Antitrust investigations lessen the formation of new cartels and hasten member exits from existing ones, a pattern observed by the European Commission across several industries (Zhou, 2016).

Evidence from South Africa, Germany, Argentina, Poland, and India shows that cement cartels are a recurring phenomenon in both advanced and emerging economies, underscoring the structural factors highlighted by Harrington *et al.* (2015). Under Brazilian law such conduct violates economic order: article 36 paragraph 3 item I letter d of Law 12.529 of 2011 bans price fixing, output restriction, market division, and bid rigging, since these practices undermine competition and cause direct harm to consumers.

Finkelstein and Levenbach (1983) show that estimating cartel damages relies on statistical methods, chiefly regressions that separate the impact of collusion from other price drivers. The authors note that the *Ohio Valley Electric Corp. v. General Electric Co.* case illustrates the tension between courts' subjective assessments and objective econometric evidence: although overcharge is the gap between observed and competitive prices, deriving the competitive benchmark involves modelling choices and data quality that often spur debate. Even so, advances in econometrics have led judges and litigants to insist on more rigorous quantitative proof when attributing price movements to external factors.

Komninos *et al.* (2010) note that Austria's Federal Chamber of Labour brought a civil action after the Cartel Court fined five driving schools €75.000 each for charging identical fees over two months. Damages were calculated as a 22% gap between the cartel price and the post-collusion market average, which fell from €1.140 to €900 and was upheld on appeal. Similarly, Erutku and Hildebrand (2010) used Difference in Differences to measure the impact of a Canadian Competition Bureau probe into a gasoline cartel in Sherbrooke. After controlling for lagged wholesale prices, seasonality, and other factors, they found that retail prices in Sherbrooke dropped by 1.75 cent per litre relative to Montreal once the investigation was announced, a figure interpreted as the cartel overcharge.

Inspired by these precedents, this study applies a Difference in Differences model to estimate the overcharge in Brazil's cement market. The exogenous shock is the search and seizure operation conducted by the Ad-

ministrative Council for Economic Defense in February 2007 at the headquarters of the investigated firms, an event that marked the breakdown of the collusive scheme and sets the temporal benchmark for comparing actual prices with the competitive counterfactual.

This study measures only the overcharge, that is, how much extra consumers paid because of collusion; it does not compute full compensation or the welfare loss from reduced quantities, since identifying potential buyers who were priced out is methodologically complex and legally disputed. The literature notes that in a competitive setting lower prices would raise sales and aggregate welfare (Khumalo *et al*., 2012), whereas the absence of rivalry pushes prices up, cuts output, and discourages innovation, which weakens allocative efficiency in the long run (Tito, 2018). Although these broader effects matter, they lie beyond the scope here, which is limited to gauging the cartel's direct impact on the prices consumers actually paid. Beyond the introduction, the study is organized into four sections. Section two explains the research methodology and the data sources. Section three presents the descriptive statistics and the econometric results. Section four closes with the main conclusions.

2. Methodology and Data

Measuring cartel damages involves estimating the overcharge consumers paid relative to the counterfactual competitive price and then multiplying that margin by the quantity sold during the infringement period[11], a method widely discussed by Afonso (2017) and formalised by Hovenkamp (2011). Although essential for gauging the direct financial impact, this calculation captures only part of the welfare loss because it does not consider suppressed demand or the effects on innovation and productive efficiency. The financial impact of the collusive conduct can therefore be expressed by the following formula:

$$Cartel\ Economic\ Damage = (P^{Cartel} - P^{Competitive})\ x\ Q^{Cartel} \quad (1)$$

[11] Hovenkamp (2011) notes that in the United States more than 90% of antitrust actions are initiated by private plaintiffs rather than by the government.

The term in parentheses on the right side of equation (1) represents the exact overcharge, and Q^{Cartel} denotes the quantity sold by the cartel during its lifetime. According to Komninos *et al.* (2010), the main difference among damage-estimation methods lies in how the counterfactual is constructed, that is, the market price that would have prevailed without collusion.

Hovenkamp (2011) observes that US antitrust practice often estimates cartel damages by comparing different markets. Two common approaches are the before and after method, which contrasts prices charged during the cartel with those observed before it formed, and the yardstick method, which compares prices, performance, or other indicators in the affected market with those in a similar competitive market. Both approaches require advanced statistical analysis and face limitations such as structural differences between the markets, artificial price stabilization by the cartel that may understate damages, and external influences like mergers and technological progress that can distort overcharge estimates.

Temporal and spatial comparison methods such as Difference in Differences examine how prices in the cartelized market change before and after an intervention relative to a control market, showing that observed shifts are not replicated in similar settings. This approach combines scientific credibility with moderate data requirements and straightforward implementation, yielding robust overcharge estimates. For these reasons it was adopted here and has been widely applied to cartel analysis, including detergents in Europe from 2002 to 2005 (Laitenberger; Smuda, 2015), cement in Germany (Hüschelrath; Müller; Veith, 2012), peroxides in Brazil (Seixas; Lucinda, 2019) and fuels in Spain after an antitrust ruling in 2015 (González; Moral, 2019).

In this study the Brazilian cement industry is treated[12] as the exposed unit, while the control group comprises other segments of the construction sector that did not face competitive disruptions during the analysis period. Because building materials are often used together, industries such

[12] The SNIC 2012 Annual Report states that the seven cartel members held about 85% of the market. Their combined share reached 87.22% in 2011 and 85.66% in 2012. Earlier SNIC figures show that the same firms controlled 86% of the market in 2006 and 88.67% in 2007.

as steel, lime, sand and crushed stone encounter similar macroeconomic shocks and follow the same cycles of the housing market. These shared characteristics make them suitable members of a well-matched control group.

Because the cement cartel spanned the entire country and involved nearly every firm, untreated regions or independent companies cannot serve as a control, and international comparisons are unsuitable because construction prices reflect each nation's economic cycles and regulations. We therefore apply a Difference in Differences design that contrasts the cement price series with those of other construction inputs not affected by antitrust action. The relative decline in cement prices after the SDE intervention, which shifted the market from cartelized to potentially competitive, represents the average treatment effect and quantifies the overcharge. The empirical model appears in equation (2).

$$log(P_{ivt}) = \beta Cartel_i\, D_t + \mu_i + \lambda_v + \delta_t + \varepsilon_{ivt} \qquad (2)$$

In equation (2), P_{ivt} is the dependent variable and records the price of construction input i (cement or a control input) in state v at month t. The dummy $Cartel_i$ equals 1 for cement and 0 for the control industries, while D_t equals 1 after the SDE intervention and 0 before. Their interaction captures the intervention's impact on cement prices, and the coefficient β is the overcharge estimate. μ_i represents input fixed effects, λ_v state fixed effects, δ_t time effects, and ε_{ivt} is the error term.

For the Difference in Differences model to produce valid estimates, the price path of the control group must resemble that of the treated cement industry in the hypothetical absence of the antitrust intervention (Angrist; Pischke, 2009). This is the parallel trends assumption, which cannot be tested directly. Its plausibility can be assessed by estimating a Difference in Differences specification that interacts the treatment indicator with dummies for each month and year. This event study design, a Difference in Differences with leads and lags, makes it possible to visualize deviations from parallel trends before and after the intervention.

$$log(P_{ivt}) = \sum_{\tau=-q}^{-1} \gamma_\tau Cartel_{i\tau} + \sum_{\tau}^{m} \theta_\tau Cartel_{i\tau} + \mu_i + \lambda_v + \delta_t + \varepsilon_{ivt} \qquad (3)$$

In this specification $Cartel_{i\tau}$ is a dummy that equals 1 only for cement industry observations in month τ. The intervention start date is $\tau = 0$, which corresponds to February 2007[13]. Equation (3) therefore includes q lead terms and m lag terms. The parallel trends assumption can be assessed by testing whether the coefficients on the leads are statistically different from zero. If they are, it would indicate that even before the antitrust intervention cement prices were following a different path from the other construction inputs in the control group. This would undermine the causal interpretation of the Difference in Differences estimates and bias the overcharge calculation.

Besides helping to verify the parallel trends assumption, equation (3) also uses the m post treatment effects to indicate when the cement cartel broke down as a result of the SDE intervention. As noted in the introduction, the case involved several distinct steps, including the initial complaint, raids to seize documents and the opening of administrative proceedings, each of which may have produced different competitive effects. Knowing the exact month and year when the SDE action likely influenced the market is essential for defining the variable D_t in equation (2). Harrington (2004a) shows that most cartels cease meetings and communication as soon as an investigation is announced, which in this case coincided with the raids. Therefore $\tau = 0$, set for February 2007, marks the start of the intervention period.

To estimate equations (2) and (3) we use median price data from the National System of Construction Cost and Index Surveys of the Brazilian Institute of Geography and Statistics, SINAPI IBGE. This dataset reports monthly median prices for 69 construction inputs in every Brazilian state from January 2003 to September 2013. In the Difference in Differences

[13] Zhou (2016) and Turner (2024) treat the date of unannounced inspections by competition authorities as the benchmark for assessing the impact of antitrust investigations.

design the treated unit is the price per kilogram of Portland composite cement (CP II E 32[14]). The control group is limited to construction inputs that share the same unit of measurement[15], are not ingredients of cement, and do not use cement in their own production. Only three inputs meet these requirements: CA 50 steel bar, CA 60 steel bar, and hydrated lime[16]. Focusing on these items improves comparability between treatment and control groups and helps preserve the parallel trends assumption.

Monthly prices for cement, steel bar and lime are used from thirteen months before the SDE intervention in February 2007 through seven months afterward. This window allows equation (2) to be estimated with thirteen lead effects and seven post treatment effects ($q = 13\,; m = 7$). A much longer period could obscure the competitive impact of the cartel breakup by introducing a higher chance of unobserved shocks that influence cement prices, while a shorter period would shrink the sample and lower estimator efficiency.

The *Programa de Aceleração do Crescimento* (PAC) launched in January 2007, shortly after the raids that exposed the cement cartel, earmarked 503 billion Brazilian reais in investment for sanitation, housing, transport, energy and water resources between 2007 and 2010, equal to 21.2% of 2006 GDP (Brazil 2007). This surge in public and private spending sharply boosted demand for construction inputs, including cement, driving rapid output growth and likely putting upward pressure on prices.

Given this context, carefully defining the time window is essential to ensure that the effects of dismantling the cartel are not mistaken for price

[14] According to the 2012 SNIC report, CP II cement accounted for 64 percent of total production in 2007.

[15] Using kilograms as the standard unit of measurement ensures that input prices are comparable and prevents distortions in identifying the treatment's causal effect. A robustness check with data from the Câmara Brasileira da Indústria da Construção (CBIC), whose cement price series is likewise expressed in reais per kilogram, further confirms the suitability of this standardization.

[16] Although both lime and cement rely on limestone, the cartel operated only in the cement market. The lime industry, which is far more fragmented with about 185 firms, was not subject to the anticompetitive conduct and therefore serves as a suitable control group. This distinction strengthens the causal identification of the antitrust intervention's effect (CETESB 2018).

changes driven by demand growth from construction-oriented industrial policies. Because stronger demand typically boosts production and pushes prices upward, including this shock could distort the proper identification of the overcharge in the period after the cartel broke up.

3. Results

Table 1 reports descriptive statistics for the sample, distinguishing the pre- and post-SDE periods and each construction input from June 2006 to August 2007. After the SDE intervention and the likely cartel breakup, the average cement price fell. The price range and standard deviation for cement widened, indicating greater dispersion. Note that the figures reflect the mean of state-level medians, which can affect the interpretation of dispersion yet still capture the overall price patterns for the period studied.

Table 1 - Descriptive Statistics

A. Before the Search and Seizure (February 2007)					
Product	**Mean**	**Median**	**Standard Deviation**	**Minimum**	**Maximum**
CA 50 Steel Bar	4,4897	4,4851	0,4079	3,5873	5,3883
CA 60 steel bar	5,6741	5,6788	0,5308	4,4984	6,8712
Hydrated Lime	0,6461	0,5468	0,2844	0,2705	1,4298
Cement	0,4922	0,4927	0,1073	0,2918	0,8183
B. After the Search and Seizure (February 2007)					
CA 50 Steel Bar	4,4645	4,4575	0,4232	3,5744	5,5342
CA 60 steel bar	5,7401	5,7301	0,5598	4,4510	7,0603
Hydrated Lime	0,6486	0,5563	0,2921	0,2643	1,4173
Cement	0,4839	0,4776	0,1089	0,2773	0,8101

Note: Author's calculations based on SINAPI IBGE data. Prices are expressed in September 2013 reais deflated with the National Broad Consumer Price Index IPCA IBGE.

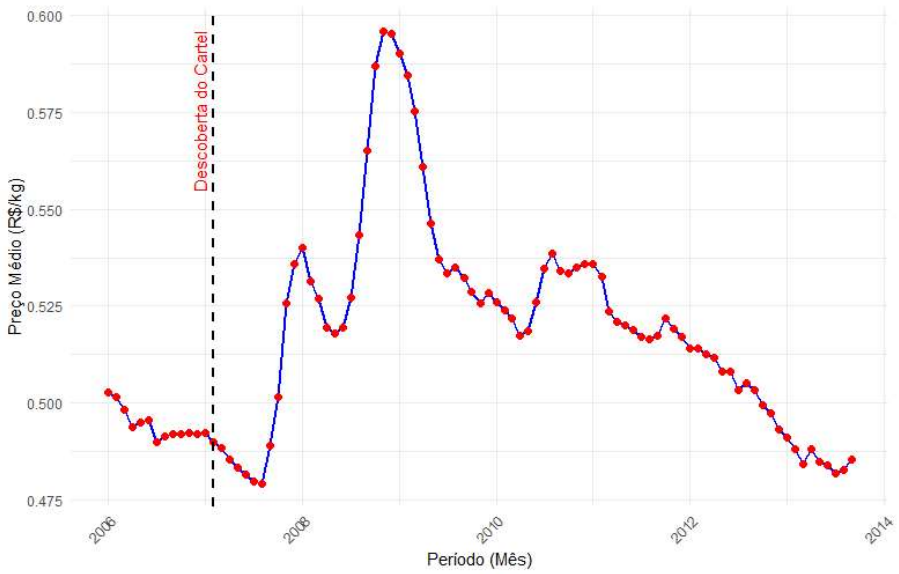
Figure 1 shows that cement prices fell immediately after the cartel was uncovered in February 2007, suggesting an instant effect of the intervention. From September 2007 onward, however, prices began to rise steadily, implying the influence of factors unrelated to the detection itself. Harrington (2004b, 2005) argues that firms engaged in illegal collusion sometimes keep prices below the profit-maximizing level to avoid drawing suspicion and triggering investigations. Once a cartel has been exposed and

explicit coordination ceases, firms may switch to tacit collusion. With no documented communication to provoke new penalties, they no longer need to conceal their behaviour and can raise prices toward the profit-maximizing level even without a formal agreement. This mechanism could explain why prices remained high or even increased after the cartel was dissolved.

Given this price pattern, event study analyses that extend too far beyond the intervention risk capturing macroeconomic shocks, sectoral changes, independent commercial strategies, or price adjustments by former cartel members. These factors undermine a clear causal link between the intervention and observed prices. A short time window is therefore essential, as it better isolates the immediate effect of uncovering the cartel on cement prices and avoids attributing outside dynamics to the event under study.

Limiting the lags lets us concentrate on short term impacts and keeps long term trends from distorting the analysis. This choice lowers the risk of assigning to the event any effects that may arise from other market dynamics. It also yields a more precise inference about the link between uncovering the cartel and cement price behaviour, producing a more robust and reliable assessment of the intervention. The final dataset for estimating equations (2) and (3) is therefore a balanced panel of monthly prices for cement, CA 50 steel bar, CA 60 steel bar and hydrated lime for every Brazilian state from January 2006 to October 2007.

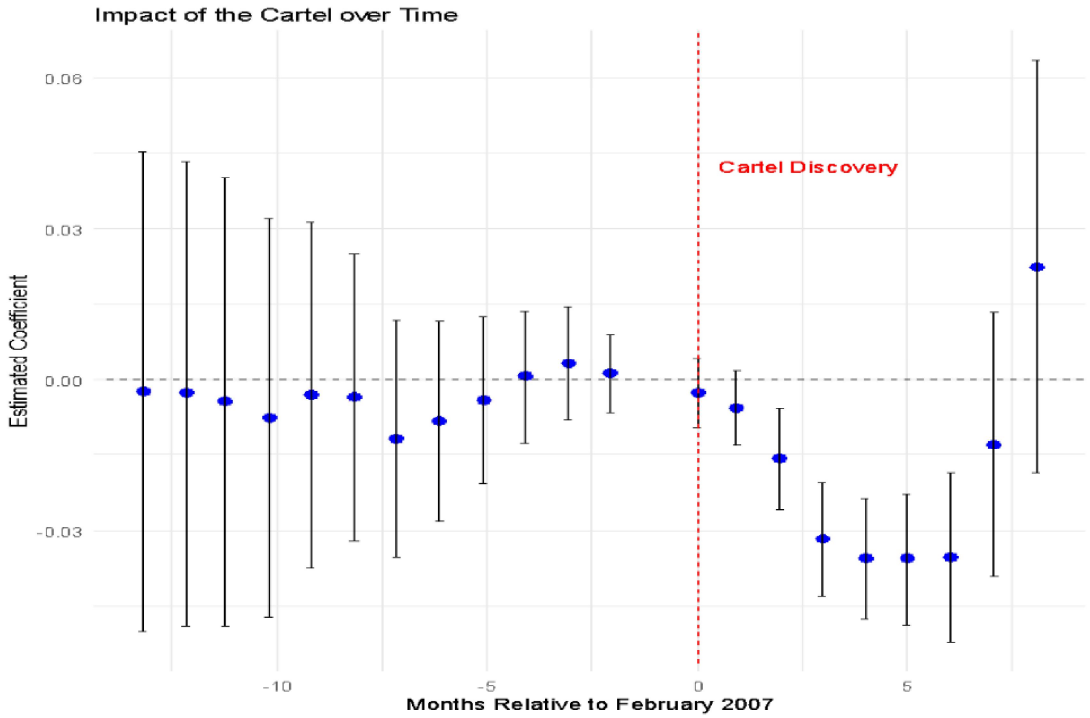
Figure 1 - Change in the Average Cement Price Over Time



Note: Author's calculations based on SINAPI IBGE data. Prices are expressed in September 2013 reais, deflated with the National Broad Consumer Price Index IPCA IBGE.

Figure 2 displays the event-study Difference in Differences estimates from equation (3). The treated group is the cement industry affected by the antitrust intervention, while the control group combines hydrated lime and CA 50 and CA 60 steel bars, all measured in kilograms. The dependent variable is the natural log of the input price in reais.

Figure 2 Event Study - The Effect of the Intervention on Cement Prices



Note: The figure plots the coefficients estimated from equation (3), along with their 95 percent confidence intervals. The red vertical line marks the start of the antitrust intervention in the cement industry in February 2006.

First, none of the coefficients on the lead terms in Figure 2 are statistically significant. This shows that, before the SDE intervention, the cement price path did not diverge from the joint path of the three control inputs, namely hydrated lime, CA 50 steel bar and CA 60 steel bar. This result supports the parallel trends assumption and lends credibility to the Difference in Differences estimator, since any post-treatment effect cannot be attributed to pre-existing divergent trends between the cement industry and the combined control group.

For the post treatment coefficients in Figure 2, which correspond to the m lags in equation 3, only the third month after the SDE raids (May[17] 2007) shows a statistically significant effect. This finding indicates that the cartel breakup and the end of anticompetitive practices began to affect the

[17] The month of April showed a p-value of 0.0512.

market from that date onward. Figure 2 also shows that the antitrust intervention reduced cement prices by between 1.58% and 3.51%, an outcome expected when a cartelized market moves toward competition.

Table 2 reports the Difference in Differences estimates from equation (2), which quantify how the antitrust intervention changed cement prices and the resulting average overcharge. Three specifications are shown: column (1) includes input fixed effects and time effects; column (2) adds state fixed effects; and column (3) further adds state by month year fixed effects. The dependent variable is the logarithm of the construction input price in reais.

Table 2 - Difference in Differences: the effect of the intervention on cement prices

June 2006 to October 2007						
	(1)	(2)	(3)	(4)	(5)	(6)
Coefficient β	-0.0141	-0.0141	-0.0141	-0.0160	-0.0160	-0.0160
	(0.0067)	(0.0067)	(0.0067)	(0.0065)	(0.0065)	(0.0065)
P-value	0.0439	0.0439	0.0454	0.0214	0.0214	0.0223
Input Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	Não	Yes	Não	Não	Yes	Não
Time Effect	Yes	Yes	Yes	Yes	Yes	Yes
State by Time Interaction	Não	No	Yes	No	No	Yes
Observations	1836	1836	1836	1836	1836	1836
Adjusted R squared	0.954	0.972	0.972	0.954	0.972	0.972
June 2006 to September 2007						
Coefficient β	-0.0191	-0.0191	-0.0191	-0.0219	-0.0219	-0.0219
	(0.0067)	(0.0067)	(0.0067)	(0.0063)	(0.0063)	(0.0064)
P-value	0.0087	0.0087	0.0091	0.0019	0.0019	0.0021
Input Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	No	Yes	No	No	Yes	No
Time Effect	Yes	Yes	Yes	Yes	Yes	Yes
State by Time Interaction	No	No	Yes	No	No	Yes
Observations	1728	1728	1728	1728	1728	1728
Adjusted R squared	0.953	0.972	0.972	0.953	0.972	0.972
June 2006 t o August 2007						
Coefficient β	-0.0204	-0.0204	-0.0204	-0.0238	-0.0238	-0.0238
	(0.0069)	(0.0069)	(0.0069)	(0.0064)	(0.0064)	(0.0065)

P-value	0.0066	0.0066	0.0070	0.0010	0.0010	0.0011
Input Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	No	Yes	No	No	Yes	No
Time Effect	Yes	Yes	Yes	Yes	Yes	Yes
State by Time Interaction	No	No	Yes	No	No	Yes
Observations	1620	1620	1620	1620	1620	1620
Adjusted R squared	0.953	0.972	0.972	0.954	0.972	0.972

Note: Clustered standard errors at the input and state levels are reported in parentheses. Columns (1) to (3) treat February 2007 as the date when the cartel broke up, while columns (4) to (6) use March 2007 as the reference.

Table 2 shows that the antitrust intervention lowered the average cement price by between 1.40% and 2.02%[18]. The effect is strongest in the short window from June 2006 to August 2007, which best captures the immediate impact of exposing the cartel, and it stays stable after controls for input, state and time, ensuring robustness. This gap is treated as the overcharge: without the breakup prices would have been about 2.02 percent higher. When March 2007, the month the administrative case was opened, is chosen as the reference point, the decline ranges from 1.59% to 2.35%, always significant at the 5 percent level, confirming that the firms lost market power after Cade's action[19].

Govinda and Khumalo (2014) report similar evidence. Using ordinary least squares (OLS) and two stage least squares (2SLS), they estimate the direct financial benefits of the Competition Commission's action after the South African cement cartel was uncovered. They find an overcharge of 7.5% to 9.7% during the cartel period, translating into consumer savings of

[18] According to Wooldridge (2006), in a semilogarithmic regression the percentage effect of a dummy variable is calculated as $(\exp(\beta) - 1) \times 100$.

[19] Two robustness checks confirm the main finding. First, the set of control inputs was rotated, always including two at a time. Cement prices still fell by 1.55% to 2.38% when February 2007 marks the break and by 1.83% to 2.74% when March 2007 is the reference, all significant at the five percent level. These magnitudes stayed stable after adding fixed effects for product, state, time and their interactions. Second, using price data from the Brazilian Chamber of the Construction Industry based on SNIC figures, the estimated drop ranged from 1.58% to 1.72%, significant at the ten percent level. Together, the checks show that the decline stems from Cade's intervention rather than peculiarities of the sample.

USD[20] 424.5 million to USD 547.1 million from 2010 to 2013. In addition to these financial gains, the market became more competitive, as new firms entered regions that had not been served while the cartel was active.

This analysis adopts the conservative assumption that the affected market becomes fully competitive once the antitrust intervention occurs. Evidence shows, however, that cartels often keep prices elevated even after discovery and litigation (Erutku, 2012). As a result, the true average overcharge is likely higher than our estimate. The point estimate of two-point zero two percent contrasts with the meta-analysis by Boyer and Kotchoni (2015), which reports average cartel overcharges between fifteen point four seven- and sixteen-point zero one percent. Connor and Lande (2008) likewise examined two hundred and thirty-four markets and found a median overcharge of twenty five percent. International cartels appear even more harmful, raising prices seventy five percent above those of domestic cartels, possibly because global competition is weaker.

Therefore, the estimate may be understated. Komninos *et al.* (2010) note that after a cartel is dismantled the market can take an extended period to reach a noncooperative price level. Confidential information often keeps circulating among firms, letting them anticipate rivals' moves and sustain collusive effects. The transition to full competition is also gradual as companies adjust their strategies and explore new market equilibria.

Harrington (2004a) shows that after a cartel has been dismantled firms may strategically keep prices high during the litigation phase to influence the counterfactual price used in damage calculations. Such behaviour artificially lowers the measured overcharge and therefore the compensation owed. The bias is strongest in highly concentrated industries and in long lived cartels, where firms have greater incentive to manipulate prices. Even without explicit collusion strategic post cartel pricing can weaken the effectiveness of antitrust sanctions.

These findings must be interpreted with caution, because evidence indicates that the cement cartel had been active since 1987. Its long life gives the firms strong incentives to keep prices high once the cartel is broken. In antitrust litigation the size of damages depends on the volume traded during

[20] United States Dollar.

collusion, so maintaining elevated prices afterward can reduce the calculated overcharge and the compensation that must be paid[21]. Harrington (2004a) notes that the cement industry is highly concentrated, which strengthens the incentive to raise prices after collusion ends and increases the bias in the counterfactual price, leading to an understated damage estimate. Ideally one would use pre cartel prices to measure the overcharge, but the cartel lasted so long that reliable data from before it began are scarce, and dating its start is harder than identifying when it dissolved.

Turner (2024) shows that, even after the United States Department of Justice and the European Commission broke up the largest international cartel ever uncovered—the air cargo cartel[22]—prices stayed high, indicating tacit collusion. Carriers kept applying the pricing formula devised during collusion, which linked a uniform surcharge to jet-fuel costs. Turner points to two weaknesses in antitrust enforcement. First, fines that cover only profits earned while the cartel was active overlook the continued gains from tacit coordination, letting firms keep above-normal profits and weakening deterrence. Second, private damage claims limited to the formal cartel period understate the real harm inflicted.

González and Moral (2019) found that antitrust sanctions on an oil cartel in Spain produced a slight rise in prices, with the additional revenue far surpassing the fine. They argue that mild penalties may fail to deter collusion. Sproul (1993) examined twenty-five cartels prosecuted between

[21] Although Law 12.529/2011 expressly provides for private antitrust damage actions in Brazil, such lawsuits remain rare. At the time the cement cartel was investigated and tried, private claims for competitive harm were not part of established legal practice, and little has changed since then. Ragazzo and Veloso (2023) note that legal uncertainty, evidentiary hurdles and high costs discourage these actions, especially in markets with highly dispersed buyers. By contrast, compensation claims are more common in sectors where purchasers are economically organized. Moreover, even after a cartel is formally dissolved, tacit coordination can persist, sustained by institutionalized practices that require no explicit communication.

[22] The air-cargo cartel is among the costliest ever punished, with fines exceeding USD 1.6 billion in the United States and USD 1.1 billion in Europe after settlements with the US Department of Justice and the European Commission (Bergman and Sokol 2015). Competition authorities in other countries also levied additional penalties that raised the global total by several hundred million dollars.

1973 and 1984 and noted that prices generally increased in the four years following price fixing charges.

3.1. Estimation of Economic Damage from Overcharge

Table 3 provides the detailed calculation of the total economic damage caused by the cement cartel from January 1994 to February 2007, following equation (1). The damage is calculated only from the estimated overcharge, defined as the difference between the prices charged under collusion and the prices that would have prevailed in a competitive scenario, multiplied by the sales volume of the firms involved. Column (A) shows the average[23] price of Portland cement 32. Column (B) reports the absolute overcharge, using the average rate of two-point zero two percent found in Table 2[24]. Column (C) records the quantity of cement consumed in Brazil that was sold directly by the cartel, based on its eighty five percent market share. Column (D) presents the damage in current reais. Column (E) lists the accumulated *Índice Nacional de Preços ao Consumidor Amplo* (IPCA) inflation from each year to January 2025. Column (F) expresses the damage in January 2025 reais. Although the calculation relies on sales made by cartel members, the inflated reference price probably influenced firms outside the agreement as well, meaning the anticompetitive conduct may have distorted the entire industry.

National data on average cement prices and quantities sold were obtained from the *Sindicato Nacional da Indústria de Cimento* (SNIC) and are freely available on the data[25] platform of the *Câmara Brasileira da Indústria da Construção* (CBIC). Although evidence suggests that the cement cartel was active in Brazil as early as 1987, price records start only in 1994. This gap prevents estimating economic harm for earlier years, so the total damage figure is understated.

[23] We use the cement price quoted in Brazilian reais for December of each year.
[24] Columns (1) to (3) of Table 2 show a 2,02% drop in cement prices. With a five percent significance level, the ninety five percent confidence interval spans from -0,69% -3,45% the competitive benchmark.
[25] CBIC. Cimento [s.d]. Available at: http://www.cbicdados.com.br/menu/materiais-de-construcao/cimento. Accessed on: March 24, 2025.

Table 3 - Economic Damage from Overcharge Generated by the Cement Cartel from 1994 to 2006

Year	A. Cement Price (per kg)	B. Average Overcharge (A × 2.02 percent)	C. Cement Consumption (kg)	D. Economic Damage (B × C)	E. Monetary Correction Factor	F. Updated Economic Damage (D × E)
1994	R$ 0,11840	R$ 0,00239	21.289.418.750,00	R$ 50.917.477,04	7,11630	R$ 362.346.246,40
1995	R$ 0,12050	R$ 0,00243	23.853.204.050,00	R$ 58.061.083,98	5,80500	R$ 337.046.412,36
1996	R$ 0,12100	R$ 0,00244	29.329.023.900,00	R$ 71.686.000,22	5,24140	R$ 375.735.740,99
1997	R$ 0,12210	R$ 0,00247	32.232.634.100,00	R$ 79.499.213,40	4,97920	R$ 395.840.761,04
1998	R$ 0,13250	R$ 0,00268	33.749.219.400,00	R$ 90.329.785,72	4,89330	R$ 442.006.873,45
1999	R$ 0,17800	R$ 0,00360	34.038.063.000,00	R$ 122.387.259,32	4,50380	R$ 551.204.208,80
2000	R$ 0,20700	R$ 0,00418	33.326.981.050,00	R$ 139.353.438,56	4,24940	R$ 592.173.844,14
2001	R$ 0,26450	R$ 0,00534	32.524.355.800,00	R$ 173.774.380,60	3,94900	R$ 686.230.005,67
2002	R$ 0,33600	R$ 0,00679	32.157.591.000,00	R$ 218.260.001,64	3,55980	R$ 776.960.289,55
2003	R$ 0,34950	R$ 0,00706	28.527.436.500,00	R$ 201.400.848,95	3,22070	R$ 645.789.212,44
2004	R$ 0,32870	R$ 0,00664	30.311.148.750,00	R$ 201.258.146,80	2,99010	R$ 601.781.718,46
2005	R$ 0,28850	R$ 0,00583	31.944.443.300,00	R$ 186.162.632,22	2,81510	R$ 524.069.721,29
2006	R$ 0,28870	R$ 0,00583	34.797.567.750,00	R$ 202.930.367,75	2,73260	R$ 554.535.674,56
2007	R$ 0,29400	R$ 0,00594	6.372.747.780,50	R$ 37.846.474,52	2,62280	R$ 99.263.826,33
						R$ 6.944.984.535,48

Note: Author's calculations based on data from the National Cement Industry Union SNIC. The estimates assume an average overcharge of 2.70 percent and a cartel market share of 85 percent. Cement consumption for 2007 reflects the combined total for January and February

According to the SNIC report (2012)[26], CP II accounted for 64 % of total cement production in 2007[27]. The average damage estimated from

[26] For further information on other reports, see http://snic.org.br/numeros-relatorio-anual.php.

[27] In 2007 the share was 64.11 percent; in 2008 63.65 percent; 2009 66.98 percent; 2010 65.08 percent; 2011 60.31 percent; and in 2012 57.75 percent. The SNIC 2007 report indicates that CP II Portland cement accounted for 73.51 percent of total production in 2002, 69.44 percent in 2003, 66.22 percent in 2004, 65.05 percent in 2005, and 64.72 percent in 2006.

the overcharge in Table 5 was about R$ 6.94 billion. Applying the same 64 % share to the 1994–2006 period lowers this figure to roughly R$ 4.44 billion. If the cartel had operated only in CP II and that share had remained constant, the estimated economic damage at the 95 % confidence level would lie between R$ 1.52[28] billion and R$ 7.59[29] billion. Evidence in the case file shows that the cartel affected other cement types as well; therefore, although the overcharge estimate relies solely on CP II[30] prices, it serves as a conservative baseline for the entire market. This extrapolation is supported by Table 4, which uses independent CBIC data and shows a statistically significant drop in average cement prices after the cartel's breakup, indicating that its impact was felt across the market. Finally, the figure of R$ 6.94 billion covers only the overcharge damage during the cartel period and excludes other potential welfare losses to society.

The drop seen in this alternative dataset shows that uncovering the cartel lowered the average price of Portland cement 32, hinting that the anticompetitive conduct may have affected other cement grades as well. Calculating damages for only one cement type is therefore conservative and likely understates the true impact.

3.2. Consumer Savings

Regression estimates for June 2006 to August 2007 show that cartel prices averaged 2.02 percent above competitive prices, a difference significant at the 1 percent level. Using this result, the study simulated two alternative scenarios: one in which the cartel remained active and another in which the Brazilian cement market operated competitively without cartel

[28] Using the upper bound of the confidence interval (−0.69 %), 64 % of the amount of R$ 2,372,296,697.75 for the 1994–2006 period was taken as the reference.
[29] Taking the lower bound of the confidence interval (−3.39 %), 64 % of the amount of R$ 11,861,483,488.73 for the 1994–2006 period was used.
[30] Since CP II-E-32 is only one variant within the CP II family, we assume its market share matches that of overall CP II and fix it at 64 % to obtain a conservative damage estimate. This percentage acts as a plausible ceiling: if the true share of CP II-E-32 is smaller, the calculated damage decreases proportionally; if it equals that limit, the estimate already captures the maximum impact attributable to this subtype without risk of overestimation.

influence. Figure 3 displays the outcomes of these simulations for July 1994 to December 2022.

Figure 3 - Effect of the Cartel on the Real Price of Cement Over Time

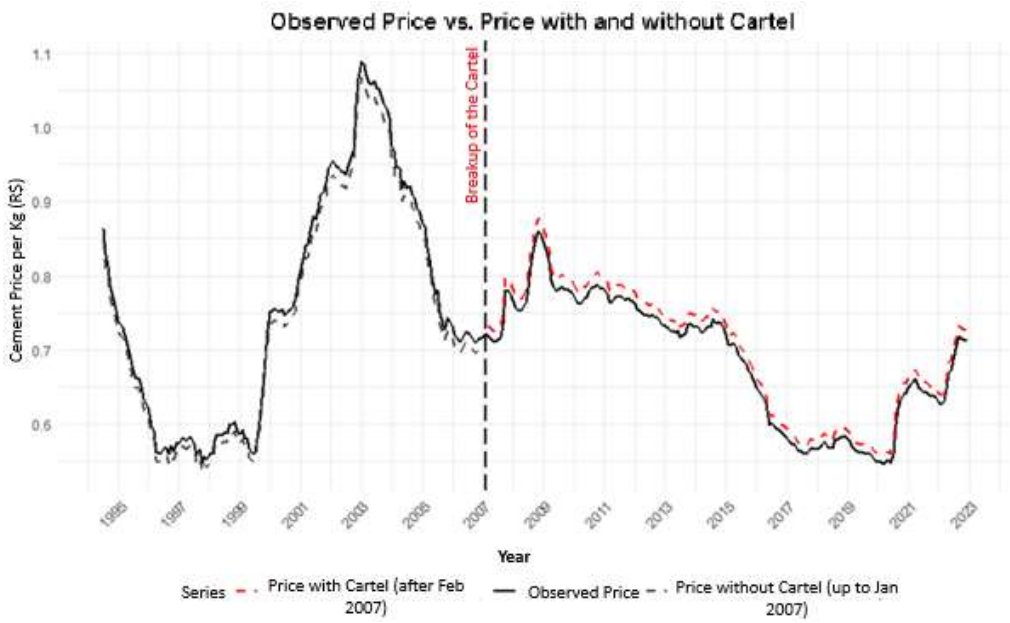


Table 4 reports the monetary savings achieved after the cartel was dismantled, covering February 2007 to December 2022. The reference price is the December observation for each year. Data come from the National Cement Industry Union SNIC and are available on the data platform of the Brazilian Chamber of the Construction Industry CBIC. All figures are expressed in December 2022[31] reais.

Had the cartel remained active until 2022, the annual burden on Brazilian consumers would have ranged from roughly 490 million to 990 million reais, depending on yearly volumes and prices. Altogether, breaking up the cartel is estimated to have saved about 11.8 billion reais from 2007 to 2022. These values were obtained by multiplying the quantity of cement consumed by the average price difference of two point zero two percent attributed to collusion. The resulting figure can also be viewed as the benefit delivered by the antitrust authority—that is, the amount consumers avoided paying once the cartel was broken up.

[31] Data are available through January 2023.

Table 4 - Estimated Savings from Ending the Cement Cartel in Brazil from 2007 to 2022

Year	A. Cement Price (per kg)	B. Average Overcharge (A × 2.02 percent)	C. Cement Consumption (kg)	D. Savings Generated (B × C)	E. Updated Savings
2007	**0,3263**	0,00659	35333609200,00	R$ 232.882.675,42	R$ 556.030.675,84
2008	**0,3823**	0,00772	43764953000,00	R$ 337.947.729,27	R$ 758.422.294,03
2009	**0,3625**	0,00732	44108465200,00	R$ 322.954.536,73	R$ 695.450.299,39
2010	**0,3858**	0,00779	51006783000,00	R$ 397.474.582,80	R$ 810.251.937,05
2011	**0,4022**	0,00813	55225990050,00	R$ 448.723.622,14	R$ 493.551.112,00
2012	**0,4074**	0,00823	58925088050,00	R$ 484.979.513,93	R$ 965.012.236,81
2013	**0,4319**	0,00873	60320754050,00	R$ 526.301.796,19	R$ 990.026.308,82
2014	**0,4568**	0,00923	60947702150,00	R$ 562.398.114,09	R$ 992.857.630,61
2015	**0,4578**	0,00925	55518278700,00	R$ 513.387.252,06	R$ 820.392.828,79
2016	**0,4314**	0,00872	49116367700,00	R$ 428.061.025,99	R$ 639.351.948,42
2017	**0,4298**	0,00868	45647709800,00	R$ 396.294.027,08	R$ 575.775.591,94
2018	**0,4587**	0,00927	45001240600,00	R$ 417.008.753,29	R$ 582.311.023,10
2019	**0,4518**	0,00913	46574724900,00	R$ 425.075.626,52	R$ 574.744.754,62
2020	**0,5512**	0,01114	51508634050,00	R$ 573.549.130,71	R$ 743.434.383,22
2021	**0,6004**	0,01213	54845515600,00	R$ 665.213.005,77	R$ 778.631.823,25
2022	**0,7116**	0,01437	53353263250,00	R$ 766.927.143,15	R$ 847.684.571,33
					R$ 11.823.929,19

Note: Author's calculations using data from the National Cement Industry Union SNIC. The estimates assume an average overcharge of 2.02 percent and a cartel market share of

85 percent. Cement consumption for 2007 covers only February through December, with January excluded.

4. Concluding Remarks

Difference in Differences estimates show that the cement cartel raised prices by an average of 2.02 percent, causing direct harm of about 6.94 billion reais in January 2025 values between January 1994 and March 2007. Antitrust action then saved consumers an estimated 11.8 billion reais from February 2007 to December 2022. The cartel's long duration demonstrates that firms can build flexible and resilient organizational structures that sustain collusion for decades even when markets and regulations change.

These figures are conservative for three main reasons. First, the analysis starts in 1994 even though documentary evidence shows cartel activity as early as 1987. Second, the overcharge of 2.02% is far below the 15.47% to 16.01% range estimated by Boyer and Kotchoni 2015 and the 25% median reported by Connor and Lande 2008. Third, the calculation captures only price damage, leaving out welfare losses linked to suppressed demand, productive inefficiency, and dynamic effects on innovation, so the deadweight loss from restricted output is not reflected.

A key research avenue is to examine whether dismantling cartels prompts mergers and acquisitions as a means to regain market power, a pattern already seen in the European Union, where total mergers increased by up to 51 percent and horizontal deals by 83 percent in the three years after antitrust decisions (Hüschelrath; Smuda, 2013). Determining whether Brazil shows a similar trend, particularly in industries with a history of collusion, could inform preventive merger-control policies. The evidence highlights that formally breaking up a cartel is not sufficient to restore full competition; lingering collusive effects, whether through tacit coordination or concentrated market structures, call for continuous monitoring and tough deterrent sanctions.

References

AFONSO, Nathalie Gressler; FÉRE, José. Cartel damage evaluation: a case study on the liquefied petroleum gas cartel in Pará, Brazil. **ANPEC**, 2017.

BERGMAN, Howard ; SOKOL, D. Daniel. The air cargo cartel: Lessons for compliance. *In*: Beaton-Wells, Caron; Tran, Christopher (eds.). **Anti-Cartel Enforcement in a Contemporary Age-Leniency Religion**. UK: Hart Publishing, 2015.

BOYER, Marcel; KOTCHONI, Rachidi. How much do cartel overcharge? **Review of Industrial Organization**, v. 47, n. 2, p. 119-153, 2015.

BRASIL. **Programa de Aceleração do Crescimento**, 2007. Available at: https://www.gov.br/fazenda/pt-br/acesso-a-informacao/acoes-e-programas/plano-de-aceleracao-do-crescimento-pac. Accessed on: March 24, 2025.

CADE. **Processo Administrativo nº 08012.011142/2006-79**, 2014. Available at: https://www.gov.br/cade/pt-br/assuntos/noticias/cade-multa-em-r-3-1-bilhoes-o-cartel-do-cimento. Accessed on: March 23, 2025.

CADE. Cadernos do cade: Mercado de cimento no brasil. **Departamento de Estudos Econômicos (DEE) – Cade***,* 2019

CONNOR, John M.; LANDE, Robert H. Cartel overcharges and optimal cartel fines. **Issues in Competition Law and Policy 2203**, ABA Section of Antitrust Law 2008, Chapter 88, 2008.

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

ERUTKU, Can. Testing post-cartel pricing during litigation. **Economics Letters**, v. 116, n. 3, p. 339-342, 2012.

FINKELSTEIN, Michael O., LEVENBACH, Hans. Regression estimates of damages in price-fixing cases. **Law and Contemporary Problems**, v. 46, n. 4, p. 145-169, 1983.

GOVINDA, Hariprasad; KHUMALO, Junior; MKHWANAZI, Siphamandla. On measuring the economic impact: savings to the consumer post cement cartel bust. *In*: **PAPER submitted for the Competition Commission and Tribunal 8th Annual Conference on Competition Law**, Economics and Policy, sep. 2014.

GONZÁLEZ, Xulia; MORAL, María J. Effects of antitrust prosecution on retail fuel prices. **International Journal of Industrial Organization**, v. 67, 2019.

HARRINGTON Jr, Joseph E. Post-cartel pricing during litigation. **The Journal of Industrial Economics**, vol. 52, n. 4, p. 517-533, 2004a.

HARRINGTON Jr, Joseph E. Cartel pricing dynamics in the presence of an antitrust authority. **RAND Journal of Economics**, p. 651–673, 2004b.

HARRINGTON Jr, Joseph E. Optimal cartel pricing in the presence of an antitrust authority. **International Economic Review**, vol. 46, n. 1, p. 145–169, 2005.

HARRINGTON Jr, Joseph E.; HÜSCHELRATH, Kai; LAITENBERGER, Ulrich; SMUDA, Florian. The discontent cartel member and cartel collapse: The case of the German cement cartel. **International Journal of Industrial Organization**, vol. 42, p. 106-119, 2015.

IVALDI, Marc; JULLIEN, Bruno; REY, Patrick; SEABRIGHT, Paul; TIROLE, Jean. The economics of tacit collusion, IDEI, Toulouse, **Final Report for DG Competition, European Commission**, 2003.

LEVENSTEIN, Margaret C.; SUSLOW, Valerie Y. What determines cartel success? **Journal of economic literature**, v. 44, n. 1, p. 43-95, 2006.

HÜSCHELRATH, K.; MÜLLER, Kathrin; VEITH, Tobias. Concrete shoes for competition: The effect of the German cement cartel on market price. **Journal of Competition Law and Economics**, v. 9, n. 1, p. 97-123, 2013.

KHUMALO, Junior; MASHIANE, Jeffrey; ROBERTS, Simon. Harm and overcharge in the South African precast concrete products cartel. **Journal of Competition Law and Economics**, v. 10, n. 3, p. 621-646, 2014.

KOMNINOS, A.; BECKERT, W.; VAN DAMME, E. E. C.; DEWATRIPONT, M.; FRANKS, J.; TEN KATE, A.; LEGROS, P. **Quantifying antitrust damages:** Towards non-binding guidance for courts. Luxemburg: Publications Office of the European Union, 2010.

LAITENBERGER, Ulrich; SMUDA, Florian. Estimating consumer damages in cartel cases. **Journal of Competition Law & Economics**, v. 11, n. 4, p. 955-973, 2015.

RAGAZZO, Carlos; VELOSO, Isabel. **Ações de reparação de danos concorrenciais no Brasil:** obstáculos e sugestões. Rio de Janeiro: Ed. dos autores, 2023.

SEIXAS, R. N. L.; LUCINDA, C. R. Computing Cartel Overcharges: when theory meets practice. **Estudos Econômicos**, v. 49, p. 569-599, 2019.

SINDICATO NACIONAL DA INDÚSTRIA DO CIMENTO (SNIC). **Relatório Anual 2012**. Brasília: SNIC, 2012. Available at: http://www.snic.org.br. Accessed on: February 10, 2025.

SINDICATO NACIONAL DA INDÚSTRIA DO CIMENTO (SNIC). **Relatório Anual 2007**. Brasília: SNIC, 2007. Available at: http://www.snic.org.br. Accessed on: February 10, 2025.

SPROUL, Michael F. Antitrust and prices. **Journal of Political Economy**, vol. 101, n. 4, p. 741–754, 1993.

TITO, Fabiana F. M. **Ensaios sobre danos de cartel: metodologias de cálculo do sobrepreço, efeito repasse (pass-on) e multa ótima**. Tese de Doutorado. Universidade de São Paulo, 2018.

TURNER, Douglas C. The impact of cartel dissolution on prices: Evidence from the air cargo cartel. **International Journal of Industrial Organization**, v. 97, 2024.

WOOLDRIDGE, Jeffrey. M. **Introdução à econometria:** uma abordagem moderna. São Paulo: Thomson Learning, trad. 4 ed., 2006.

ZHOU, Jun. The rise and fall of cartels with multi-market colluders. **Review of Industrial Organization**, v. 48, p. 381-403, 2016