LOST IN TIME AND SPACE: THE DETERRENCE EFFECT OF CARTEL BUSTS ON THE RETAIL GASOLINE MARKET

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ABSTRACT. In this paper we intend to focus on the preventive goal of anti-cartel policy. We investigate if cartel busts have an effect on prices, price margins and price variance in the future knowing that a typical feature of cartel behavior is to increase prices and margins, as well as to reduce price variance. We do that looking for the Brazilian case which we believe is particularly apt to study this research question. Our results indicate that immediately after a cartel bust, price levels and price margins drop for the municipality where the collusion took place as well as for the markets that are somehow closer related to it (here expressed by the cities in the same State as the municipality where the cartel operated). The results for price variance, nonetheless, are inconclusive since we don't identify a difference in the coefficient of variance between the markets during the cartel operation. Still these changes are largely neutralized after a few weeks in the market as a whole, although there seem to be a long lasting reverse to the mean for the collusive and the nearby markets, that is, they seem to obey the market rule after the breakdown of the cartel.

Key-words: cartel bust, deterrence effect, retail gasoline stations.

RESUMO. Neste trabalho tem como objetivo o analisar o efeito preventivo da política anti-cartel. Investigamos se rupturas do cartel têm efeito sobre os níveis de preços, as margens e variâncias de preços no futuro, sabendo que uma característica típica do comportamento de cartel é aumentar preços e margens, bem como reduzir a variação de preços. Nós fazemos isso olhando para o caso brasileiro que acreditamos ser particularmente apto a estudar esta questão. Nossos resultados indicam que, imediatamente após a ruptura de um cartel, os níveis e as margens de preços caem para o município em que houve a colusão, bem como para os mercados que estão de alguma forma relacionados mais proximamente a eles (aqui expressos pelas cidades pertencentes ao mesmo Estado em houve o funcionamento do cartel). Os resultados para variância de preço, no entanto, não são conclusivos, uma vez que não identificam a diferença no coeficiente de variação entre os mercados durante a operação de cartel. Ainda assim essas mudanças são em grande parte neutralizadas no mercado como um todo depois de algumas semanas seguidas a ruptura, embora pareça ter havido uma inversão à média que se manteve nos municípios onde houve o conluio e os mercados próximos a eles, isto é, eles parecem obedecer a regra de mercado após o colapso do cartel.

Palavras-chave: ruptura do cartel, efeito dissuasão, postos de combustíveis.

JEL: L41, L44 and L81.

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1. Introduction

The design and application of competition law, in particular law against price fixing, involves a combination of corrective, retributive and preventive justice: society deems it is fair to punish parties guilty of a price fixing offense (correction); sometimes forcing them to compensate victims, that is, buyers (retribution); hoping that the example of justice meted out will move firms away from price fixing in the future (prevention).

In this paper, we focus on the preventive goal of anti-cartel policy. Specifically, we ask the following question: do cartel busts have an effect on the likelihood of cartel-like prices in the future? This is not exactly the right question when it comes to prevention; the right question would be: do cartel busts reduce the likelihood of future cartels? However, knowing that a typical feature of cartel behavior is to increase prices and margins, as well as to reduce price variance and volatility, we can ask the question of whether cartel busts have an effect on price levels, price margins and price volatility.

In order to address our basic research question, we analyze data from Brazilian gasoline retail pricing. Our data includes retail and wholesale prices at the retail pump level for a large sample of gasoline stations across Brazil's 26 states, from July 2001 to December 2011. During this period, many cases of cartel behavior were discovered and punished.

The Brazilian case is particularly apt to study the research question at hand for three reasons. First, while there is a federal competition policy authority (Conselho Administrativo de Defesa Econômica, or CADE for short), retail gasoline price-fixing cases are typically initiated at the municipal level by the local prosecutor as a criminal act. Second, gasoline producers and retailers have separate ownership by law; and while some retailers own multiple stations, downstream ownership is typically local. Third, Brazil is a large country, and while all states share the same language and national media, there is also considerable separation across states in the way news are presented (for example, a considerable fraction of newspapers readership is at the state level).

We expect that immediately after a cartel bust, price levels and margins drop; and price volatility increases. However, these changes are probably largely neutralized after a few weeks. Moreover, we believe that these effects are greatest in the municipality where the cartel bust takes place; lower in neighboring municipalities; and lowest (essentially zero) in out-of-state municipalities. This is essentially the research question we want to answer. In other words, we would like to be able to answer if and how the effects of a cartel bust are lost in time and space.

There is a large body of literature on cartel screening and the internal functioning of cartels. In the first group Harrington [2005b], Abrantes-Metz et al. [2006], Ellison [1994] among many others suggest many different techniques on how to identify cartel behavior. In the second group Porter and Zona [1993], Asker [2010], Clark and Houde [2014] give detailed information on how cartels operate and how they create incentives to sustain the agreement.

At the same time, the impact of regulatory activities is believed to be of great importance to law enforcement, which on its turn can influence the companies pricing behavior. This idea was first introduced by Stigler [1966] in which the author presents a quantitative notion of the effects of the antitrust laws. He concludes that his findings were sparse and unassertive. Stigler [1966] states that the Sherman Act had a modest effect in reducing concentration, but it reduced the availability of the most efficient methods of collusion and thereby reduced the amount and effects of collusion.

Antitrust enforcement can chance the firms' perception regarding the probability of detection and conviction if charged for anti-competitive activities. For that matter, we would

expect prices to fall across all markets in response to an antitrust enforcement. Theoretical and empirical works predict that the probability of prosecution and subsequent penalty deter anticompetitive behavior, with deterrence effects declining over time. Feinberg [1980] and Block et al. [1981] present models demonstrating this features.

Feinberg [1980] examines the effects of antitrust indictment on subsequent firm behavior; the results presented indicate that the Sherman Act charges against a firm hold a deterrent impact on deviations of price from cost, lowering the firms' market power (represented by the Lerner Index) by more than two percentage points. In addition the author finds that indictments against other firms in the industry tend to make a firm's pricing behavior more cautious, although this result is somewhat weak. The author makes no statement regarding the timing of any price effects of antitrust activity, owing to the fact that he did not dispose of time series data.

Block et al. [1981] formulate and test a model of collusive pricing in the presence of public and private antitrust enforcement. The authors show that a cartel's optimal price is an intermediate price between the competitive price and the price that the cartel would set in the absence of antitrust enforcement, that is, the cartel price depends on the levels of antitrust enforcement efforts and the penalties charged by the antitrust authority in case of conviction. Applying to the bread industry, Block et al. [1981] find that: (i) increasing antitrust enforcement capacity or filing a price-fixing complaint had the deterrent effect of reducing industry's markups; (ii) a price-fixing case against bakers in one city induces bakers in neighboring cities to reduce markups; and (iii) if discovered and prosecuted, convicted firms tend to reduce their markups in the following year. Importantly, the authors find that the effective deterrent mechanism to price fixing was not the ordinary government-imposed fines but the credible threat of large damage awards to private class actions (treble damage in the case of the U.S. antitrust authority ruling).

Many other studies follow trying to fill this literature gap and the results as to the advantages of the antitrust enforcement as a deterrence mechanism on price-fixing cases are inconclusive. Some studies are in line with Feinberg [1980] and Block et al. [1981] arguing to the benefits of the antitrust activity, such as Feinberg [1986] which found evidence of relatively short-term deterrence effects but little long-term impact when examining European antitrust cases. Clarke and Evenett [2003] analyze a global cartel and find evidence that the cartel inflicted greater harm in economies without active antitrust enforcement measures [1].

Coatney and Tack [2014] analyze the impacts of an antitrust investigation on the purchasing practices of a buying collaboration and its common bidding agent. They find that auction prices in the targeted auctions: (i) significantly increased as soon as the targets were made aware they were under investigation; (ii) remained higher as long as the investigation was open; and (iii) systematically declined to the same low pre-knowledge state after the closure of the investigation without prosecution.

Finally, Block and Feinstein [1986] evaluate how the threat of antitrust enforcement spills over from one industrial submarket to another through a formal model later applied to the highway construction industry. This study is closely related to ours regarding its objective. The authors find that primary states - a state which has suppliers in common with at least one state where an indictment has already occurred - are more responsive than the remaining states. Surprisingly, the authors do not find stronger deterrent effect of antitrust enforcement in states where an indictment occurred when comparing to non-indictment states.

Our analysis also explore the spill over effects of an antitrust action as a deterrence mechanism in other markets. Our results indicate that the deterrence effect is indeed higher

[1]Other papers that defend the benefit of an active competition agency are: Baarsma et al. [2012], Werden [2003], Werde(2008), among others.

for the indictment markets (primary states in Block and Feinstein [1986] terminology) since their shift from the market norm is higher than the others and they just as well converge to the market norm post cartel bust.

Other studies find mixed evidences regarding the advantages of a competition agency. Feinberg [1984] accesses weather the various stages of the antitrust process influenced pricing behavior. Some evidence of a deterrent effect is found with real prices lower than their pre-investigation level following the conclusion of the case; a major part of the pricing reaction occurs prior to the filing of formal charges. The author also provides additional evidence of the existence of such a short-term 'strategic' reaction of price reduction to the onset of investigation in a sample of industries for which investigation never led to indictment. He suggest that different industries should bring different deterrence effects on future prices and indicate that the deterrence effect of an indictment should weaken over time[2].

Lastly, some papers argue against an active antitrust agency. Sproul [1993] found no significant effects of antitrust prosecution on prices charged by firms indicted for price fixing when analyzing U.S. antitrust cases. Also Crandall and Winston [2003] assesses the effects of antitrust policy and enforcement on consumer welfare and find no evidence that antitrust policy in the areas of monopolization, collusion, and mergers has provided much benefit to consumers and, in some instances, they find evidence that it may have lowered consumer welfare. They also do not find any evidence that antitrust policy has deterred firms from engaging in actions that could harm consumers. Further, Newmark [1988] re-access Block et al. [1981] empirical results and deny them, showing that the deterrence effect found by Block et al. [1981] disappear when using a more appropriate dataset to the same problem [3].

In this paper, we focus on the deterrent effect of cartel busts on pricing of the municipalities where the collusive activity was uncover as well as in other, geographically, close and distant markets. The deterrent effects are only likely to occur if firms' believe that the uncover of specific cases raises the likelihood of future cartel detection by the antitrust authority, modifying their pricing behavior.

Our hypothesis is that the closer the market is to the busted case the stronger should be the firms reaction to the collapse of the anti-competitive activity because: (i) it will have easier and faster access to the news; and (ii) it will assume that the antitrust agency will analyze nearby markets in conjunction to the uncovered one even if solely to use as a comparison because of market similarities as well as common suppliers.

We believe our work is relevant as it contributes to the literature that access the effectiveness of cartel busts as a deterrence mechanism. We do find that the deterrence effect is limited to reverse the busted and the nearby market prices and margins to the national average which is maintained over time, although no effect of price/margin reduction has been encounter in the market as a whole. That is, we find a restricted deterrence effect of cartel busts on time and space.

2. Data

The data used in this study is from the Brazilian National Petroleum Agency (ANP), Sistema de Levantamento de Preços (SLP), that comprises weekly data from July 2001 through December 2011 (548 weeks) for 555 municipalities in Brazil, approximately 10% of the municipalities in the country.

[2]Other papers that are inconclusive with respect to the benefits of an antitrust agency are: Baker [2003], Ciarreta [2012] and Cyrenne [1999], among others

[3]Smith et al. [1987] and Thompson and Kaserman [2001] also find evidence against the competition authority's practices.

The data corresponds to weekly gasoline prices on the gas station level. Not all stations are audited on a weekly basis, in fact the number of gas stations audited each week is previously determined. The assortment of gas stations that will be audit each week is randomly assigned by the national agency, making the dataset an unbalanced panel. Note that the gas station employees do not know which gas stations have been assigned until the agency's technician is at the designated stations.

It is important to mention that during this period eighteen cases of cartel activity were uncover and condemned in Brazil. Mostly they were investigated by CADE because of a previous criminal investigation by the local prosecutor authority. There are evidence of anti-competitive activity in Bauru (SP), Belo Horizonte (MG), Caxias do Sul (RS), Cuiabá and Várzea Grande (MT), Florianópolis (SC), Goiânia (GO), Guaporé (RS), Lages (SC), Londrina (PR) and its metropolitan region, Manaus (AM), Recife (PE) and its metropolitan region, Santa Maria (RS), Teresina (PI) and Vitória and its metropolitan region (ES). These cases were uncovered and then analyzed and condemned by the Brazilian Antitrust Authority (CADE).

Among 5,287,996 observations compiled 5,247,280 (99.23%) reported prices for gasoline. These gas stations had their prices measured during 548 weeks (Jul/2001 through Dec/2011), covering on average 9,989.09 gas stations per week (minimum of 1 and maximum of 12,690) and 604 municipalities, with 32,715 gas stations overall in the sample. Each municipality had on average 66.44 gas stations audited each week (minimum of 1 and maximum of 840), although that varies according to the size of the municipality as well as the time within the survey. In the beginning, the survey had a much smaller scale than it has in the more recent period.

The dataset contains information on prices of retail and acquisition of gasoline for each gas station sampled. We will take the prices of which the retailer buys gasoline from the distributor (the acquisition price) as a cost proxy. We understand that there are many other costs related to the operation of a gas station such as labor and rent but we believe this is the main cost. That is, with the acquisition price even if we don't know the exact cost function of the firm we have the single most important variable cost of the business which is the price with which the establishment acquires its main retail product[4]. The data also contains information on its location/address, company owner, and brand in the case which the station is not independent and has a distributor associated with it.

We have also included data on automobile fleet for all municipalities. The data is of monthly frequency, so for the weeks that correspond to the same month the values were repeated among those weeks.

Finally, we obtain detailed information on each cartel case, including relevant dates, through court files. Primarily, we are interested in identifying the exact or most approximate date when the cartel was uncover. This means not necessarily when the antitrust agency or the local court started investigating it but rather when the participants of the collusive agreement learned that they where being indicted. Other relevant dates are also included.

In what follows we will describe the variables that will be used as well as provide some descriptive statistics.

2.1. **Dependent Variables.** Knowing that a typical feature of cartel behavior is to increase prices and margins, as well as to reduce price variance, we will analyze the effect of cartel busts on price levels (natural logarithm of price), price margins measured in percentage

[4]The cost data is not reported for every single data entry. In this sample, 65.70% of the gas stations reported the price with which they acquired the gasoline they were retailing. For the remainders we input the average acquisition price of the referred week. From now on this price will be referred as the *cost proxy* variable.

points (we constructed the price margins using our *cost proxy* variable) and price variance (measure by the coefficient of variation).

Expressed by:

$$ln\_price_{ict} = ln(P_{ict})$$

$$Margins\_pp_{ict} = \frac{(P_{ict} - cost\_proxy_{ict})}{P_{ict}}$$

$$Coef\_Variation_{ct} = \frac{SdPrice_{ct}}{\bar{P}_{ct}}$$

where i indexes each gas station at city c in week t. P is price, $\bar{P}$ is the average price across all gas stations i and $SdPrice$ stands for standard deviation of prices.

2.2. **Independent Variables.** We have variables that indicate the collusive periods - d_cartel - as well as the cities where they took place - d_M. We have also created a variable - d_S - that represents the States where there was a cartel excluding the cities where the cartel took place. We use this variable to represent a closer related market, via news or business related matters. Finally, among the variables that we are interested we have d_bust_Xw where Xw represents 2, 4, 8, 12, 16 and 20 weeks following a cartel bust. The $2w$ time frame represents the time from the bust until 2 weeks after, $4w$ is from 2 to 4 weeks, $8w$ is from 4 to 8 weeks and so forth; witch means that these variables are complementaries and have no intersection between them.

We interact these variables to get the effect of a cartel bust on the city that the collusion took place - d_bust**x**w*d_M -, on the state to which this city belongs - d_bust**x**w*d_S -, and the overall market - d_bust**x**w - during the above mentioned time frames.

Finally, other variables included as control variables are the number of stations in the market, the price of acquisition of gasoline, a measure of number of different brands and the proportion of branded and independent stations[5] in the market.

Table 1 reports some descriptive statistics from the sample.

TABLE 1. Descriptive Statistics

Variable	N° observations	Mean	Std. Deviation	Minimum	Maximum
Price	5,247,280	2.35	0.36	1.17	3.72
ln_price	5,247,280	0.84	0.16	0.16	1.31
Price Variance	5,241,949	0.00	0.00	0.00	0.25
Coeficient of Variance	5,241,949	0.02	0.01	0.00	0.19
Margins	5,082,026	0.32	0.12	-1.73	1.62
Margins in p.p.	5,082,026	0.13	0.04	-0.79	0.75
d_cartel	5,247,280	0.64	0.48	0.00	1.00
d_M	5,247,280	0.08	0.27	0.00	1.00
d_S	5,247,280	0.54	0.50	0.00	1.00
Acquisition Price	3,447,707	2.01	0.29	0.44	3.91
Proportion of Branded Stations	5,247,280	0.71	0.45	0.00	1.00
N° stations in the market	5,247,280	64.47	116.68	0.00	809.00
N° diff brands	5,247,280	7.36	3.30	1.00	26.00
N° high brands	5,247,280	36.03	55.73	0.00	317.00
Proportion of independents	5,238,490	0.44	0.23	0.00	3.00

[5]All brands except the ones that are part of Sindicom - the national union of fuel distributors - are considered independent brands in the context of this work.

3. RESULTS

We are interested in the effect that a cartel bust has on price, price margin and price variability in the municipality that it took place, in the in-state municipalities (closer cities) and in out-of-state municipalities. As well as how this effect, if existent, behaves over time.

For that we estimate the following model using cross-section as well as panel data. We also estimate the models in aggregate terms, that is, using each city's weekly average variable to check if the results hold in aggregate terms.

$$\begin{aligned} Y_{it} = \quad & \beta_0 + \beta_1 * cartel_{ict} + \beta_2 * cartel_{ict} * d\_M_{ict} + \beta_3 * cartel_{ict} * d\_S_{ict} \\ & + \Gamma * d\_bust\mathbf{x}w_{ict} + \Theta * d\_bust\mathbf{x}w_{ict} * d\_M_{ict} + \Omega * d\_bust\mathbf{x}w_{ict} * d\_S_{ict} \\ & + \alpha * controls + \mu_i + \delta_t + \epsilon_{it} \end{aligned} \tag{1}$$

where:

Y_{it} can be price (ln_price), price margins ($Margins\_pp$) or price dispersion ($Coef\_Variation$) depending on the equation;

$cartel_{it}$ is a cartel dummy that equal 1 for the weeks when there was an operating cartel and zero otherwise;

$d\_Members$ is a dummy that equals to 1 for the gas stations that took part in the collusive agreement and zero otherwise. When the Union was responsible for organizing the cartel I assume all the gas stations were involved in the agreement and so all the gas stations operating in that municipality at that time were considered members;

d_M is a dummy that equals to 1 for the gas stations operating in the municipalities where a collusion took place at some point in time (excluding the gas station that were members of the cartel) and zero otherwise. When all the gas stations took place in the agreement (case in which the cartel was organized by the Union) this variable is zero for the municipality since the effect of the cartel bust in the municipality excluding the cartel members is nil.

d_S is a dummy that equal 1 for all municipalities inside the State where there was a cartel except for the city where the cartel actually happened (since they are represented by d_M) and zero otherwise.

$d\_bust\mathbf{x}w_{it}$ is the dummy variables that indicate the time after a cartel bust, where $\mathbf{x}w$ can represent weeks 2 (0-2 weeks following the bust), 4 (2-4 weeks following the bust), 8 (4-8 weeks following the bust), 12 (8-12 weeks following the bust), 16 (12-16 weeks following the bust) and 20 (16-20 weeks following the bust) as described above. The dummies are equal to 1 for the **x** weeks appointed following a cartel bust (for the entire sample) and zero otherwise;

μ_i is the gas station fixed effect in the panel version and is the municipality's fixed effect in the cross-section version;

δ_t is the time fixed effect (weekly measured);

ϵ_{ict} is the error term.

Table 2 reports the results from our estimates. Columns (1) and (2) are estimated in cross-section data using city's fixed effects. In addition, columns (2) incorporates time fixed effects. Columns (3) and (4) are estimated using panel data with gas station fixed effects, with (4) adding time fixed effects.

TABLE 2. Results: Cartel Bust effect on time and space

	ln_price				margins_pp				Coef_Variation			
	cross section		panel		cross section		panel		cross section		panel	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
d_cartel_d_M	0.015***	0.016***	0.013**	0.014**	0.013***	0.012***	0.011***	0.011***	0.001	0.001	0.001	0.001
	(0.005)	(0.005)	(0.005)	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)
d_cartel_d_S	-0.007***	0.002	-0.005**	0.004*	-0.005***	-0.005***	-0.004**	-0.004**	0.003***	0.004***	0.002***	0.003***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
d_bust_2w (1-2 weeks)	0.001**	-0.014	0.001	-0.035	0.001***	0.003*	0.001***	-0.049	-0.000	-0.000	-0.000	0.011
	(0.000)	(.)	(0.000)	(3.364)	(0.000)	(0.001)	(0.000)	(0.368)	(0.000)	(0.043)	(0.000)	(.)
d_bust_2w_d_M (1-2 weeks)	-0.001	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	0.001	0.001	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
d_bust_2w_d_S (1-2 weeks)	-0.000	0.001	0.000	0.001*	-0.001	-0.001	-0.000	-0.000	0.001***	0.001***	0.001**	0.001***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
d_bust_4w (2-4 weeks)	-0.001**	0.025	-0.001***	-0.007	0.000	0.009***	0.000	0.000	-0.000	0.001	-0.000	0.011
	(0.000)	(.)	(0.000)	(3.319)	(0.000)	(0.001)	(0.000)	(.)	(0.000)	(0.032)	(0.000)	(.)
d_bust_4w_d_M (2-4 weeks)	-0.000	-0.000	0.000	0.000	-0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
d_bust_4w_d_S (2-4 weeks)	-0.000	0.000	-0.000	0.000	-0.000	-0.000	-0.000	-0.000	0.001***	0.001***	0.001***	0.001***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
d_bust_8w (5-8 weeks)	0.000	0.003	0.000	-0.037	0.001***	0.010***	0.001**	0.001	0.000**	-0.001	0.000**	0.006
	(0.000)	(.)	(0.000)	(2.177)	(0.000)	(0.001)	(0.000)	(0.060)	(0.000)	(0.077)	(0.000)	(0.024)
d_bust_8w_d_M (5-8 weeks)	-0.004**	-0.004**	-0.004**	-0.004**	-0.003*	-0.003*	-0.003*	-0.003*	0.001	0.001	0.001	0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
d_bust_8w_d_S (5-8 weeks)	0.000	0.001	0.001	0.001*	0.000	0.000	0.001	0.001	0.000*	0.000**	0.000*	0.000*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
d_bust_12w (9-12 weeks)	0.001*	-0.039	0.001	-0.005	0.001***	0.006***	0.001***	-0.053	-0.000	0.000	0.000	-0.005
	(0.000)	(.)	(0.000)	(2.247)	(0.000)	(0.002)	(0.000)	(0.142)	(0.000)	(0.014)	(0.000)	(.)
d_bust_12w_d_M (9-12 weeks)	-0.003	-0.004*	-0.003	-0.004*	-0.002	-0.002	-0.002	-0.002	0.002***	0.002***	0.002***	0.002***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
d_bust_12w_d_S (9-12 weeks)	0.000	0.001	0.001	0.001*	-0.000	-0.000	0.000	0.000	0.000*	0.000**	0.000*	0.000*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
d_bust_16w (13-16 weeks)	-0.003***	-0.000	-0.003***	-0.005	-0.000	0.018***	-0.001	-0.059	0.000	0.003	0.000	0.001
	(0.000)	(.)	(0.000)	(1.195)	(0.000)	(0.002)	(0.000)	(.)	(0.000)	(0.056)	(0.000)	(.)
d_bust_16w_d_M (13-16 weeks)	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	0.000	0.000	0.000	-0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
d_bust_16w_d_S (13-16 weeks)	-0.001	0.001	-0.001	0.001	-0.001**	-0.001**	-0.001*	-0.001	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
d_bust_20w (17-20 weeks)	-0.002***	0.031	-0.002***	-0.011	-0.001**	-0.003***	-0.001**	0.014	-0.001***	-0.002	-0.001***	0.005
	(0.000)	(.)	(0.000)	(5.290)	(0.000)	(0.001)	(0.000)	(0.054)	(0.000)	(0.049)	(0.000)	(.)
d_bust_20w_d_M (17-20 weeks)	-0.001	-0.001	-0.001	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
d_bust_20w_d_S (17-20 weeks)	-0.001**	-0.000	-0.001*	-0.000	-0.001**	-0.001**	-0.001*	-0.001*	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Table 2 (continued). Results: Cartel Bust effect on time and space

	ln_price				margins_pp				Coef_Variation			
	cross section		panel		cross section		panel		cross section		panel	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
city fixed effects	no	no	no	no	no	no	no	no	no	no	no	no
gas station fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
time fixed effects	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
Constant	-2.117***	-1.580	-0.108***	0.087	0.222***	-0.949***	0.144***	0.191	0.026***	0.058***	0.036***	0.051
	(0.041)	(.)	(0.006)	(.)	(0.003)	(0.040)	(0.001)	(.)	(0.002)	(0.017)	(0.002)	(.)
Observations	5,074,512	5,074,512	5,074,512	5,074,512	5,074,512	5,074,512	5,074,512	5,074,512	5,071,341	5,071,341	5,071,341	5,071,341
R-squared	0.943	0.951	0.927	0.940	0.357	0.401	0.015	0.102	0.540	0.555	0.028	0.061
Number of cod_id			32,462	32,462			32,462	32,462			32,431	32,431

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

From the results regarding prices, we obtain that during a cartel, prices tend to be higher in the municipalities where the collusion takes place, but also in the State to which they belong as it can be seen in equation (4) which includes time fixed effects. Following our intuition, the effect is larger at the municipality than at the State level but we can still observe a negative externality from the anti-competitive agreement on the geographically nearby markets. Following the cartel bust we observe that the collusive market's price immediately reverts to the national average. The non-significance of the coefficient in any direction (positive or negative) indicates that there is no shift of the city in relation to the overall market. There is, nonetheless, a shift towards the average.

The variable $d\_bust\mathbf{2}w_{ict} * d\_S_{ict}$ indicates that immediately following a cartel uncover the other state municipalities still charge prices above the market average but is effect is dissipated after only two weeks. This is most likely due to the time news take to arrive to more distant locations. We also notice that during weeks 5 till 12 following a cartel bust gasoline prices in the cities that were colluding are significantly below average, but other than that, the effect of an antitrust investigation and operation seems to have no impact of reducing prices below average in the municipality, state or national levels, even though it is successful in reverting prices back to the market average. This is seen by noticing that the interaction variables on city and State - $d\_bust\mathbf{x}w_{ict} * d\_M_{ict}$ and $d\_bust\mathbf{x}w_{ict} * d\_S_{ict}$ - are not significantly different from zero and neither is the bust variable - $d\_bust\mathbf{x}w_{ict}$. With that, we take that the deterrence effect on the extensive market is non existent, but it is successful in preventing prices in the cities and state municipalities to remain above the market average.

Moving to the analysis of price margins we observe that margins are consistently higher in the cartel municipalities but lower in-State municipalities. It is also interesting to notice that the coefficient on d_cartel - negative and significant - indicates that the cartel period is a time for low price margins in the overall market, that is, cartel periods are periods where the overall market tend be experiencing below average margins, although this result is not sustained in the panel estimation with time fixed effects. With respect to the deterrence affect post-bust, again we observe a reverse to overall market price margin on the municipality and also in the in-State markets. Columns (1) through (3) indicate that there is an increase in the overall market price margin average during this period with respect to the overall market during periods not affected by a cartel or a cartel bust. This is seen by the coefficients in the out-of-state variables - $d\_bust\mathbf{x}w_{ict}$ - that are positive and significant.

Finally, the results regarding price variance are not very conclusive. The cartel variables indicate that during collusive periods the overall market is undertaking a lower variance period and that the municipality where the cartel took place does not behave different than the national market, that is, it doesn't stray far from the market rule, although this is not sustained when we include time fixed effects on the equations. Independently of the equation, the in-state municipalities clearly have higher dispersion of prices than the overall market which would indicate that the nearby cities are not influenced by the collusive agreement. The same pattern is repeated after the bust with the in-state municipalities having higher dispersion and the collusive and the overall market behaving like the period unaffected by a cartel or its bust. It is only 9th week following a cartel that the collusive market seem to increase its price variance, which doesn't last after the 12th week.

The explanation we find for this rather odd results considering price variance is that: (i) these cartels in most cases are not perfect cartels in the sense that all the gas stations in that market participate, but rather some of the competitors fix prices through agreements which implies that variance not necessarily decreases substantially; (ii) once the cartel is uncover, the competitors, including the ones that did not participate on the cartel feel threatened and for that matter tend to avoid deviate from the market norm.

Overall, we conclude that: (i) during cartel period the anti-competitive agreement seem to generate a negative externality on its neighbors in terms of prices even though it doesn't translate into higher margins than the overall market (represented here by the municipalities in the same State); (ii) this cannot be evidenced by lower price variance as we would expect it would; and (iii) the deterrence effect of a cartel bust seem to work on the city and the State where the cartel took place as to revert the price and margin to the market average but not reducing them. This effect is sustained over time since prices and margins don't rise again, however, it is lost in space - it does not reach further markets - as evidences by the non-significance of the out-of-state variables - $d\_bust\mathbf{x}w_{ict}$.

3.1. **Robustness Check.** We now turn to a robustness check where instead of representing the post bust period with dummy variables we try to model the price, margins and variance trend trajectory for the 20 weeks following the uncover of a cartel. We create a variable t that is defined as the current week minus the week when the cartel was busted for the interval up to 20 weeks after the bust; assuming value zero before and after this period. We then calculate the quadratic and the cubic terms of it and include them when they help to better specify the path followed by the variables after the bust. In addition, we interact with the dummy for municipality and in-state municipalities in the same fashion as previously done.

Thus, we estimate the equation below:

$$\begin{aligned} Y_{it} = \quad & \beta_0 + \beta_1 * cartel_{ict} + \beta_2 * cartel_{ict} * d\_M_{ict} + \beta_3 * cartel_{ict} * d\_S_{ict} \\ & + \Gamma * trend_{ict} + \Theta * trend_{ict} * d\_M_{ict} + \Omega * trend_{ict} * d\_S_{ict} \\ & + \alpha * controls + \mu_i + \delta_t + \epsilon_{it} \end{aligned} \tag{2}$$

where $trend_{ict}$ can be t, t^2 and/or t^3.

Table 4 presents the results for equation 2. For the price equations we confirm the result that the collusion agreement has negative externalities on the in-state markets, translated here by positive and significant coefficients on the $cartel_{ict} * d\_S_{ict}$ variable. The trajectory of prices post cartel uncover indicate that prices initiate a trend of decrease in prices at an essentially constant rate, but the same cannot be said about the deterrence effect in other markets, in-state or out-of-state. This would translate into the fact that the uncover of a cartel has no significant impact in terms of deterrence in the markets except for the one where the collusion took place. The exact same conclusions can be taken when we analyze market margins.

In regards to the coefficient of variation we can't identify any difference between the variation in the collusive market and the more distant markets during cartel period, whilst the in-state markets present higher price variance. Still, the post bust period maintains the same behavior. With respect to the price variance in the in-state markets it presents a positive and significant trajectory of price variance but the coefficients are essentially zero.

We have also estimated the models using the data collapse on weekly average variables and with city fixed effect as oppose to gas station fixed effects. The results are fairly similar and corroborate the pattern seen in the disaggregate data.

TABLE 4. Results robustness check: Cartel Bust effect on time and space

	ln_price				Margins_pp				Coef_variation			
	cross section		panel		cross section		panel		cross section		panel	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
d_cartel	0.000	0.028***	-0.001	0.122	-0.004**	-0.002	-0.004***	-0.019	-0.003***	-0.015	-0.003***	-0.013
	(0.002)	(0.003)	(0.002)	(4.112)	(0.002)	(0.003)	(0.001)	(.)	(0.001)	(0.015)	(0.001)	(.)
d_cartel_d_M	0.015***	0.016***	0.013**	0.014**	0.013***	0.012***	0.011***	0.011***	0.001	0.001	0.001	0.001
	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)
d_cartel_d_S	-0.007***	0.002	-0.005**	0.004*	-0.006***	-0.006***	-0.004**	-0.004**	0.003***	0.004***	0.002***	0.003***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
t	0.000	-0.002***	0.000	-0.039	0.000*	-0.008***	0.000	-0.011	-0.000**	0.001	-0.000*	-0.003
	(0.000)	(0.000)	(0.000)	(.)	(0.000)	(0.001)	(0.000)	(.)	(0.000)	(.)	(0.000)	(0.471)
t_d_M	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
t_d_S	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001***	0.001***	0.001***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
t_2	-0.000**	0.000***	-0.000*	0.002	-0.000	0.000***	-0.000	0.000	0.000*	-0.000	0.000*	0.000
	(0.000)	(0.000)	(0.000)	(.)	(0.000)	(0.000)	(0.000)	(.)	(0.000)	(0.001)	(0.000)	(0.064)
t_2_d_M	0.000*	0.000**	0.000*	0.000**	0.000**	0.000*	0.000**	0.000*	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
t_2_d_S	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
t_3									-0.000**	0.000	-0.000**	-0.000
									(0.000)	(0.000)	(0.000)	(0.001)
t_3_d_M									0.000	0.000	0.000	0.000
									(0.000)	(0.000)	(0.000)	(0.000)
t_3_d_S									0.000***	0.000***	0.000***	0.000***
									(0.000)	(0.000)	(0.000)	(0.000)
controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
city fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
gas station fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
time fixed effects	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
Constant	-3.142***	-1.492***	-0.106***	-0.027	0.221***	-0.900***	0.143***	0.194	0.026***	0.057***	0.036***	0.065
	(0.061)	(0.033)	(0.006)	(4.984)	(0.003)	(0.039)	(0.001)	(.)	(0.002)	(0.016)	(0.002)	(.)
Observations	5,074,512	5,074,512	5,074,512	5,074,512	5,074,512	5,074,512	5,074,512	5,074,512	5,071,341	5,071,341	5,071,341	5,071,341
R-squared	0.943	0.951	0.927	0.940	0.356	0.401	0.014	0.102	0.540	0.554	0.027	0.061
Number of cod_id			32,462	32,462			32,462	32,462			32,431	32,431

4. Conclusion

In this paper, we intended to focus on the preventive goal of anti-cartel policy. We investigated if cartel busts have an effect on prices, price margins and price variance in the future knowing that a typical feature of cartel behavior is to increase prices and margins, as well as to reduce price variance.

We believe the Brazilian case is particularly apt to study this research question because there is a federal competition policy authority, but retail gasoline price-fixing cases are typically initiated as a criminal offense at the municipal level by the local prosecutor. Also, gasoline producers and retailers have separate ownership; and while some retailers own multiple stations, downstream ownership is typically local. Finally, there is also considerable separation across states in Brazil in the way news are presented in addition to the national media.

Our results indicate that immediately after a cartel bust, price levels and price margins drop for the municipality where the collusion took place, not below the market rule but it is no longer shift upwards as it is during cartel activity, as well as for the markets that are somehow closer related to it (here expressed by the cities in the same State as the municipality where the cartel operated). The results for price variance, nonetheless, are inconclusive since we don't identify a difference in the coefficient of variance between the markets during the cartel operation. We do find that during the collusive period in-state municipalities have higher price variance but the price variance in the collusive municipality is not different than the overall market during or off cartel periods.

Very little is seen in terms of over compensating the collusive period, that is, prices and margins don't go substantially low in the municipalities where the cartel took place and price variance doesn't became higher after a cartel uncover, mostly there seem to be a long lasting reverse to the mean for the collusive and the nearby markets, that is, they seem to obey the market rule after the breakdown of the cartel. This means that even though the deterrence effect is not persistently strong in the overall market it is successful in avoiding the re-insurgency of the cartelized market. That is, the deterrence effect is greatest in the municipality where the cartel bust took place; lower in the municipality that take part in the same state; and lowest (essentially zero) in out-of-state municipalities. In other words, the effects of a cartel bust are lost in time and space.

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5. Appendix

TABLE 5. Aggregate results: Cartel Bust effect on time and space

	ln_price				margins_pp				Coef_Variation			
	cross section		panel		cross section		panel		cross section		panel	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
d_cartel	-0.005***	-0.005	-0.001	-0.031***	-0.006***	-0.027	-0.008***	-1.982	-0.004***	-0.017***	-0.003***	-0.015***
	(0.001)	(2.355)	(0.001)	(0.002)	(0.001)	(95.525)	(0.001)	(.)	(0.000)	(0.002)	(0.000)	(0.002)
d_cartel_d_M	0.002	0.002	0.014***	0.014***	0.002	0.002	0.011***	0.012***	-0.002	-0.001	-0.000	0.000
	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)
d_cartel_d_S	-0.007***	-0.005***	-0.007***	-0.000	-0.002*	-0.002	-0.004***	0.002	0.003***	0.004***	0.003***	0.004***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
d_bust_2w (1-2 weeks)	0.000	0.015	0.001*	0.013***	0.001***	0.006	0.001***	0.470	-0.000*	0.003***	-0.000	-0.000
	(0.000)	(0.165)	(0.000)	(0.001)	(0.000)	(16.714)	(0.000)	(.)	(0.000)	(0.001)	(0.000)	(0.001)
d_bust_2w_d_M (1-2 weeks)	-0.006***	-0.006***	-0.002	-0.002	-0.005***	-0.005***	-0.002	-0.002	0.000	0.000	0.000	0.000
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
d_bust_2w_d_S (1-2 weeks)	0.000	0.000	-0.000	0.000	0.000	0.000	-0.000	0.000	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
d_bust_4w (2-4 weeks)	-0.001**	0.023	-0.001**	0.044***	0.001**	0.022	0.000**	0.699	-0.000	0.006***	-0.000	0.001
	(0.000)	(1.804)	(0.000)	(0.002)	(0.000)	(41.662)	(0.000)	(.)	(0.000)	(0.001)	(0.000)	(0.001)
d_bust_4w_d_M (2-4 weeks)	-0.006***	-0.005***	-0.002*	-0.003*	-0.004***	-0.004***	-0.002	-0.002	-0.001	-0.001	-0.000	-0.000
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
d_bust_4w_d_S (2-4 weeks)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
d_bust_8w (5-8 weeks)	0.001***	-0.003	0.002***	0.013***	0.001***	0.017	0.001***	0.951	0.000	-0.006***	0.000	-0.001
	(0.000)	(1.027)	(0.000)	(0.001)	(0.000)	(55.839)	(0.000)	(.)	(0.000)	(0.001)	(0.000)	(0.001)
d_bust_8w_d_M (5-8 weeks)	-0.008***	-0.008***	-0.004***	-0.004***	-0.007***	-0.007***	-0.003***	-0.003***	0.000	0.000	0.001	0.001
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
d_bust_8w_d_S (5-8 weeks)	0.000	0.000	-0.000	-0.000	0.000	0.000	-0.000	0.000	0.000***	0.001***	0.000***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
d_bust_12w (9-12 weeks)	0.002***	-0.013	0.002***	-0.014***	0.002***	0.001	0.002***	0.722	-0.000	0.009***	-0.000	0.000
	(0.000)	(0.164)	(0.000)	(0.002)	(0.000)	(38.219)	(0.000)	(.)	(0.000)	(0.001)	(0.000)	(0.001)
d_bust_12w_d_M (9-12 weeks)	-0.008***	-0.008***	-0.003*	-0.003**	-0.007***	-0.006***	-0.003**	-0.003**	0.000	0.000	0.001*	0.001*
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
d_bust_12w_d_S (9-12 weeks)	-0.000	-0.000	-0.001*	-0.001*	-0.000	-0.000	-0.001*	-0.001*	0.000**	0.000**	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
d_bust_16w (13-16 weeks)	-0.002***	0.004	-0.001***	-0.015***	-0.000	0.006	-0.000	-0.503	-0.000	0.004***	-0.000	-0.002
	(0.000)	(0.454)	(0.000)	(0.001)	(0.000)	(25.416)	(0.000)	(.)	(0.000)	(0.001)	(0.000)	(0.001)
d_bust_16w_d_M (13-16 weeks)	-0.007***	-0.007***	-0.002	-0.002	-0.006***	-0.005***	-0.001	-0.002	-0.000	-0.000	0.000	-0.000
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
d_bust_16w_d_S (13-16 weeks)	-0.001	-0.001	-0.001***	-0.001*	-0.001	-0.001	-0.001***	-0.001**	0.000	0.000	0.000	0.000*
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
d_bust_20w (17-20 weeks)	-0.002***	0.010	-0.002***	-0.033***	-0.001***	0.006	-0.001***	0.213	-0.000***	0.000	-0.000***	0.006***
	(0.000)	(1.530)	(0.000)	(0.002)	(0.000)	(12.337)	(0.000)	(.)	(0.000)	(0.001)	(0.000)	(0.001)
d_bust_20w_d_M (17-20 weeks)	-0.007***	-0.007***	-0.001	-0.001	-0.006***	-0.006***	-0.001	-0.001	-0.000	-0.000	0.000	0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
d_bust_20w_d_S (17-20 weeks)	-0.001	-0.001	-0.001**	-0.001	-0.000	-0.000	-0.001**	-0.001	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Table 5 (continued). Aggregate results: Cartel Bust effect on time and space

	ln_price				margins_pp				Coef_Variation			
	cross section		panel		cross section		panel		cross section		panel	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
state fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
city fixed effects	no	no	yes	yes	no	no	yes	yes	no	no	yes	yes
time fixed effects	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
Constant	-0.148***	-0.126	-0.102***	0.086***	0.164***	0.156	0.185***	0.920	0.024***	0.080***	0.031***	0.068***
	(0.009)	(12.274)	(0.006)	(0.016)	(0.006)	(30.887)	(0.003)	(81.754)	(0.002)	(0.006)	(0.001)	(0.005)
Observations	255,089	255,089	255,089	255,089	255,089	255,089	255,089	255,089	251,918	251,918	251,918	251,918

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

TABLE 7. Aggregate results robustness check: Cartel Bust effect on time and space

	ln_price				margins_pp				Coef_Variation			
	cross section		panel		cross section		panel		cross section		panel	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
d_cartel	-0.004***	0.009	-0.001	0.021***	-0.005***	-0.006	-0.008***	-0.136	-0.004***	-0.018	-0.003***	-0.010
	(0.001)	(22.670)	(0.001)	(0.002)	(0.001)	(.)	(0.001)	(6.258)	(0.000)	(0.049)	(0.000)	(.)
d_cartel_d_M	0.003	0.004	0.014***	0.014***	0.003	0.003	0.011***	0.011***	-0.002	-0.001	-0.000	0.000
	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)
d_cartel_d_S	-0.007***	-0.005***	-0.007***	-0.000	-0.003*	-0.003*	-0.004***	0.002	0.003***	0.005***	0.003***	0.004***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
t	0.000**	0.002	0.000***	0.001**	0.000***	-0.000	0.000***	0.003	-0.000	-0.001	-0.000	-0.001
	(0.000)	(5.207)	(0.000)	(0.000)	(0.000)	(2.654)	(0.000)	(.)	(0.000)	(0.072)	(0.000)	(.)
t_d_M	-0.003***	-0.003***	-0.001***	-0.001***	-0.002***	-0.002***	-0.001***	-0.001***	-0.000	-0.000	0.000	0.000
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
t_d_S	0.000	0.000	-0.000	-0.000	0.000	0.000	-0.000	-0.000	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
t_2	-0.000***	-0.000	-0.000***	0.000***	-0.000**	-0.000	-0.000***	-0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.204)	(0.000)	(0.000)	(0.000)	(0.086)	(0.000)	(0.038)	(0.000)	(0.015)	(0.000)	(.)
t_2_d_M	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000**	0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
t_2_d_S	-0.000	-0.000	0.000	0.000	-0.000	-0.000	0.000	0.000	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
t_3									-0.000	0.000	-0.000	-0.000
									(0.000)	(0.001)	(0.000)	(.)
t_3_d_M									-0.000	-0.000	-0.000	-0.000
									(0.000)	(0.000)	(0.000)	(0.000)
t_3_d_S									0.000***	0.000**	0.000***	0.000***
									(0.000)	(0.000)	(0.000)	(0.000)
controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
state fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
city fixed effects	no	no	yes	yes	no	no	yes	yes	no	no	yes	yes
time fixed effects	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
Constant	-0.147***	-0.140	-0.101***	0.035**	0.162***	0.161	0.184***	0.433	0.024***	0.096***	0.031***	0.073***
	(0.009)	(25.141)	(0.006)	(0.015)	(0.006)	(16.653)	(0.003)	(.)	(0.002)	(0.008)	(0.001)	(0.006)
Observations	255,089	255,089	255,089	255,089	255,089	255,089	255,089	255,089	251,918	251,918	251,918	251,918
R-squared	0.943	0.948	0.962	0.970	0.208	0.278	0.040	0.216	0.195	0.217	0.021	0.043
Number of cod_id			590	590			590	590			561	561

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1