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Cartelization: is it worth it?

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Abstract

Existing policies aim at deterring cartel formation and sanctioning detected cartel cases. However, a precise measure of how much firms benefit from collusion is needed in order to design effective policies. In this study I evaluate the causal effect of having been involved in a collusive agreement on the revenues and profits of cartelized firms. Using a dataset of discovered cartel cases in Spain from 1992 to 2014 and an alternative dataset of firms' balance sheets, I can distinguish between cartelized and non-cartelized firms (treatment and control group). I estimate the average treatment effect using the difference-in-difference estimator on a matched sample. Results show that firms increase their revenues between 19% and 26% due to the collusive agreement on average, while no significant effect is found on profits. However, when results by cartel duration are considered, I find out that members belonging to a cartel that lasted long, not only do they increase their revenues by $29\% - 50\%$, but also increase their profits by around $82 - 91.5\%$ when compared to the average net income of the firms involved in these types of cartels. Further analysis shows that cartels that are profitable from the beginning tend to last longer and do not apply for Leniency Programs. These results have several policy implications.

JEL Codes: L4; D7; K2; M2

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1. Introduction

There is consensus in the economic literature that competition restrictions through collusion are undesirable. Companies participating in a cartel produce less and earn higher profits. Resources are misallocated and consumer welfare is reduced. In concrete, cartels are considered one of the most flagrant infringements of competition law. Fighting against cartels and preventing their formation is not only one of the main tasks of the European Commission but also of most of the National Competition Authorities. Thus, analyses that contribute to a better understanding of the determinants and consequences of the existence of cartels will be helpful for both detection and deterrence of collusive agreements.

The existing competition policies aim at deterring and detecting cartel formation. In particular, national and European laws establish a punishment for firms in case they are detected after having participated in a cartel. Fines depend on the gravity and the duration of the infringement. However, there exists a cap of 10% of a business' turnover in the year before the Authority's decision. Additionally, some lenient treatments and fines reductions are offered if the offender is the first one revealing the existence of the collusive agreement to the Antitrust Authority.

Nevertheless, we lack a precise measure of how much firms profit from collusion. The existing literature has studied the drivers of collusion and the determinants of cartel formation, stability and breakup (Levenstein and Suslow, 2011). It has also been analyzed which is the harm that is being caused by firms or prevented by the Antitrust Authorities' activities or by the competition policy (add references: harm or amount of overcharges). On the other hand, there are some papers that study the impact of competition policy and Antitrust Authorities' actions on firms' profits and firms' valuation (Aguzzoni, Langus and Motta, 2013). However, to the best of my knowledge, the existing analyses regarding the effect of collusion on profitability either lack a (good) counterfactual or do not address the problem of causality properly.

In this project, I am interested in quantifying the impact of cartelization on firms' profits and revenues. Understanding how big are the incentives for firms to participate in a collusive agreement is relevant and essential for the design and effectiveness of competition policy. Therefore, in this study I use policy evaluation techniques to identify the causal effect of interest.

For this purpose, I use a panel data of cartelized and non-cartelized Spanish firms for the period 1992-2014 coming from two different sources. On the one hand, I use information provided by the reports of the cartels that have been sanctioned by the Spanish Antitrust Authority in the last two decades, which specify which firms have participated in a cartel case and when it took place. On the other hand, I have information of the balance sheet of around 21,000 Spanish firms. Therefore, I can identify which firms have participated in a

discovered cartel case and designate them as *cartelized* firms (treatment group), and which of them have not been cartelized in principle (*non-cartelized* firms). After finding a good counterfactual or control group for the treated firms, I can estimate the effect of belonging to a cartel on firms' revenues and profits by using the difference-in-differences estimator.

Results show that firms' revenues increase around $19\% - 26\%$ due to participation in a collusive agreement. However, profits measured as net income or profit margin do not show a significant impact on average. In the first three years of cartelization, which corresponds to the average cartel duration in the full sample, firms increase their revenues by $14\% - 17\%$. More importantly, only when the sample is split into *short-lived* and *long-lived cartels* a significant effect is found on net income on the latter. This is, firms that belong to a cartel that lasted between 8 and 13 years increase their revenues by $29\% - 50\%$. Also, these revenues are translated into profits since net income is on average 2.15-2.33 times higher than what these cartelized firm would have earned if they had not been involved in a cartel case. These longer-lasting cartels appear to be more profitable since initial periods. Finally, there exists some weak evidence that only members of non-profitable cartels apply for the Leniency Program.

IIt is well known in the industrial organization literature that data related to collusive agreements suffer from important limitations. Firstly, we can only work with discovered cartels since we know nothing or very little from the underlying population. In this particular analysis, this would mean that the control group could be cartelized but has not been discovered yet. In that case, I would not find a significant difference in the outcome variable for the two groups. Moreover, I would need the firm in the control group to be cartelized at the same exact time than the treated one, to completely invalidate the results. However, the placebo tests provide some evidence that this situation is unlikely to be happening in the data. Secondly, some firms could benefit from the existence of collusion in the market since there is less competition. Or alternatively, the colluding firms may try to expel these firms from the market. Thus, results must be interpreted as the effect of belonging to a cartel and not as the effect of the existence of a cartel.

The placebo tests presented below show that is no significative difference between the control group and the new artificial control group created to mimic the main analysis performed in this study. This robustness check provides some signal about the possibility that these two potencial issues may not be severe in this specific study. Despite the limitations of the data, the present paper contributes to the existing literature analyzing the incentive firms have (on average) to participate on a cartel by constructing and using for this purpose the best counterfactual possible given the limitations mentioned above.

The paper is structured as follows. In Section 2, I review the existing literature. After presenting in Section 3 the data and the methodology used for the analysis, Section 4 dis-

cusses the results. The last two sections present the robustness check of the analysis and summarize the main ideas of the paper.

2. Literature Review

The relationship between profitability and collusion has already been addressed in the literature.

Asch and Seneca (1976) examine empirically the role of collusion on the profitability of American manufacturing corporations during the period 1958-1967. The sample consists of 51 collusive firms that were found guilty in response to the Sherman Act and other 50 firms as controls that were randomly drawn from the pool of non-collusive firms. They analyze the effect of being a collusive firm (dummy variable) on profit rates. In order to isolate the effect of interest, they control for other variables that may affect profits such as firm size (total assets), concentration in the industry, advertising-sales ratio and growth of the firm during the period studied. They find that the presence of collusive behavior is negatively associated with profitability. This counterintuitive result makes them consider the problem of causality, which would have led to a biased estimate of the effect of interest. They wonder whether collusion is a determinant of firm profitability, with the resulting empirical conclusion that collusive behavior leads to lower profit rates, or whether it is the case that an unsatisfactory profit performance by the firm will provide an incentive to collude. Therefore, they study the effect of profits on the probability of colluding and they find that poor profit performance increases the probability of collusion.

The empirical evidence regarding the impact of cartelization on firm's profits is mixed. Levenstein & Suslow (2006) examine case studies of individual cartels and four types of cross-section samples of cartels in order to analyze what determines cartels success. They find that some cartels are able to increase prices and profits to varying degrees. Lübbers (2009) studies the case of the Rhenish Westphalian Coal Syndicate (RWCS), which took place between 1893 and 1913. Employing event study methodology and using a dynamic panel data analysis, they assess the effect of belonging to the Rhenish-Westphalian Coal Syndicate (RWCS) on the reaction of stock markets and on the companies' profitability. He concludes that the RWCS had no significant effect on the profitability of its members.

Guenster (2012) studies how cartel formation and termination affects the performance and efficiency of their members. He analyzes the profitability, productivity and innovation of cartel members using firm-specific data for a sample of 141 publicly listed firms involved in 49 cartels infringements in the European Union between 1983 and 2004. He compares the performance and efficiency of firms during the cartel period with those in the years before the formation and after the termination of the cartel. Results show an increase in firms' profitability (0.5%) during the cartel years and a decrease in efficiency. Another interesting conclusion is that the longer cartels are in place, the more profitable its members

become and the weaker their incentives to produce efficiently.

On the other hand, the issue of self-selection into cartelization due to firms' financial conditions has been studied from different points of view. Bertrand, Lumineau & Fedorova (2014) use a sample of firms involved in cartels prosecuted by the European Commission between 2001 and 2011 to study which are the factors that explain the likelihood of a firm entering a cartel. They find that firms with relatively larger market share are more likely to participate in cartels while firms with high liquidity ratio are less likely to participate in cartels. They also show that relatively older firms tend to participate more in cartels and that the size of the firm is positively related to the likelihood of cartelizing, although this effect varies with industry concentration.

Gustafson, Ivanov and Ritter (2015) look at airfare hikes occurring between January 2005 and December 2005 and they conclude that firm-level financial conditions determine the extent to which firms collude. They find that in the context of low idle capacity, financially weak airlines appear to value the immediate cash flows of increased cooperation, but only liquidity-constraint firms seem willing to incur the cost of cooperative attempts. Thus, short-term liquidity and long-term financial concerns increase an airline's propensity to cooperate. Low levels of short-term liquidity predict airfares hike initiation, while the long-term financial health of the firm determines the hike success.

However, the existing approaches in the literature that study the relationship between collusion and profitability have not addressed the problem of causality carefully enough and lack a (good) counterfactual. To the best of my knowledge, this is the first study that aims at identifying and quantifying the causal effect of participating in a cartel on firms' profitability after having corrected for self-selection into treatment. Moreover, while the literature usually focuses on one important case or one sector, a variety of collusive sectors are represented in the data.

The contributions of this paper are several. First of all, I make use of a control group in order to be able to compare the evolution of revenues and benefits of cartelized firms with a group of reference. The second relevant contribution is that the problem of self-selection into treatment has been considered. This is to say, there exists a set of factors that are conductive to increase the likelihood of participating in a collusive agreement, and which are related to the revenues and benefits a firm could earn. Therefore, the construction of the control group is based on having cartelized and non-cartelized firms similar in these factors and also in the likelihood of cartelization. The control group reflects as accurate as possible the potential evolution of the cartelized firms had they not belonged to a cartel. In addition, the difference-in-differences estimator allows for the existence of a difference in levels between the two groups and controls for common factors affecting all cartelized firms, affecting both groups of firms during the cartelization period and to control for un-

observable effects.

3. Data and Methodology

In order to study the question of interest, I have collected a panel dataset from the Iberian Balance sheet Analysis System (SABI), which is a tool developed by Bureau Van Dijk. It contains information about the balance sheets of Spanish firms. In concrete, I had access to the information of the 21,514 biggest Spanish firms measured as the Operating Revenues in the year 2014. The biggest firm earned €22 billion in Operating Revenues in 2014 and the smallest earned €10m. The sample period ranges from 1992 to 2014.

On the other hand, I have information regarding the 68 cartel cases reports sanctioned by the Spanish Antitrust Authorities since 1990. A certain number of the cases were discovered due to investigations started by the Authority's own initiative or complaints and the rest have been detected under the Leniency Program. From the reports I can obtain information regarding the date of formation and breakup of the cartel. The date of formation refers to the first moment for which the Authority has evidence of the existence of the cartel. The breakup date is either the date in which the cartel died naturally, or the date in which they were caught and had to stop colluding. In addition, I have information about which were the firms that participated in the case and in which period they were a member of the cartel. There are around 748 cartelized firms that have been sanctioned in the period 1990-2014. Specifically, 253 out of these 748 cartelized firms have been matched in the dataset containing the balance sheets.

Therefore, I can distinguish which firms have participated in a collusive agreement (*cartelized*) from those that either have never participated in a cartel or have not been discovered yet (*non-cartelized*). The fact that there may exist cartelized firms that we cannot classify as such is one of the limitations of working with this data. However, I create a matched sample and use the difference-in-differences estimator in order to study the effect of interest. If the firms in the control group were a member of an undetected collusive agreement and I still find significant results, this would mean that the undetected cartels are less profitable (or their members are able to hide their illegal profits). Moreover, I only focus on firms that have been cartelized once during my period sample, so I exclude from my analysis the repeated offenders. If a firm is involved in many cases at the same time or over time, the intensity of treatment is different for these observations. In addition, the effect of interest may not be linear with respect to the number of cases in which the firm has been involved.

Since I am interested in the causal effect of cartelization on firms' profits and revenues, it is not enough to compare the outcome of cartelized firms pre- and post-treatment as in Guenster (2012). The reason being that changes in either observable or unobservable characteristics, which are not related to cartelization, may have affected firms' profits. On

the other hand, it is not appropriate to compare cartelized firms to any non-cartelized firm since they may differ both in observable and unobservable characteristics and therefore it would not be a good counterfactual for our treated observations.

In order to overcome these empirical difficulties, I combine two different strategies following Artés, Jiménez & Perdiguero (2015). Firstly, I construct a matched sample where the treatment and the control group are very similar in certain relevant observed characteristics. Secondly, I estimate the effect of interest using the difference-in-differences estimator in the matched sample in order to control for unobservable differences.

The different techniques employed in order to make sure that both cartelized and non-cartelized firms are comparable and that results are trustworthy are explained in the following subsections. It must be noted that this data processing, together with the imposed restrictions, come at the cost of losing observations not only from non-cartelized firms but also from cartelized firms. In the latter case, I start with the 253 cartelized firms that I can identify in the SABI dataset. After truncating the sample, 239 cartelized firms are left. As explained above, I work with those firms that have been involved in one cartel case only. With this restriction, 202 firms remain in the sample. Additionally, since the matching has to be performed on pre-treatment variables, I work with those firms that started being cartelized after 1995. With this, 38 firms more are lost and I keep on working with 164 of them. After performing the matching, I end up with 99 cartelized firms. Summary statistics of the characteristics of the cartel cases are presented in Table 1.

Table 1. Summary Statistics

	Total			**Matched Sample**		
Cartel Cases	68			27		
Number of different firms	748			99		
Number of affected sectors	12			9		
	Mean	**Mode**	**Median**	**Mean**	**Mode**	**Median**
# of firms per cartel	12.24	6	7	3.67	1	2
Duration (in years)	3.27	2	4	4.03	1	2
Year of start	2001	2008	2004	2006	2008	2008
Year of end	2007	2009	2009	2010	2013	2011

Another important remark that needs to be made is that even if I am working with a dataset of Spanish firms and cartel cases that affected the Spanish market, I have no reason to think that there exist certain characteristics that would produce different results in comparison to other countries. In particular, after the matching I end up with a sample of 196 firms, 99 cartelized and 97 non-cartelized. From the 196 firms, I have been able to obtain information about the global ultimate owner of 115 of them. Around 30% of the firms have an international global owner, this figure being almost 34% in the case of cartelized firms. Therefore, this indicates that both Spanish and non-Spanish firms that operate in several countries may be colluding in these different locations too. Additionally, Spain is subject to common laws, as the other countries of the European Union, so the environment under which these illegal collusive agreements emerge is similar. Moreover, half

of the sectors of the economy, classified by NACE Rev.2 sections classification, are represented both in the full sample and in the matched sample. Figures are presented in Table 2[2]

Table 2. Cartelized firms by sector

	Total Sample		**Matched Sample**	
Sector	**Cases**	**Freq.**	**Cases**	**Freq.**
A	3	1.19	1	1.01
B	1	0.4	0	0.00
C	74	29.25	21	21.21
D	3	1.19	0	0.00
E	17	6.72	9	9.09
F	33	13.04	22	22.22
G	70	27.67	28	28.28
H	24	9.49	10	10.1
J	4	1.58	0	0.00
K	5	1.98	1	1.01
M	2	0.79	1	1.01
N	17	6.72	6	6.06
Total	253	100.00	99	100.00

3.1. Truncation

Before constructing the matched sample, I drop from the sample the outliers belonging to the upper and lower tails of the distribution. The reason for doing this is that I may not be able to find a good counterfactual for these observations. Since I am working with firms, an outlier in terms of profits could drive the results of the estimation, and having a good counterfactual for the cartelized firms is crucial for the validity of the results. Moreover, it is a common procedure in the literature when working with firm-level data.

I proceed as follows. I look for the firms that have been, at least in one of the years (1992-2014), below the 0.1% or above the 99.9% of the distribution of the following dependent variables: Profit Margin, Net Income, Operating Revenues, Ebitda or Ebit. Once I have identified these firms, I drop them from the sample. From the initial 21,514 firms, I end up with 20,757 firms in the truncated sample. In Table 3, it can be seen the number of total different firms that have been excluded from each distribution and the total number of different firms dropped from the sample.

3.2. Matched Sample

In order to construct the matched sample, I have performed the matching five years

[2]Description of NACE Rev.2 Sector Classification by Section: A - Agriculture, forestry and fishing. B - Mining and quarrying. C - Manufacturing. D - Electricity, gas, steam and air conditioning supply. E - Water supply; sewerage, waste management and remediation activities. F - Construction. G - Wholesale and retail trade; repair of motor vehicles and motorcycles. H - Transportation and storage. J - Information and communication. K - Financial and insurance activities. M - Professional, scientific and technical activities. N - Administrative and support service activities.

Table 3. Truncation: Number of firms dropped

	Profit Margin		Net Income		Operating Revenues		Ebitda		Ebit		Total
	< 0.01	> 99.9	< 0.01	> 99.9	< 0.01	> 99.9	< 0.01	> 99.9	< 0.01	> 99.9	
$\#Firms$	243	164	170	80	256	42	157	62	150	75	757

before the treatment takes place[3]. For example, if a firm starts being a member of a cartel in 2000, I have looked for a control in the year 1995, using the characteristics of both firms in the year 1995. Then, I can track the evolution of the outcomes of *cartelized* and *non-cartelized* firms over time. An exemption is made with those firms that started participating in a collusive agreement in 1995 and 1996. Given that the sample starts in 1992, the matching for these firms was made three and four years before the start of the treatment, respectively[4]. Moreover, since the matching should be done on pre-treatment characteristics, I exclude from the analysis those cartel cases that started before 1995.

In particular, I apply the non-parametric nearest neighbor matching method. I follow Imbens & Wooldridge (2009) to define the algorithm. Let Y_i denote the outcome of interest, let X_i be the observable characteristics on which we are matching and let C_i be the treatment variable. Given a sample $\{Y_i, X_i, C_i\}_{i=1}^{N}$, let $\ell_1(i)$ be the nearest neighbor to i, that is:

$$\ell_1(i) = j, \;\; for \;\; j \in \{1, ..., N\}, \;\; if \;\; C_j \neq C_i, \;\; and \;\; ||X_j - X_i|| = \min_{k: C_k \neq C_i} ||X_k - X_i||$$

where the metric used is the Mahalanobis metric, which is based on the inverse of the full sample variance-covariance matrix and is the most common in the literature. In addition, I have used the option *exact* in Stata for one of the characteristics. Following Abadie et al. (2004), this option allows to specify exact, or as exact as possible, matching on one or more variables. In practice, it multiplies the corresponding elements in the weight matrix by 1,000 relative to the weights placed on the other variables; and in this case, the inverse sample standard errors are used for the variables specified in *exact*.

The observable characteristics used for the matching are based on the firms' financial conditions that have been found to predict cartel participation in the literature. I follow Bertrand, Lumineau & Fedorova (2014), who find that firms with relatively larger market share are more likely to participate in cartels while firms with high liquidity ratio are less likely to participate in cartels. They do also find that relatively older firms tend to participate more in cartels and that firm's size is positively related to the likelihood of participating in a cartel, although this effect varies with industry concentration.

In this case, I match *cartelized* and *non-cartelized* firms on the following observable characteristics: age, indebtedness (or debt ratio), the ratio of long-term debt over total as-

[3]I have also performed two other matchings: three years before the treatment and in the first year of the sample (1992). However, the match is especially not accurate in the second case.

[4]There are 2 cartel cases in 1995, which involve four firms; and 1 cartel case in 1996, which involves 3 firms.

sets, leverage, sector (at two digits level), costs of employees, the ratio of costs of employee over operating revenues, the solvency ratio and total assets. This last variable was used in the *exact* option, which means that the size of the firm is the most relevant variable when looking for a good control.

While total assets account for firm's size and are related to profitability, the long-term debt over assets controls for the loans and financial obligations lasting over one year with respect to the firms' assets. In addition, I use two different measures of the company's leverage. On the one hand, the debt ratio (or indebtedness) compares a company's total debt to its total assets. On the other hand, leverage is the level of a company's debt related to is equity capital and is expressed in percentage form. It shows the extent to which its operations are funded by lenders versus shareholders. Finally, I use two measures of personnel expenses which are costs of employees and the ratio of costs of employee over operating revenues, measured in levels and in percentage, respectively. Symeonidis (2008) finds no evidence of any effect of collusion on wages, while he shows that there exists a negative effect of collusion on labor productivity growth. For this reason, I look for a firm in the control group that has similar costs of employees than the *cartelized* firm before the treatment in order to control for firm's efficiency.

The summary statistics are presented in Table 4. Table 5 shows the t-test of mean equality for the matching variables in the whole pre-treatment period. The equality of means shown in Table 5 are never rejected if they are computed year by year in the pre-treatment period. The variable *sector* was not included in Table 5 because the digits of the sector have no economic interpretation. Nevertheless, it can be seen in Table 2 above how sectors are represented in the matched sample.

Table 4. Summary Statistics

Variable	Mean	Median	Std. Dev.	Min.	Max.	N
Age	30.43	26	19.39	2	114	2581
Total Assets	104266.9	28394.69	247482.2	1014.06	2257771	2258
Indebtedness	63.84	65.3	22.16	3.64	225.1	2258
Long-term Debt/Assets	0.11	0.07	0.15	0	1.88	2056
Costs of Employees	12224.39	4121.25	36219.61	45.22	533103	2258
Costs of Employees/Operating Revenues	15.98	12.81	13.13	0.26	106.1	2258
Solvency Ratio	1.50	1.24	1.27	0.06	26.33	2258
Leverage	119.91	61.73	479.10	–10803.45	9227.825	2258

Note: Age is expressed in years. Total Assets and Costs of Employees are expressed in thousand euros. The rest are expressed in percentage.

With respect to the outcome variables of interest, I want to study the effect of cartelization on firms' profitability. Therefore, I focus the analysis on three main variables: Operating Revenues, Net Income and Profit Margin. Note that since the variable Operating Revenues only takes on positive values, I can normalize this variable and work with the logarithm of it. Given that the distribution of firms' revenues is very skewed, this transformation will help making the relationship between the treatment variable and the outcome

Table 5. T-test of mean equality

Variable	Non-cartelized	Cartelized	Difference	p-value	N
Age	25.81 (0.83)	25.59 (0.85)	0.22	0.85	972
Total Assets	67978.92 (6705.87)	76733.87 (8984.51)	-8754.94	0.44	926
Indebtedness	67.08 (0.90)	67.21 (0.90)	-0.13	0.92	926
Long-term Debt/assets	0.12 (0.01)	0.10 (0.004)	0.02	0.05	884
Costs of Employees	7214.04 (585.42)	6685.40 (511.96)	528.64	0.50	926
Costs of Employees/Operating Revenues	13.88 (0.58)	15.70 (0.61)	-1.83	0.03	926
Solvency Ratio	1.37 (0.04)	1.28 (0.03)	0.09	0.05	926
Leverage	147.74 (35.64)	123.97 (7.15)	23.77	0.50	926

Note: Standard deviation in brackets.

variable more linear. It also allows to interpret the coefficient of interest in percentage terms (as an elasticity). Table 6 presents the summary statistics of the treatment variable and the outcomes of interest.

Table 6. Summary statistics

Period	Variable	Non-Cartelized					Cartelized				
		Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Pre-treatment	Cartelized	481	0	-	0	0	491	1	-	1	1
	Operating Revenues	453	61743.4	88091.37	215.02	545822	473	105570.1	415633.7	198.6	4707617
	Log of Operating Revenues	453	10.34	1.16	5.37	13.21	473	10.29	1.35	5.29	15.36
	Profit Margin	453	3.47	11.49	-159.92	34.45	473	6.29	49.58	-632.742	686.39
	Net income	453	1990.74	7523.92	-56906.64	47620	473	2127.31	7253.92	-32874	57282
Treatment	Cartelized	492	0	-	0	0	492	1	-	1	1
	Operating Revenues	421	81524.1	148819.4	4248.63	954321	467	128473.3	293007.4	4048.038	4699735
	Log of Operating Revenues	421	10.57	1.07	8.35	13.77	467	10.80	1.26	8.31	15.36
	Profit Margin	421	4.28	10.27	-50.69	115.43	467	5.13	58.84	-919.43	652.61
	Net income	421	1893.08	6864.07	-39713	47049	467	5729.42	20794.23	-81413	146205

Note: Profit Margin is expressed in percentage. Operating Revenues and Net Income are expressed in thousand euros.

The Operating Revenues are the revenues generated from a company's business activity, which means revenues posted from selling the company's products and services. It allows to study the effect of cartelization of firms' revenues. The second measure considered is a profitability ratio, the Profit Margin, which is calculated as net income divided by revenue or net profits divided by sales. This variable is expressed in percentage and it measures how much out of every dollar of sales a company actually keeps in earnings. The third variable of interest, Net Income, reflects the company's total earnings. It is calculated by taking revenues and subtracting the costs of doing business such as depreciation, interest, taxes and other expenses. This variable is considered to be an important measure of how profitable the company is over a period of time.

3.3. Difference-in-Differences Estimator

As pointed out above, I apply the difference-in-differences estimator in order to obtain the causal effect of interest. This method allows to control for unobserved differences between treated and control observations and for common shocks through the variables *cartelized* and *period*. In particular, I run the following regression on the constructed matched sample:

$$Y_{it} = \beta_0 + \beta_1 Cartelized_i + \beta_2 Period_t + \beta_3 Cartelized_i * Period_t + \alpha_i + \delta_t + u_{it} \qquad (1)$$

where Y_{it} is the outcome of interest described in the previous section; $Cartelized_i$ takes

value 1 if the firm has ever been cartelized in the sample period and 0 otherwise; $Period_t$ takes value 1 the years in which the treatment took place and 0 before; $Cartelized_i * Period_t$ is the interaction of the previous two dichotomous variables, so it takes value 1 for the cartelized firm during the period in which it was cartelized and 0 before; α_i represents individual fixed effects; δ_t represents time fixed effects; and u_{it} is the error term. Note that the variable $Period_t$ takes value 1 for the *non-cartelized* firm whenever it takes value 1 for its match in the treatment group[5].

The coefficient of interest is β_3, which tells how much more cartelized firms earned during the period of cartelization compared to the non-cartelized ones. Thus, it gives the average treatment effect of the treated. The estimation of β_3 by OLS from the matched panel data sample is going to be the baseline specification, which is equivalent to fixed effects (FE) estimator for panel data when individual and time fixed effects are included in the regression. I also estimate the random effects (RE) estimator and the random-effects linear model with an AR(1) disturbance (AR(1)). This last model uses the generalized least-squares method to estimate the parameters in a linear regression model in which the errors are serially correlated - the errors are assumed to follow a first-order autoregressive process.

Since firms start and stop participating in a cartel at different moments in time, we can consider the period 0 as the year in which they become a member of a cartel. Given the way I have constructed the matched sample, meaning five years before the treatment, in most of the cases I will have information for five periods before the treatment takes place (this would be up to distance -5 from period 0), except for those two first years in which the matching was made three and four years before the treatment. Similarly, each additional year in which the firm is still cartelized will show up, and the maximum distance from treatment that could be found in the sample is 13[6]. This distance from treatment determines the different divisions of the sample that I use in the estimations.

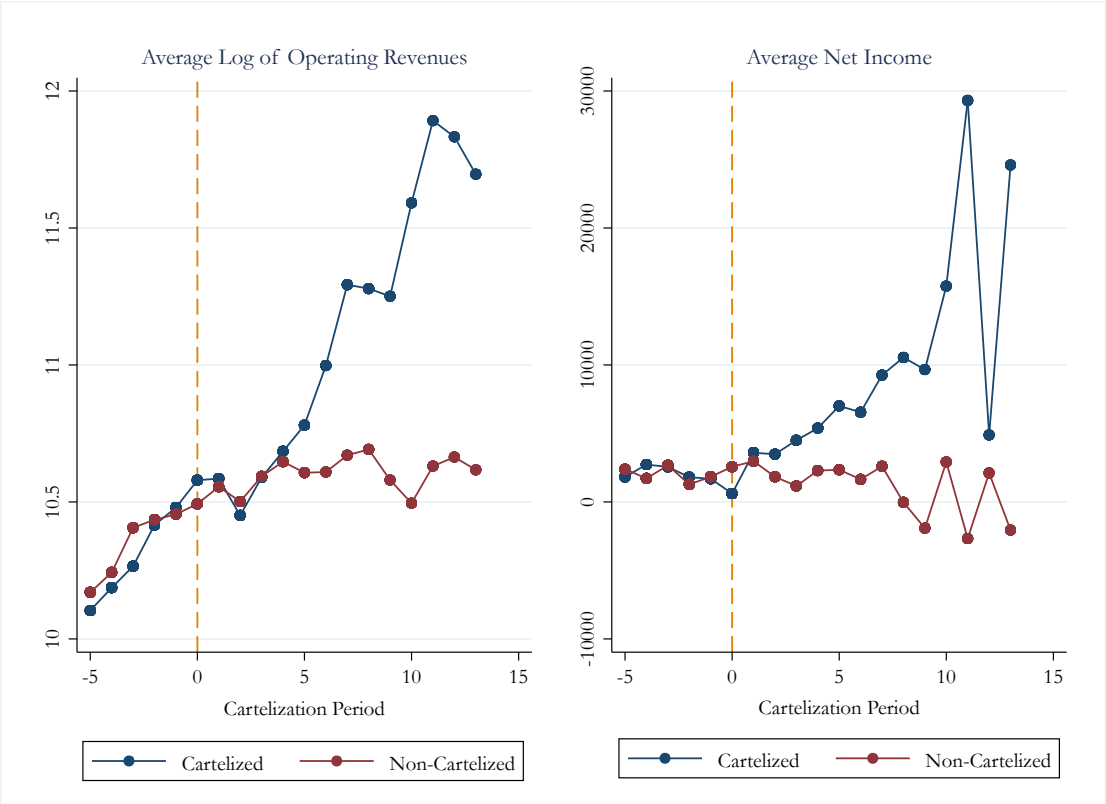
The basic identifying assumption of the difference-in-differences estimator is that the trends in the two groups are the same in the absence of intervention (reference?). As mentioned above, the matching has been performed five periods before the treatment starts. Despite having showed that the variables used in the matching are on average equal for the treatment and control group in each of the pre-treatment period, it still remains to test whether the outcome variables of interest follow parallel trends in the two groups. Figure 1 represents the average logarithm of operating revenues and the average net income for

[5]In order to cluster the standard errors by cartel, all the matches of the firms that belong to a given cartel are treated as if they would have formed another cartel themselves had they been cartelized. Therefore, apart from having pairs of treated and control firms, I have an artificial *control cartel* for each existing cartel when it comes to standard errors.

[6]There are only three firms that lasted up to 15 periods in a cartel, but they are outliers in terms of the outcome variable. Therefore, they are excluded from the estimation sample, so that results are not driven by these outliers.

cartelized and non-cartelized firms. It can be seen that these outcomes follow similar patterns before the treatment starts, and then evolve differently over time.

Figure 1: Average outcome by Cartelized and Non-Cartelized firms.



Note: The dot line indicates the first period in which treatment takes place. This graph represents the average outcome variable for the treated and control group.

Additionally, I perform two different tests. First, I test for the equality of average changes in the treatment and control group before the treatment following Galiani, Gertler and Schargrosdky (2005). Secondly, I test if there exists any difference in time patterns before the treatment takes place.

For the test of parallel trends, I consider only the pre-treatment period for cartelized firms while the observations of the control group are considered for the whole period. I estimate the fully saturated model and test for equality of the relevant coefficients. Tests are performed for the different outcome variables of interest and for the different samples considered in the regressions. Results are shown in Table A.2. in the Appendix. In most of the cases we cannot reject the null hypothesis that the trends of the treatment and control group are the same in the pretreatment period at the 10% and 5% significance level. The same applies for the trends of non-cartelized firms before and after the treatment, and equality of trend of cartelized before the treatment and non-cartelized before and after the treatment.

When the trends of the series can be better approximated by a non-linear function, there exists an alternative way to test the pattern in each of the periods before the cartelization takes place. Using again the sample of cartelized firms in the pretreatment period and the non-cartelized firms in the whole period, I estimate a regression that contains a dummy for each pre-treatment period for each treatment group. In this case, there exist differences in the levels of the outcome variables between cartelized and non-cartelized firms. However, what matters for the difference-in-differences models is that this difference in levels is constant over time in the pretreatment period. Therefore, the tests performed study whether the difference between cartelized and non-cartelized firms is the same in two or more periods. The null hypotheses of the tests and the corresponding results are presented in Table A.3. in the Appendix. Given that there exist many possible combinations, I tested the differences in consecutive periods from five years before the treatment up to one period before, and also all of them together. In most of the cases it cannot be rejected the hypothesis that the difference in the levels of the outcome variables of cartelized and non-cartelized firms is constant in the pre-treatment period.

4. Results

Given that I am interested in the overall profitability of cartelization, the main results are the ones coming from the full sample. Thus, the first sample (denoted *Until Dist 13*) contains all the observations, meaning the *cartelized* firms and their pair from the control group from distance -5 until distance 13. Secondly, since many of the cartel cases break up after a few years, after distance 2 I start observing an important decrease in the number of treated observations (and consequently in the control group counterpart). Table 1 shows that the average duration of cartels is around 3 years in the full sample. Therefore, the second sample of interest (*Until Dist 2*) contains all the observations from distance -5 until distance 2, which again means from five years before the treatment and up to three years of treatment. This will allow me to examine whether there exists a short-term effect of cartelization on profits. Additionally, I am interested in studying whether the effect of cartelization on firms' profits is different for those cartels that do not last long and for those that last for many years. Since the maximum distance from treatment is 13, I have considered two groups: 1) the first one is composed only by those firms that were in a cartel up to 7 periods or less (*short-lived cartels*, from distance -5 until distance 7); 2) the second group considers only firms that were cartelized more than 7 periods (*long-lived cartels*, from distance -5 until distance 13).

This section presents the results obtained from the different estimations. First, the main results corresponding to the overall treatment effect and the short-term effect of cartelization on firms' profits will be analyzed. Then, the results by cartel duration are considered.

4.1. Main Results

Table 7 summarizes the results of the difference-in-differences estimator for the samples corresponding to the full matched sample (including up to 13 periods after the start of the treatment) and the matched sample up to 2 periods after the beginning of the cartelization. Firstly, results show that being a member of a cartel has a positive and significant overall impact on revenues. The operating revenues of the cartelized firms are around $19\% - 26\%$ higher than the operating revenues of the non-cartelized firms during the period of cartelization. This effect on firms' revenues is also present in the short-run, although it is lower. In the first three years of cartel membership, firms manage to increase their revenues by $14\% - 17\%$ compared to what they would have obtained if they had not been cartelized.

Table 7. Log of Operating Revenues. Diff-in-diff coefficient (β_3).

Sample	**OLS**	**FE**	**RE**	**AR(1)**
Overall Effect	**0.26****	**0.26****	**0.26****	**0.19*****
	(0.11)	(0.10)	(0.11)	(0.05)
N	1814	1814	1814	1814
R^2	0.888	0.406	0.888	0.886
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year
Short-term Effect	**0.17****	**0.17****	**0.17****	**0.14*****
	(0.08)	(0.08)	(0.08)	(0.05)
N	1368	1368	1368	1368
R^2	0.905	0.268	0.905	0.904
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year

Note: *p<0.10, **p<0.05, ***p<0.01 significance test. Cluster standard errors by cartel in brackets.

Other measures of profitability such as Profit Margin and Net Income are not significantly affected by the cartelization. This is, neither overall nor in the short-run the impact is significantly different compared to the non-cartelized firms. Results for the variable Net Income are shown in Table A.4. in the Appendix.

Thus, the first important result is that cartelization increases firms' revenues by $19\% - 26\%$ on average, but this is not translated into profits or earnings. This result may reflect the fact that managers are the ones making the decision of colluding or not. If their reputation or salary bonuses are based on the performance of the firm, which can be measured with firms' sales, then getting involved in a cartel may be beneficial for their own interests. However, these personal interests may not always be aligned with shareholders' interests.

It should be noted that one of the limitations of the work is that the firms I am considering as non-cartelized, could have been involved in a collusive agreement that was never discovered. If it was the case, results may be biased downwards and the total effect of cartelization may be higher when compared to truly non-cartelized firms. Additionally, since results show a positive and significant effect on the treatment group compared to the control group, then they may be reflecting the fact that the discovered are cartels were more successful in terms of revenues than the existing and not discovered ones.

On the other hand, another possible limitation of the data is that the firms of the control group, even if they have never belonged to a collusive agreement, they could benefit or free-ride from the reduced competition in the market. Or they could be harmed if the collusive firms try to expel them from the market. If this was the case, then the treatment would not be being cartelized versus not being cartelized but participating in a collusive agreement versus not participating, given the existence of collusion in the market. Thus, in that setting results should be interpreted as how much more do firms benefit from directly participating in the collusive agreement compared to the rest. However, this scenario does not seem to be the most plausible in the matched sample. I have estimated a simple OLS regression on the control group to test the existence of a different trend before and during the period of treatment. The null hypothesis of equality of coefficients cannot be rejected at standard significance levels.

4.2. Short- and Long-lived cartels

A second interesting result is found when the sample is split in two, distinguishing between firms that belonged to cartels that lasted long enough and those that lasted less. From Table 8, it can be seen that firms that colluded for seven periods at most, manage to increase their revenues by $13\% - 15\%$ on average. However, no significant impact is found on Net Income. Similarly, Table 9 presents the results for the firms belonging to *long-lived* cartels. These firms had on average $29\% - 50\%$ higher revenues than what they should have got if they had not been cartelized. Additionally, cartelization also had a positive and significant impact on the Net Income of these firms. Due to cartelization, they gained on average 7939-8811 thousand euros more than they should have. This increased quantity is more than two times higher than the average profits they would have earned if they had not been cartelized. Again, Profit Margin is not significantly affected in any of the cases.

Table 8. Short-lived Cartels. Diff-in-diff coefficient (β_3).

Sample	**OLS**	**FE**	**RE**	**AR(1)**
Log of Op. Revenues	**0.15***	**0.15***	**0.15***	**0.13****
	(0.09)	(0.08)	(0.09)	(0.06)
N	1201	1201	1201	1201
R^2	0.896	0.211	0.896	0.896
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year
Net Income	**-445.97**	**-445.97**	**-445.97**	**-535.74**
	(729.27)	(678.85)	(729.27)	(1000.42)
N	1201	1201	1201	1201
R^2	0.398	0.058	0.398	0.398
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year

Note: *p<0.10, **p<0.05, ***p<0.01 significance test. Cluster standard errors by cartel in brackets.

The second conclusion that can be extracted from the results is that cartelization always increases firms' revenues on average, but there exists a difference in the effects on profits. Two alternative scenarios are possible. On the one hand, it may be that both types of cartels are similar from the beginning in terms of profitability, but being cartelized long enough is the only way to turn the increase in revenues into profits gains (organizational

Table 9. Long-lived Cartels. Diff-in-diff coefficient (β_3).

Sample	**OLS**	**FE**	**RE**	**AR(1)**
Log of Op. Revenues	**0.50***	**0.50****	**0.50****	**0.29*****
	(0.23)	(0.22)	(0.23)	(0.11)
N	514	514	514	514
R^2	0.876	0.530	0.876	0.871
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year
Net Income	**8811.16***	**8811.16***	**8811.16****	**7939.08*****
	(4011.20)	(3883.04)	(4011.20)	(2632.21)
N	514	514	514	514
R^2	0.639	0.097	0.639	0.639
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year

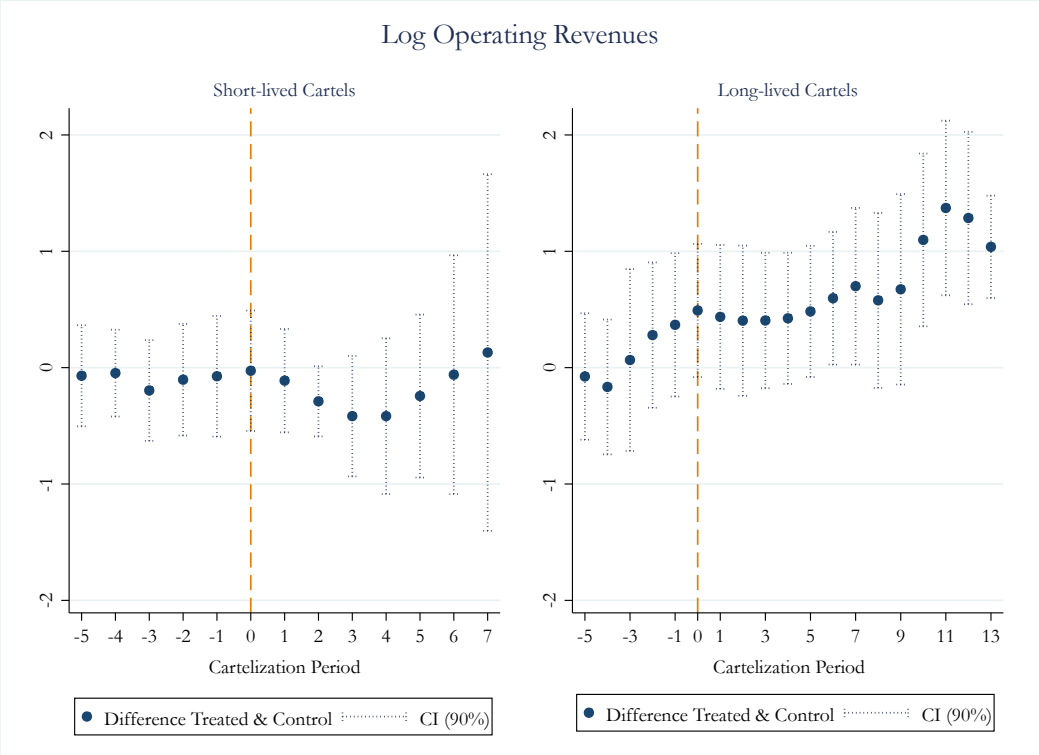
Note: *p<0.10, **p<0.05, ***p<0.01 significance test. Cluster standard errors by cartel in brackets.

costs are reduced, for instance). On the other hand, the causality could go in the opposite direction, meaning that some cartels are more profitable than others from the very beginning and this is one of the reasons why they last longer. These two competing ideas are studied in the next section.

4.2.1. Evolution of Revenues and Profits

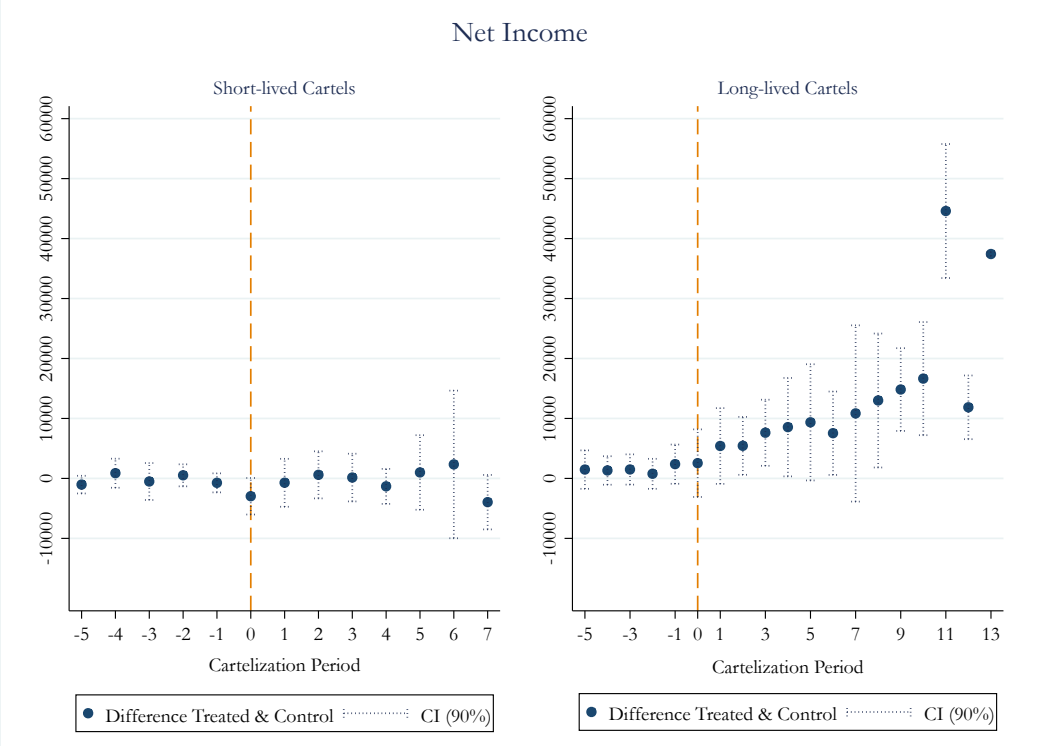
In this section, I analyze the evolution of revenues and profits period by period for short-lived and long-lived cartels separately. In Figure 2 and 3 we can observe some suggestive evidence that the amount of revenues and profits that cartelized firms earn, in comparison with non-cartelized firms, may be different since the first period of treatment for the two different cartel durations. However, these results should be interpreted carefully for two reasons. First of all, the sample contains 99 cartelized and 97 non-cartelized firms. Therefore, when the sample is split in two, according to cartel duration, the number of firms in each group is smaller. There are 80 cartelized firms that belonged to a short-lived cartel, and 16 cartelized firms that belonged to a long-lived cartel. The second reason is that firms drop out of the sample when they abandon the cartel or when the cartel dies - whatever happens first. Therefore, while in the short-lived cartels observations start from period 1 onwards, the observations of long-lived cartels start dropping from after period 7.

Figure 2: Comparison of average Revenues between Treated and Control group.



Note: The dot line indicates the first period for which treatment takes place. This graph represents the difference in equality of means between control and treated group.

Figure 3: Comparison of average Profits between Treated and Control group.



Note: The dot line indicates the first period for which treatment takes place. This graph represents the difference in equality of means between control and treated group.

In order to analyze the evolution of revenues and profits thoroughly, I perform two different tests. Pooling all the observations in the same regression, I test whether the overall impact of cartelization on firms' profitability is different for short-lived and long-lived cartels. In addition, I test whether there exists any difference in the revenues and profits earned by cartelized firms, compared to what the non-cartelized firms earned in the cartelization period, between the short-lived and long-lived cartels. For this last test, I have considered both a dummy variable for each period and another dummy variable that considers the cumulative effect up to the given period.

Results are presented in Table 10 and in Table 11. From these regressions and tests, it can be concluded that the overall impact of cartelization on profitability is different for short-lived and long-lived cartels, on average. With respect to results by period, there exists some evidence pointing at the existence of differences between the cartels duration since the first period. This evidence is stronger when the cumulative effect is considered.

Table 10. Test equality of diff-in-diff coefficient (β_3) across regression. Log of Operating Revenues.

Diff-in-diff (β_3)	Distance	Short		Long		Short	Long	Chi^2	p-val
		Coeff	Std. Err.	Coeff	Std. Err.	N	N		
Cumulative	0-1	0.12	(0.07)	0.37*	(0.18)	1002	220	2.27	0.13
	0-2	0.11	(0.08)	0.36*	(0.18)	1074	250	2.13	0.14
	0-3	0.13	(0.08)	0.35*	(0.18)	1114	281	1.88	0.17
	0-4	0.14	(0.08)	0.35*	(0.19)	1148	312	1.68	0.20
	0-5	0.15*	(0.08)	0.36*	(0.19)	1177	343	1.69	0.19
	0-6	0.15*	(0.09)	0.38*	(0.19)	1195	373	1.66	0.20
	0-7	0.15*	(0.09)	0.40*	(0.20)	1201	401	1.81	0.18
	All	0.15*	(0.09)	0.50*	(0.23)	1201	514	2.96	**0.09**
Dummy	0	0.13	(0.08)	0.35*	(0.18)	1201	514	1.67	0.20
	1	0.17	(0.12)	0.37*	(0.18)	1201	514	1.32	0.25
	2	0.05	(0.10)	0.35*	(0.19)	1201	514	3.00	**0.08**
	3	0.24	(0.20)	0.35*	(0.18)	1201	514	0.28	0.59
	4	0.20	(0.19)	0.39*	(0.21)	1201	514	0.66	0.42
	5	0.27	(0.22)	0.43**	(0.19)	1201	514	0.41	0.52
	6	0.28	(0.29)	0.45*	(0.24)	1201	514	0.26	0.61
	7	-0.04	(0.30)	0.53*	(0.26)	1201	514	2.36	0.12

Note: *p<0.10, **p<0.05, ***p<0.01 significance test. Cluster standard errors by cartel in brackets. Fixed effects for Firm & Year have been included in the regression

Table 11. Test equality of diff-in-diff coefficient (β_3) across regression. Net Income.

Diff-in-diff (β_3)	Distance	Short		Long		Short	Long	Chi2	p-val
		Coeff	Std. Err.	Coeff	Std. Err.	N	N		
Cumulative	0-1	-1030.05	(853.76)	2328.28	(1852.53)	1002	220	3.59	**0.06**
	0-2	-724.53	(840.69)	2828.33	(1662.59)	1074	250	4.77	**0.03**
	0-3	-579.12	(768.77)	3607.94*	(1767.05)	1114	281	6.06	**0.01**
	0-4	-585.52	(751.18)	4266.67*	(2088.63)	1148	312	6.17	**0.01**
	0-5	-503.94	(735.13)	4848.70*	(2422.50)	1177	343	5.66	**0.02**
	0-6	-440.79	(736.40)	5001.67*	(2462.66)	1195	373	5.54	**0.02**
	0-7	-445.97	(729.27)	5458.09*	(2853.70)	1201	401	4.92	**0.03**
	All	-445.97	(729.27)	8811.16*	(4011.20)	1201	514	6.14	**0.01**
Dummy	0	-2912.03	(2367.11)	1331.12	(1536.26)	1201	514	3.06	**0.08**
	1	1035.56	(1834.12)	3751.56	(2452.01)	1201	514	0.87	0.35
	2	97.76	(1941.46)	3925.34*	(1855.86)	1201	514	2.39	0.12
	3	970.04	(1425.35)	5149.00*	(2501.66)	1201	514	2.52	0.11
	4	108.79	(1066.12)	6984.77*	(3259.35)	1201	514	5.19	**0.02**
	5	2264.28	(2364.01)	7558.13*	(4000.49)	1201	514	1.43	0.23
	6	2917.78	(5367.53)	5823.51*	(2819.80)	1201	514	0.25	0.62
	7	-449.93	(1145.31)	9241.60	(5703.33)	1201	514	3.09	**0.08**

Note: *p<0.10, **p<0.05, ***p<0.01 significance test. Cluster standard errors by cartel in brackets. Fixed effects for Firm & Year have been included in the regression

4.3. Leniency Program

One of the main policies at the disposal of Antitrust Authorities aiming at detecting and sanctioning cartels is the Leniency Program. This policy offers companies involved in a cartel either total immunity from fines or fines reduction if they self-report the existence of the cartel or if they cooperate with the Authority. The Leniency Program also aims at deterring cartel formation by destabilizing the trust among cartel members. The controversial effects of this policy have been studied in the literature In Spain, the Leniency Program was passed in 2007 and implemented since 2008.

In this section, I analyze whether there exists any difference between the profitability of cartels that applied for Leniency Program and those that were discovered due to any other reason. This analysis is relevant because it helps us studying whether this program incentivizes the breakup and discovery of all types of cartels, or only of those that are not profitable and would have broken up anyway.

There are 18 cartelized firms that were members of a cartel that was discovered under the Leniency Program, while 81 cartelized firms belonged to a cartel in which no member applied for the Leniency Program. The last cartelization year of the firms belonging to a collusive agreement that was not discovered under the program was 2007 or afterwards. This means that by the time most of these firms stopped colluding they were aware of the existence of this law. Therefore, it is not the case that these cartels could not apply for the Leniency Program (due to time restrictions) but the case in which the members decided not apply for it.

Table 12. Log of Operating Revenues. Diff-in-diff coefficient (β_3).

Sample	**OLS**	**FE**	**RE**	**AR(1)**
Leniency	**0.06**	**0.06**	**0.06**	**0.04**
	(0.11)	(0.11)	(0.11)	(0.10)
N	386	386	386	386
R^2	0.882	0.458	0.882	0.880
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year
No Leniency	**0.33*****	**0.33*****	**0.33*****	**0.24*****
	(0.12)	(0.11)	(0.12)	(0.06)
N	1428	1428	1428	1428
R^2	0.891	0.405	0.891	0.889
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year

Note: *p<0.10, **p<0.05, ***p<0.01 significance test. Cluster standard errors by cartel in brackets.

Following the previous econometric strategy, I first analyze the effect of cartelization on firms' revenues and profits, distinguishing between these two types of detection. Results are shown in Table 12 and 13. The main conclusion that can be drawn is that cartels that did not apply for the Leniency Program benefited from an increase in revenues, compared to non-cartelized firms, while those cartels that applied for Leniency Program did not experience this increase. The evidence is weaker when the outcome variable Net Income is considered, as shown in Table 13. A question left for further research (and further data

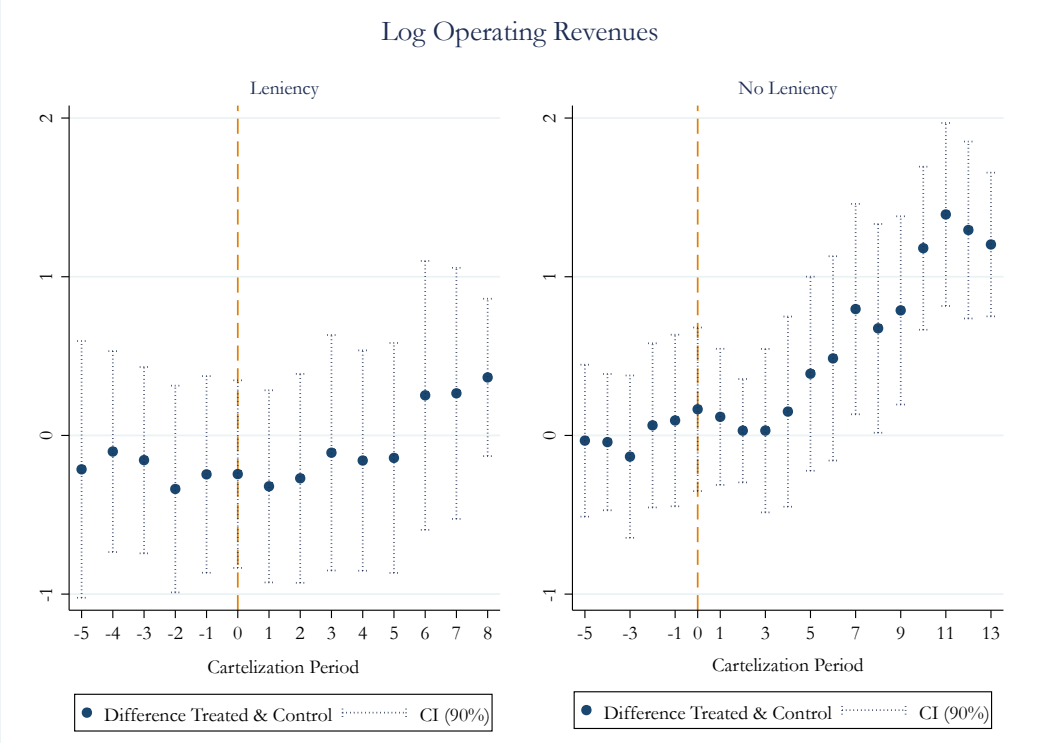
availability) is whether there exists a difference in cartel profitability in comparison to cartels finalized and discovered before the implementation of the Leniency Program. This is, whether the mere existence of the program (even if not all cartels apply for it) has some deterrence impact with respect to cartel profitability.

Table 13. Net Income. Diff-in-diff coefficient (β_3).

Sample	OLS	FE	RE	AR(1)
Leniency	**-1014.74**	**-1014.74**	**-1014.74**	**-1561.73**
	(1597.01)	(1520.59)	(1597.01)	(1455.09)
N	386	386	386	386
R^2	0.383	0.126	0.383	0.375
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year
No Leniency	**2910.79**	**2910.79**	**2910.79**	**2600.10****
	(1971.78)	(1855.94)	(1971.78)	(1226.90)
N	1428	1428	1428	1428
R^2	0.537	0.024	0.537	0.537
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year

Note: *p<0.10, **p<0.05, ***p<0.01 significance test. Cluster standard errors by cartel in brackets.

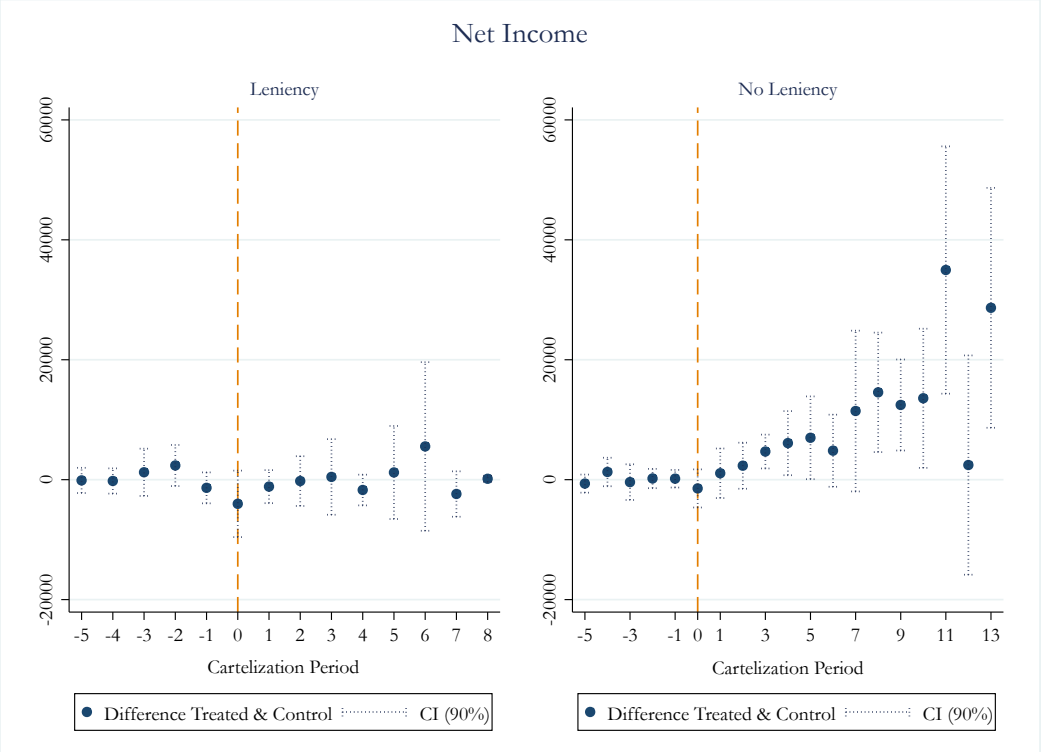
Figure 4: Comparison of average Revenues between Treated and Control group.



Note: The dot line indicates the first period for which treatment takes place. This graph represents the difference in equality of means between control and treated group.

Apart from the average impact of the treatment, the effect can also be analyzed period by period. From Figure 4 and Figure 5, it cannot be concluded that cartelization had a different impact on firms' revenues and profits when they were or were not discovered under the Leniency Program. Again, there exists some weak evidence that should be tested and it should also be taken into account the data limitations in terms of the number of

Figure 5: Comparison of average Profits between Treated and Control group.



Note: The dot line indicates the first period for which treatment takes place. This graph represents the difference in equality of means between control and treated group.

observations. Results are summarized in Table 14 and Table 15. There is clear evidence in Table 14 of the existence of significant statistical differences in the revenues earned by the firms belonging to cartels discovered under these two types of detection. In particular, for the members of cartels applying for the Leniency Program, cartelization did not produce a significant impact on revenues, while the effect of cartelization on revenues is significant when cartels not applying for the program are considered. On the other hand there is not significant impact on firms' profits (in most of the periods) when the analysis is performed period by period. However, Table 15 shows that there exists a statistical significant difference between the additional profits earned by the cartelized firms belonging to a cartel discovered under the Leniency Program and the ones belonging to cartels discovered due to other reasons (always in comparison with the control group).

Table 14. Test equality of diff-in-diff coefficient (β_3) across regression. Log of Operating Revenues.

Diff-in-diff (β_3)	Distance	Leniency		No Leniency		Len	No Len	Chi2	p-val
		Coeff	Std. Err.	Coeff	Std. Err.	N	N		
Cumulative	0-1	0.05	(0.12)	0.21	(0.08)	230	1030	1.63	0.20
	0-2	0.01	(0.10)	0.22**	(0.09)	259	1109	2.93	**0.09**
	0-3	0.04	(0.09)	0.23**	(0.09)	285	1160	2.86	**0.09**
	0-4	0.04	(0.10)	0.25**	(0.10)	312	1204	2.86	**0.09**
	0-5	0.05	(0.11)	0.26**	(0.10)	338	1243	2.69	**0.10**
	0-6	0.07	(0.11)	0.27***	(0.10)	356	1278	2.14	0.14
	0-7	0.06	(0.12)	0.29***	(0.10)	369	1304	2.48	0.11
	0-8	0.06	(0.11)	0.30***	(0.10)	378	1328	2.80	**0.09**
	All	0.06	(0.11)	0.33***	(0.12)	386	1428	3.03	**0.08**
Dummy	0	0.02	(0.20)	0.21**	(0.08)	386	1428	0.97	0.33
	1	-0.04	(0.17)	0.29**	(0.11)	386	1428	3.27	**0.07**
	2	-0.08	(0.13)	0.24*	(0.12)	386	1428	3.94	**0.05**
	3	0.16	(0.24)	0.37**	(0.16)	386	1428	0.64	0.42
	4	0.16	(0.26)	0.39***	(0.14)	386	1428	0.75	0.39
	5	0.16	(0.27)	0.42***	(0.15)	386	1428	0.84	0.36
	6	0.23	(0.32)	0.39**	(0.15)	386	1428	0.24	0.62
	7	0.02	(0.24)	0.55***	(0.15)	386	1428	4.43	**0.04**
	8	0.11	(0.20)	0.53***	(0.17)	386	1428	2.92	**0.09**

Note: *p<0.10, **p<0.05, ***p<0.01 significance test. Cluster standard errors by cartel in brackets. Fixed effects for Firm & Year have been included in the regression

Table 15. Test equality of diff-in-diff coefficient (β_3) across regression. Net Income.

Diff-in-diff (β_3)	Distance	Leniency		No Leniency		Len	No Len	Chi^2	p-val
		Coeff	Std. Err.	Coeff	Std. Err.	N	N		
Cumulative	0-1	-2918.27	(2105.80)	281.72	(818.34)	230	1030	2.72	**0.10**
	0-2	-2276.99	(1641.20)	543.59	(848.54)	259	1109	3.05	**0.08**
	0-3	-1821.29	(1347.64)	927.40	(864.63)	285	1160	3.75	**0.05**
	0-4	-1846.41	(1301.47)	1246.96	(968.38)	312	1204	4.53	**0.03**
	0-5	-1531.68	(1425.02)	1489.79	(1090.13)	338	1243	3.51	**0.06**
	0-6	-1055.50	(1629.42)	1524.08	(1136.34)	356	1278	2.07	0.15
	0-7	-1141.47	(1612.88)	1722.32	(1259.62)	369	1304	2.40	0.12
	0-8	-1120.50	(1618.30)	1971.44	(1365.91)	378	1328	2.60	0.11
	All	-1014.74	(1597.01)	2910.79	(1971.78)	386	1428	2.85	**0.09**
Dummy	0	-5938.16	(4501.35)	-1405.78	(2352.76)	386	1428	1.00	0.32
	1	-2256.72	(1774.50)	2618.70	(1854.90)	386	1428	4.39	**0.04**
	2	-739.24	(1945.17)	1486.09	(1819.64)	386	1428	0.85	0.36
	3	530.67	(2946.15)	2672.41**	(1296.18)	386	1428	0.55	0.46
	4	-1681.08	(1581.55)	5373.86***	(1761.73)	386	1428	10.66	**0.00**
	5	2446.32	(3812.26)	4908.06*	(2575.98)	386	1428	0.35	0.55
	6	5326.49	(7449.84)	2987.70	(2302.75)	386	1428	0.11	0.74
	7	-838.04	(2333.42)	9299.08*	(4856.97)	386	1428	4.19	**0.04**
	8	-658.70	(1791.73)	10179.01**	(4064.66)	386	1428	7.01	**0.01**

Note: *p<0.10, **p<0.05, ***p<0.01 significance test. Cluster standard errors by cartel in brackets. Fixed effects for Firm & Year have been included in the regression

5. Robustness Checks

5.1. Placebo Test

In order to ensure that the effects found are due to the treatment, two different placebo tests are performed. Following (reference?), the first placebo test is performed in the pre-treatment period to check whether some effect on firms' profits can be observed before the treatment takes place. The second placebo test replicates the estimations of interest in a sample formed by the control group and a new match for each of the firms belonging to it.

5.1.1. Placebo Test in Pre-Treatment Period

The test is performed in the sample of cartelized and non-cartelized firms in the pre-treatment period only. The following regression is estimated:

$$Y_{it} = \beta_0 + \beta_1 Cartelized_i + \beta_2 PeriodPla_t + \beta_3 Cartelized_i * PeriodPla_t + \alpha_i + \delta_t + u_{it} \quad (2)$$

where Y_{it} is the outcome of interest ; $Cartelized_i$ takes value 1 if the firm has ever been cartelized in the sample period and 0 otherwise; $PeriodPla_t$ takes value 0 for distances to treatment period -5 and -4, and takes value 1 for distances to treatment period -3 and -2; $Cartelized_i * PeriodPla_t$ is the interaction of the previous two dichotomous variables; α_i represents individual fixed effects; δ_t represents time fixed effects; and u_{it} is the error term. The period previous to the start of the treatment (distance -1) has not been included in this regression because this date could be measured with error given that cartels are an illegal activity. Given that the pre-treatment period is only composed by five periods, such a relevant period could have an important weight and impact in the estimated coefficients[7].

Table 16. Log of Operating Revenues. Diff-in-diff coefficient (β_3).

Sample	**Placebo Pre-Treatment Period**			
	OLS	**FE**	**RE**	**AR(1)**
Distance -5 to -1	**0.08**	**0.08**	**0.08**	**0.08**
	(0.08)	(0.07)	(0.08)	(0.06)
N	750	750	750	750
R^2	0.92	0.186	0.92	0.92
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year
Medium	**0.27**	**0.27**	**0.27**	**0.27**
	(0.37)	(0.32)	(0.37)	(0.19)
N	127	127	127	127
R^2	0.889	0.254	0.889	0.889
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year

Note: *p<0.10, **p<0.05, ***p<0.01 significance test. Cluster standard errors by cartel in brackets.

The results of the first placebo test are presented in Table 16. It can concluded that cartelized firms do not behave differently from non-cartelized firms two and three periods before the treatment starts compared to four and five periods before cartelization.

[7] I have performed the placebo test also including also this period and the coefficients and its significance are basically not affected.

5.1.2. Placebo Test for Control Group

In this case, I work only with the non-cartelized firms. They are going to be the *artificial treatment group* in the placebo test. Therefore, I treat them as if they were the cartelized firms in the new sample I create. The period of treatment I use is the one that was artificially imputed to them when they were used as control, therefore, the one that corresponds to the cartelized firm for which they are the match. Thus, I can repeat the procedures explained in sections 3.2 and 3.3. For each of these non-cartelized firms, that are considered as *treated* in this case, I look for a pair or control in the full sample of non-cartelized firms. Again, I apply the non-parametric nearest neighbor matching method, and the observable characteristics used for the matching are the same as before. After constructing the matched sample, I apply the difference-in-differences estimator in order to check whether the coefficients of interest are significant in this case. Moreover, I test whether the outcomes of the *treated* and *non-treated* firms have parallel trends in the pre-treatment period as it was done in section 5.1. It is also tested whether the *non-treated* firms show different trends in their outcome variables for the pretreatment and treatment period.

Table 17. Log of Operating Revenues. Diff-in-diff coefficient.

Sample	**OLS**	**FE**	**RE**	**AR(1)**
Overall Effects	**-0.04**	**-0.04**	**-0.04**	**-0.04**
	(0.05)	(0.04)	(0.05)	(0.04)
Obs	1725	1725	1725	1725
R2	0.921	0.396	0.921	0.921
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year
Short-term Effects	**-0.03**	**-0.03**	**-0.03**	**-0.03**
	(0.05)	(0.05)	(0.05)	(0.04)
N	1318	1318	1318	1318
*R*2	0.938	0.266	0.938	0.938
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year

Note: *p<0.10, **p<0.05, ***p<0.01 significance test. Cluster standard errors by cartel in brackets.

The estimation results of the outcome variable logarithm of operating revenues for the overall and the short-term effects are presented in Table 17. The placebo results of the analysis for short- and long-lived cartels are summarized in Table 18 and Table 19. No significant impact of *cartelization* on firms' revenues or profits can be found in these placebo analyses. This confirms that the main results obtained for cartelized and non-cartelized firms actually represent the causal effect of being a member of a cartel on firms' revenues or profits.

Table 18. Short-lived cartels. Diff-in-diff coefficient (β_3).

Sample	OLS	FE	RE	AR(1)
Log of Op. Revenues	**-0.08**	**-0.08**	**-0.08**	**-0.07**
	(0.06)	(0.06)	(0.06)	(0.05)
N	1132	1132	1132	1132
R^2	0.923	0.206	0.923	0.923
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year
Net Income	**707.18**	**707.18**	**707.18**	**920.81**
	(869.48)	(806.31)	(869.48)	(778.75)
N	1132	1132	1132	1132
R^2	0.71	0.083	0.71	0.709
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year

Note: *p<0.10, **p<0.05, ***p<0.01 significance test. Cluster standard errors by cartel in brackets.

Table 19. Medium-lived cartels. Diff-in-diff coefficient (β_3).

Sample	OLS	FE	RE	AR(1)
Log of Op. Revenues	**0.04**	**0.04**	**0.04**	**0.06**
	(0.10)	(0.10)	(0.10)	(0.09)
N	501	501	501	501
R^2	0.92	0.523	0.92	0.919
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year
Net Income	**-906.18**	**-906.18**	**-906.18**	**-899.64**
	(841.74)	(814.22)	(841.74)	(1060.59)
N	503	503	503	503
R^2	0.333	0.084	0.333	0.333
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year

Note: *p<0.10, **p<0.05, ***p<0.01 significance test. Cluster standard errors by cartel in brackets.

6. Conclusions

This study evaluates the causal effect of having been involved in a collusive agreement on the revenues and profits of cartelized firms. For this purpose, I use a panel data of cartelized and non-cartelized Spanish firms for the period 1992-2014 coming from two different sources: the reports of the cartels that have been sanctioned by the Spanish Antitrust Authority in the last two decades and the balance sheets of firms. After finding a good counterfactual or control group for the treated firms using the matching nearest neighbor algorithm, I can estimate the effect of belong- ing to a cartel on firms revenues and profits by using the difference-in-differences estimator.

Results show that firms revenues increase around 19% ? 26% due to participation in a collusive agreement. However, profits measured as net income or profit margin do not show a significant impact on average. In the first three years of cartelization, which corresponds to the average cartel duration in the full sample, firms increase their revenues by 14%?17%. More importantly, only when the sample is split into short-lived and long-lived cartels a significant effect is found on net income on the latter. This is, firms that belong to a cartel that lasted between 8 and 13 years increase their revenues by 29% ? 50%. Also, these revenues are translated into profits since net income is on average 2.15-2.33 times higher than what these cartelized firm would have earned if they had not been involved in a cartel case. These longer-lasting cartels appear to be more profitable since initial periods. Finally, there exists some weak evidence that only members of non-profitable cartels apply

for the Leniency Program.

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Appendix

A.1. Distribution of Cartelized Firms by Sector[8]

Table A.1. Cartelized firms by sector

	Total Sample		Matched Sample	
Sector	**Firms**	**Freq.**	**Firms**	**Freq.**
A	3	1.19	1	1.01
B	1	0.4	0	0.00
C	74	29.25	21	21.21
D	3	1.19	0	0.00
E	17	6.72	9	9.09
F	33	13.04	22	22.22
G	70	27.67	28	28.28
H	24	9.49	10	10.1
J	4	1.58	0	0.00
K	5	1.98	1	1.01
M	2	0.79	1	1.01
N	17	6.72	6	6.06
Total	253	100.00	99	100.00

A.2. Parallel Trends

The first step is to test whether the cartelized and non-cartelized firms have parallel trends in their outcome variables before the treatment takes place. In this regression it is considered only the pretreatment period for each cartelized firm while the observations of the control firms are considered for the whole period. The following fully saturated model is estimated:

$$Y_{it} = \beta_1 CB_i + \beta_2 CB_i * Trend_t + \beta_3 NCB_i + \beta_4 NCB_i * Trend_t + \beta_5 NCA_i + \beta_6 NCA_i * Trend_t + \alpha_i + \delta_t + u_{it}$$

where CB_i is a dummy variable that takes value 1 for cartelized firms in the pretreatment period and 0 otherwise; NCB_i is a dummy variable that takes value 1 for non-cartelized firms in the pretreatment period and 0 otherwise; NCA_i is a dummy variable that takes value 1 for non-cartelized firms in the treatment period and 0 otherwise; $Trend_t$ is a trend variable and takes value 1 for distance -5 and increases in one unit for each distance until taking value 14 for distance 13; α_i represents individual fixed effects; δ_t represents time fixed effects; and u_{it} is the error term.

[8]Description of NACE Rev.2 Sector Classification by Section: A - Agriculture, forestry and fishing. B - Mining and quarrying. C - Manufacturing. D - Electricity, gas, steam and air conditioning supply. E - Water supply; sewerage, waste management and remediation activities. F - Construction. G - Wholesale and retail trade; repair of motor vehicles and motorcycles. H - Transportation and storage. J - Information and communication. K - Financial and insurance activities. M - Professional, scientific and technical activities. N - Administrative and support service activities.

Table A.2. Test of Parallel Trends

Dependent Variable	Sample	Fixed Effects	H_0: β_2=β_4		H_0: β_4=β_6		H_0: β_2=β_4=β_6	
			F-stat	**p-value**	**F-stat**	**p-value**	**F-stat**	**p-value**
Log of Operating Revenues	Until Dist 13	No	0.27	0.61	3.91	0.05	3.34	0.04
		Firm	1.42	0.24	0.10	0.76	1.29	0.28
		Firm and Year	3.60	0.06	0.12	0.73	3.24	0.05
	Until Dist 2	No	0.27	0.61	0.61	0.44	0.64	0.53
		Firm	1.36	0.25	0.40	0.53	1.28	0.29
		Firm and Year	4.08	0.05	0.02	0.90	2.27	0.11
	Short-lived cartels	No	0.03	0.87	0.27	0.61	0.13	0.87
		Firm	0.48	0.49	0.29	0.59	0.72	0.49
		Firm and Year	1.68	0.20	0.96	0.33	2.51	0.09
	Long-lived cartels	No	1.96	0.19	71.40	0.00	37.24	0.00
		Firm	1.60	0.23	183.94	0.00	94.21	0.00
		Firm and Year	1.51	0.24	1.21	0.30	1.50	0.27
Net Income	Until Dist 13	No	0.13	0.72	0.54	0.47	0.52	0.60
		Firm	0.73	0.40	0.01	0.93	0.48	0.62
		Firm and Year	0.66	0.42	0.30	0.58	0.33	0.72
	Until Dist 2	No	0.13	0.72	0.23	0.64	0.20	0.82
		Firm	0.59	0.45	0.39	0.54	0.40	0.67
		Firm and Year	0.62	0.43	1.83	0.18	0.93	0.40
	Short-lived cartels	No	0.04	0.84	0.69	0.41	0.35	0.71
		Firm	0.62	0.43	1.96	0.17	0.98	0.38
		Firm and Year	0.53	0.47	1.88	0.18	0.94	0.40
	Long-lived cartels	No	3.18	0.10	34.69	0.00	18.25	0.00
		Firm	2.40	0.14	10.10	0.01	5.34	0.02
		Firm and Year	1.81	0.21	4.04	0.07	2.22	0.16

A.3. Test Difference in Coefficients for each distance

When the trends of the series can be better approximated by a non-linear function, there exists an alternative way to test the pattern in each of the periods before the cartelization takes place. Using again the sample of cartelized firms in the pretreatment period and the non-cartelized firms in the whole period, I estimate the following equation:

$$Y_{it} = \beta_0 + \beta_1 CD5 + \beta_2 NCD5 + \beta_3 CD4 + \beta_4 NCD4 + \beta_5 CD3 + \beta 6 NCD3 + \beta_7 CD2 + \beta_8 NCD2 + \beta_9 CD1 + \beta_{10} NCD1 + \alpha_i + \delta_t + u_{it}$$

where $CD5$ is a binary variable that takes value 1 for cartelized firms five periods before the treatment and 0 otherwise; $NCD5$ is a binary variable that takes value 1 for non-cartelized firms five periods before the treatment and 0 otherwise; the same reasoning applies for the rest of the binary variables where the number denotes the number of periods before the treatment; α_i represents individual fixed effects; δ_t represents time fixed effects; and u_{it} is the error term.

Table A.3. Test of Constant Difference by Distance to Treatment

Dependent Variable	Sample	Fixed Effects	H_0: β_2-β_1=β_4-β_3		H_0: β_4-β_3=β_6-β_5		H_0: β_6-β_5=β_8-β_7		H_0: β_8-β_7=$\beta_1$0-β_9		All Differences	
			F-stat	p-value	F-stat	p-value	F-stat	p-value	F-stat	p-value	F-stat	p-value
Log of Operating Revenues	Until Dist 13	No	0.02	0.88	0.69	0.41	2.30	0.14	1.21	0.28	0.89	0.47
		Firm	0.13	0.72	0.01	0.93	2.16	0.15	0.96	0.33	0.70	0.60
		Firm and Year	0.09	0.76	0.01	0.92	3.16	0.08	2.04	0.16	1.50	0.22
	Until Dist 2	No	0.02	0.88	0.69	0.41	2.29	0.14	1.21	0.28	0.89	0.48
		Firm	0.07	0.79	0.01	0.94	2.14	0.15	0.93	0.34	0.67	0.61
		Firm and Year	0.09	0.76	0.01	0.90	3.19	0.08	2.11	0.15	1.67	0.17
	Short-lived cartels	No	0.09	0.77	1.75	0.19	0.82	0.37	0.31	0.58	0.77	0.55
		Firm	0.12	0.73	0.06	0.81	1.21	0.28	0.36	0.55	0.40	0.81
		Firm and Year	0.20	0.66	0.09	0.77	2.00	0.16	0.96	0.33	0.80	0.53
	Long-lived cartels	No	2.38	0.15	0.54	0.48	2.09	0.18	7.40	0.02	2.86	0.08
		Firm	2.16	0.17	0.49	0.50	1.27	0.28	6.71	0.03	3.06	0.06
		Firm and Year	2.21	0.16	0.45	0.52	1.07	0.32	6.60	0.03	2.51	0.10
Net Income	Until Dist 13	No	1.94	0.17	1.99	0.16	0.35	0.55	0.89	0.35	1.18	0.33
		Firm	1.65	0.20	1.37	0.25	0.21	0.65	0.17	0.68	0.90	0.47
		Firm and Year	1.47	0.23	1.64	0.21	0.20	0.65	0.01	0.92	0.79	0.54
	Until Dist 2	No	1.94	0.17	1.98	0.16	0.35	0.56	0.89	0.35	1.18	0.33
		Firm	1.59	0.21	1.52	0.22	0.21	0.64	0.17	0.69	0.88	0.48
		Firm and Year	1.53	0.22	1.80	0.19	0.22	0.64	0.03	0.85	0.91	0.47
	Short-lived cartels	No	1.81	0.18	2.01	0.16	0.66	0.42	2.19	0.15	1.78	0.15
		Firm	1.51	0.23	1.32	0.26	0.45	0.50	0.98	0.33	1.64	0.18
		Firm and Year	1.53	0.22	1.96	0.17	0.41	0.52	0.41	0.53	1.51	0.22
	Long-lived cartels	No	0.03	0.86	0.12	0.74	3.16	0.10	3.44	0.09	3.36	0.05
		Firm	0.03	0.87	0.11	0.75	2.84	0.12	3.12	0.11	2.74	0.08
		Firm and Year	0.03	0.87	0.11	0.74	2.75	0.13	2.47	0.14	1.11	0.40

Note: Test of all differences: H_0: β_2-β_1=β_4-β_3=β_6-β_5=β_8-β_7=β_{10}-β_9

A.4. Estimation results of variable Net Income

Table A.4.Net Income. Diff-in-diff coefficient (β_3).

Sample	OLS	FE	RE	AR(1)
Overall Effect	**1974.42**	**1974.42**	**1974.42**	**1657.29**
	(1700.99)	(1605.61)	(1700.99)	(1011.75)
N	1814	1814	1814	1814
R^2	0.524	0.025	0.524	0.523
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year
Short-term Effect	**-48.26**	**-48.26**	**-48.26**	**-156.98**
	(783.22)	(724.18)	(783.22)	(883.29)
N	1368	1368	1368	1368
R^2	0.453	0.016	0.453	0.453
Fixed Effects	Firm & Year	Year	Firm & Year	Firm & Year

Note: *p<0.10, **p<0.05, ***p<0.01 significance test. Cluster standard errors by cartel in brackets.