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CÀTEDRA PASQUAL MARAGALL D'ECONOMIA I TERRITORI

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WHEN ARE CARTELS MORE LIKELY TO BE FORMED OR BROKEN? THE ROLE OF BUSINESS CYCLES

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Abstract

The literature presents mixed contributions about the economic conditions under which cartels form and collapse, and about how stable they are across firm-specific and industry-wide business cycles. The relationship between cartel life cycles and business cycles has not been sufficiently analyzed to date. In this paper, we study in depth whether collusion is pro-cyclical or counter-cyclical. We analyze the relationship between cartel startups/breakups and economic cycles using a dataset of sanctioned cartels by the European Commission that were active between 1997 and 2012, after the leniency program had already been introduced. We also double check whether this relationship has changed with respect to the pre-leniency period from 1991 to 1996. Our results show that cartels are more likely to be formed in upturns, but that cartels tend to breakup also in booms. Upturns in economic cycles appear to cause cartel turnovers: existing cartels die while new ones are set up. Collusion appears to be pro-cyclical with respect to cartel creation, while it seems to be counter-cyclical with regard to cartel demise.

Keywords: Cartels; Business Cycles; Business Expectations, Antitrust.

JEL Codes: D7; K2; L4; O4.

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1. Introduction

In the last decades, the tools at the disposal of Antitrust Authorities in the fight against cartels have improved considerably, being the leniency program the cornerstone of the most important instruments. Although some improvements have been made, the fact that cartels are illegal makes them highly secretive, which complicates the task of proving their existence. Therefore, it would be useful to have some collusive markers or some screening instruments to monitor some markets with environments conductive to collusion.

There are two seminal papers that linked business cycles and cartel stability: Rotemberg and Saloner (1986) and Haltiwanger and Harrington (1991). However, the former shows that collusion is counter-cyclical while the latter that it is pro-cyclical. All in all, collusion may be one or the other depending on the modelling details that prevail on the data.

Bagwell and Staiger (19997), Fabra (2006), Levenstein and Suslow (2011 & 2016), or Antonielli and Mariniello (2014), among others, have also tried to offer insights on this question.[5] Moreover, there are meta-analyses of case studies of cartel cases formed before the 1950's, as it is the case in Levenstein and Suslow (2006); or other papers look at some statistics like the percentage of months in the sample in which an economic downturn took place and the percentage of cartels formed in that period, as it is the case also in Suslow (2005). The question of whether collusion is pro-cyclical or contra-cyclical is however unsettled.

In this paper we focus both on cartel formation and breakups, and how these two events relate to firm-specific business cycles, price expectations, and industry-wide cycles. We study how both the number of cartels formed or collapsing is determined not only by the current firm-specific and industry economic situation, but also by the expectations that firms' managers have.

To address these questions we work with the number of cartels formed and with the number of cartels broken due to internal reasons in the European Union every month, mostly after the introduction of the leniency program (1997-2012), but also during the pre-leniency period ranging from 1991 to 1996. By estimating a Poisson regression model, we

[5] For a revision of this literature, see Levenstein and Suslow (2014).

analyze which is the effect of the sector real production (industry growth or decline), of the business evolution perceptions in the last months (firm perceived dynamics) and the managers' price expectations on the likelihood of setting-up or breaking-apart of any cartel.

The contributions of this paper are several. First, we study cartel formation itself, using an EU database, which has not been broadly studied from an empirical point of view so far. Second, we make use of business surveys to analyze cartel formation and breakups, a link that has not been used in the literature for this purpose despite the information it provides regarding business managers' point of view. Finally, we do not only analyze the relationship between cartels and business cycles, but we do also analyze the effect of price expectations on cartel formation and breakup.

Our results show that cartels are more likely to be formed in upturns, but also that cartels tend to breakup also in booms. Cartels are more prone to be created when managers consider that their firm production has evolved positively in the last three months (growing firms) and when they expect a decrease in prices in the near future (with expected declining prices). Cartels are more likely to collapse when firms face upturns in real production at the EU level. Upturns in economic cycles appear to cause cartel turnovers: existing cartels die while new ones are set up. Collusion appears to be pro-cyclical with respect to cartel creation, while it seems to be counter-cyclical with regard to cartel demise.

This paper is structured as follows. After this brief introduction, the second section contains a literature review. The data is described and discussed in section 3. Section 4 details the empirical strategy, before analyzing the results in section 5. Section 6 offers a wide set of robustness checks. Finally, the main conclusions of this work are discussed in section 7.

2. Literature Review

The literature that relates business cycle and cartels focuses mostly on the stability of cartels instead of cartel startups or breakups. It has been studied the effect of business cycle on cartel duration and collusive pricing from a theoretical and empirical point of view, although conclusions are contradictory.

The classic cartel dilemma was established by Stigler (1964) and developed by Tirole (1988). It analyzes if collusion can be sustained if the expected profit from colluding today outweighs the expected profit of defecting from a cooperative agreement (see Levenstein

and Suslow, 2016, for further explanation). In this model, the impatience of any firm owners, so the firm-specific risk premium, is a cornerstone of the cartel stability.

From the theoretical point of view, the model proposed by Rotemberg and Saloner (1986) is a pioneering work linking business cycles and cartel life cycles. Their model looks at collusion and business cycles, defined as a boom or recession of demand, but assumes that the level of demand is determined each period from an independent and identically distributed process. So, in their setup, booms and busts occur from time to time with some known probability, but it cannot be predicted when they finally happen.

The authors investigate the effect of such business cycles of booms and busts on optimal collusive pricing. They conclude that for moderate values of the discount factor (mature industries, or at least not too risky industries or activities), collusion is countercyclical: cartels are more likely to break up in demand booms as deviation today from collusive price is less costly in terms of foregone profits in the future, and also the gain of deviating from a collusive agreement is greatest during booms. Additionally, collusive price is countercyclical: firms also tend to price competitively in demand downturns.

By contrast, Haltiwanger and Harrington (1991) present a model that allows for both the level of current demand and firms' expectations on future demand to change over time. Those authors conclude that while the gain of deviating from a collusive agreement is greatest during booms, firms find it even more difficult to collude during recessions, as the forgone profits from inducing a price war are relatively low. Therefore, collusion is pro-cyclical, more difficult in busts, easier in booms.

These two seminal contributions differ with respect the dynamics of the business cycle, obtaining completely contradictory results: when booms and bust come from i.i.d processes, collusion is countercyclical; but, when business expansions and downturns have some correlation over time, collusion is pro-cyclical.

Bagwell and Staiger (1997) extend the model of collusive pricing assuming that demand movements are stochastic and persistent. A Markov process determines the transition between slow-growth and fast-growth states. In this case, they show that collusive prices are weakly pro-cyclical when demand growth rates are positively correlated through time.

Bagwell and Staiger (1997) note that the empirical evidence is mixed since there is both pro-cyclical and countercyclical pricing (see, among others, Bils, 1987a; Domowitz, Hubbard and Petersen, 1986a, 1986b, 1987; and Rotemberg and Saloner 1986).

Extending the Rotemberg and Saloner (1986) model by introducing capacity constraints, Fabra (2006) shows that when capacity constraints are sufficiently tight, firms find it more difficult to collude during booms, whereas the contrary is true for larger capacity values.

From an empirical point of view, Hyytinen, Steen and Toivanen (2011) use a hidden Markov model, which consists of a hidden process (the industry cartel dynamics in this case, since there may be industries never investigated or convicted) and an observation process that reveals information on the state of the hidden process for some periods (what the researcher knows about the state of the industry in a given period). They find that the chance of forming a cartel is around 20%, increases over their sample period and responds to positive shocks to GDP being then pro-cyclical.

Suslow (2005) uses an empirical model to test for the importance of demand uncertainty and cartel organizational characteristics in determining cartel duration. She finds out that economic uncertainty, measured as the fluctuation of an industrial production index, accounts for most of the variance in the duration of the cartel agreements. Also Levenstein and Suslow (2011) analyze the impact of cartel organizational features, as well as macroeconomic fluctuations and industry structure, on cartel duration. They find that firm-specific measures of impatience are systematically related to cartel breakup. In a later work (Levenstein and Suslow, 2016), these authors found a positive relationship between market interest rates and probability of cartel breakup, outcome that they did not find for the international cartels analyzed in their previous work.

Table 1 summarizes the contributions of the literature on the relationship between collusion and business cycles.

Table 1: Empirical and theoretical literature regarding business cycles and cartel formation/breakups

Year	Authors	Methodology	Database	Results
1986	Rotemberg and Saloner	Theoretical	-	**Collusion is counter-cyclical.** Collusion is more difficult in booms, easier in downturns.
1991	Haltiwanger and Harrington	Theoretical	-	**Collusion is pro-cyclical**. Firms find easier to collude during booms, more difficult to collude during recessions.
1997	Bagwell and Staiger	Theoretical	-	**Collusion is pro-cyclical**, more likely in booms, when demand growth rates are positively correlated through time.
2005	Suslow	Proportional Hazard Model	71 international manufacturing and commodities cartels: 1920-1939	**Collusion is pro-cyclical**: economic uncertainty, measured as the fluctuation of an industrial production index, accounts for most of the variance in the duration of the cartel agreements.
2006	Fabra	Theoretical	-	**Collusion is counter-cyclical** when capacity constraints are sufficiently tight, firms find it more difficult to collude during booms. The contrary is true, **collusion is pro-cyclical,** for large capacity values.
2011	Hyytinen, Steen and Toivanen	Hidden Markov Model	109 legal Finnish manufacturing cartels: 1951-1990	**Collusion is pro-cyclical.** The chance of forming a cartel is around 20%, it increases over their sample period and responds to positive shocks to GDP.
2011	Levenstein and Suslow	Proportional Hazard Model	81 international cartels (US or EC): 1990-2007	Firm-specific measures of impatience (firm risk premiums) are systematically related to cartel breakup.
2016	Levenstein and Suslow	Proportional Hazard Model	247 US non-bid-rigging cartels: 1961-2013	Cartels are more likely to break up during periods of high real interest rates.

Source: Own elaboration.

As we have seen above, theory papers are offering different conclusions with respect to the relationship of cartel stability and the business cycle, and also the evidence provided by the empirical literature is mixed. There is a gap in the literature to study more in depth to what extend and in which circumstances collusion is pro-cyclical or counter-cyclical. Instead of relying in country data, we are going use data coming from business surveys regarding firm-

specific business dynamics and price expectations, and also industry specific production dynamics to analyze startups and breakups of cartel discovered and sanctioned by the European Commission.

Therefore, the objective of this paper is to study whether the conditions or the variables related to the firm and industry business cycle affect the stability of collusive agreements, and to what extend such variables affect the formation and breakup of these illegal agreements symmetrically.

3. Data

The dataset has been constructed from the European Commission's decisions in cartel cases between 1976 and 2012. The European Commission has sanctioned 121 cartels over this period. Most of these cartels were discovered due to investigations initiated by the Commission's own initiative or following complaints by third parties (67 cartel cases), and the other 54 cartel cases have been detected under the EU Leniency Program since it was set up in 1996.

From the published Commission's decisions we obtained information regarding the formation and breakup date of the cartels. The former corresponds to the first moment for which the authority has evidence of a collusive agreement, which usually is a date before the starting date of the investigation. The latter is the first moment for which the cartel breaks up which could be a date before or after the opening of the investigation procedures.[6]

In this paper, we are going to analyze the likelihood of two different events across time (months): (1) the event of a cartel set up in the manufacturing industry in the EU in any month from January 1997 to December 2012 according to the European Commission files of sanctioned cartels; (2) the event of a cartel break up in the manufacturing industry in the EU in any month from January 1997 to December 2012 according to the European Commission files of sanctioned cartels. We also double check whether the introduction of the leniency program in 1996 changed the impact of economic cycles on cartel set up and

[6] See Connor (2014) for a discussion of the potential difficulties in setting exactly the date of birth and death of cartels.

breakup using evidence of the previous pre-leniency period from January 1991 to December 1996.[7]

When studying cartel breakups, we restrict the empirical analysis to the cartels for which the breakups are due to cartel internal reasons. We qualify a cartel breakup as one due to "internal reasons" whenever the cartel breakup date precedes the date at which the investigation started, and also all the cases that start by a leniency application: the cases in which the cartel breakup date is in any date before or after the opening of the investigation whenever it is triggered after any cartel member applies for the leniency program.

Recall that cartel investigations may have been launched by four different means: (1) Commission own initiative (*ex-officio*), (2) third party complaint, (3) after a cartel member notification during the pre-2004 regime in which agreements among firms had to be notified and could be authorized by the Commission (when they were not authorized, a cartel investigation could also be launched), (4) after one or more cartel members notified their participation in a cartel and applied for a lenient sanctioning treatment under the leniency program available since 1996 onwards.

We do only focus on these cases in which the break-up is due to internal reasons because we are interested in analyzing firms' behavior regarding cartel activities taking into account their appraisal about the business cycle: firm perceptions of past business evolution, firm selling price expectations, and EU real production cycles. We leave for further investigation the question of what are the drivers of cartels breakups when there is an external action such as an European Commission investigation triggered by the EC own initiative (with or without having denied an agreement authorization), after a third partly complain, or when the break up occurs sometime after one of the cartel members apply for the leniency program.

We have also computed the date of the final decision adopted by the European Commission to create a variable called *sanctioned cartels* (the number of sanctioned cartels by month), which will control for the potential destabilizing effect of the European

[7] The time series of business evolution and price expectations starts in January 1985, while the series of production index at European level starts in January 1991. This is the reason why our pre-leniency sample only goes back only until January 1991.

Commission cartel law enforcement on existing cartels, and its deterrent effect on cartels that would not have formed yet.

We restrict the empirical analysis to the manufacturing industry sector (sector C in NACE Rev.2 classification) because it is the only sector for which we have information for all the independent variables, i.e., business evolution, price expectations and the production index. Although we are not able to exploit the fact that more and different industries different from manufacturing are cartelized due to the unavailability of data of either the business surveys or economic data, we do not consider this to be a major problem for two reasons.

First, 96 out of the 121 cartel cases sanctioned between 1976 and 2014 by the European Commission that we use to construct our dataset belong to the manufacturing sector (79%)[8]. As shown in table 2, 71 out of 98 cartels sanctioned between 1991 and 2012, the whole time period pre- and post-leniency program used below in our estimates, belong to the manufacturing sector (72%). And also, 67 out of 85 cartels sanctioned in the post-leniency program period from 1997 to 2012 belong to the manufacturing industry (79%).

In addition, 48 out of the 96 cartel cases in the manufacturing sector have been discovered under the Leniency Program (50%),[9] which means that the firms cooperate with the European Commission and therefore, the date of formation reflects on average more closely the start of the collusive agreement.[10]

On the other hand, if we look at the EU-27's non-financial business economy at the NACE section level, the manufacturing sector is summing up a wide variety of activities. Additionally, around 10% of all enterprises belong to the manufacturing industry. Moreover, within the EU-27's non-financial business economy, in 2012, the manufacturing was the second largest in terms of its contribution to employment (22.6%) and the largest contributor to value added (26.8%).[11] Given the importance of the manufacturing sector in

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[8] Sorting the sectors by number of cases discovered, the Manufacturing Sector is followed by the Transportation and Storage Sector, which has 12 cases.

[9] In 54 out of 121 cartel cases considered (44.63%), the European Commission's investigation was initiated following applications for leniency.

[10] Actually, 15 out of the 19 cases for which we analyze cartel formation and 45 out of the 50 cartels for which we study the breakup in the period 1997-2012 were discovered under the leniency program (78.95% of the formed ones and 90% of the broken ones).

[11] Source: Eurostat

the EU, it is relevant to focus in this industry. Moreover, as Levenstein and Suslow (2014) state, there are some industries that seem particularly prone to collusion activity. Specifically they cited those characterized by high fixed costs as in manufacturing sector.

Table 2: Summary of cartel cases sanctioned by the European Commission (1991-1996 & 1997-2012) (% of cartel cases belonging to the manufacturing sector)

	All Sectors		Manufacturing Sector	
	1991-1996	**1997-2012**	**1991-1996**	**1997-2012**
Cartel sanctioned	13	85	4 (30.77%)	67 (78.82%)
Cartel set up	33	29	25 (75.76%)	19 (65.52%)
Cartel break up	21	80	12 (57.14%)	62 (77.5%)
Cartel break up (internal reasons): A+B. A+a+b	7	59	5 (71.43%)	50 (84.75%)
A. Breakup before opening investigation (no leniency)	4	8	2 (50%)	5 (83.33%)
B. Investigation started by leniency program	3	51	3 (100%)	45 (88.24%)
a. Breakup after leniency application	0	19	0	15 (78.95%)
b. Breakup before leniency application	3	32	3 (100%)	30 (93.75%)

Source: Own elaboration

As table 2 shows, 50 out of 67 cartels of the manufacturing industry sanctioned by the EC after 1997 broke up due to internal reasons, not as a result of a targeted investigation initiated by the Commission on its own initiative or following a complaint. 45 out of those 50 were initially investigated using the leniency program, so the leniency application of one cartelist enabled the Commission to initiate an investigation: 30 of them broke apart before the leniency application, while 15 of them broke apart after the leniency application. The other 5 out of 50 broke apart before the Commission started the investigation by its own initiative or third party complaint, not using the leniency program. Finally, only 19 (discovered) cartels were started up after January 1997. Table 2 also shows that most of the cartels sanctioned belongs to the manufacturing industry, particularly in the 1997 to 2012 period.

The variables we are going to model are denoted as *formed cartels* and *broken cartels*. The former tells us the number of (discovered) cartels that were formed each month of the database in the manufacturing sector. The latter is the number of (discovered) cartels in the

manufacturing sector that were broken due to internal reasons each month of the period studied.[12]

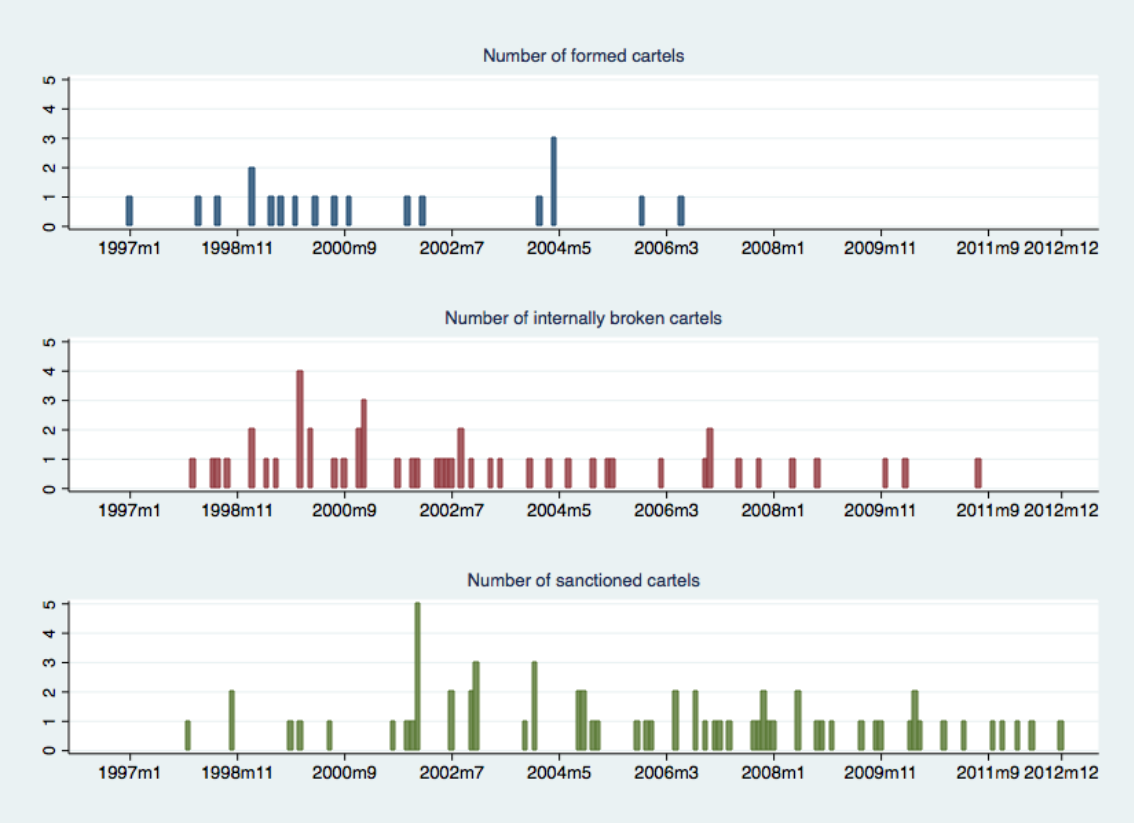
As summarized in Table 3, the variable regarding monthly cartel formation takes value from 0 to 3, while the one of monthly cartel breakup takes value from 0 to 4. The variable *sanctioned cartels*[13] takes value from 0 to 6, which means that up to 6 cartels were sanctioned the same month by the Commission.

Figure 1 depicts all three variables over time. As we focus in the cartels sanctioned between January 1997 and December 2012 that at the same time were formed in that time span, the figure shows that cartels sanctioned were mostly set up at the first half of the period under study. By contrast, the figure shows that cartels sanctioned break up all along the period under study, since many of them were formed before 1997. The cartels sanctioned during the period of study refer to cartels born before or after 1997 in any sector, although the cartels sanctioned in Figure 1 refer only to the manufacturing sector.

[12] As explained before, we include all the cartels that collapsed due to internal causes: they had broken up before they were discovered by the Commission or a third party, and also those that broke because one of the members applied for leniency. In the latter case, we use the date of the application as breakup date if application occurred before the collusive agreement completely collapsed as leniency application are noticed and the data shows that it does not take long to completely collapse.

[13] This variable includes the cartels sanctioned by the European Commission every month in all sectors, since the discovery of a relevant cartel in another sector could increase the deterrent effect of the Commission in any unrelated sector. Results are robust to considering only the cartel cases sanctioned in the manufacturing sector.

Figure 1: Number of monthly formed, sanctioned and broken by internal reasons cartels in the manufacturing sector (1997-2012)



Source: Own elaboration

As noted above, we introduce a novel approach with regard to the related literature by taking into account business managers' expectations. The variables *business evolution* and *price expectations* were obtained from the Business and Consumer Surveys, which is a harmonized survey managed by the Directorate-General for Economic and Financial Affairs of the European Commission.[14] The data consists of monthly time series according to the Classification of economic activities in the European Community (NACE) at the two digits level, so it is disaggregated by sector and subsector.

According to Taylor and McNabb (2007), the business confidence indicator is pro-cyclical and it can generally predict movements in GDP over the business cycle and downturns.

Since the process of forming a cartel takes some time, we are glad to use the survey variable on *price expectations* instead of the current price as the decision of engaging in cartels

[14] The Joint Harmonised EU Programme of Business and Consumer Surveys, *User Guide*, 2007. Source: http://ec.europa.eu/economy_finance/db_indicators/surveys/index_en.htm

today could be more affected by price expectations in the future than by current price levels.

Both variables are indices, and they correspond respectively to the questions "*how has your production developed over the past 3 months?*" and "*how do you expect your selling price to change over the next 3 months?*" The surveys are conducted at firm level, and then the data is classified and aggregated by stratum (i.e., by sector) and countries, using adequate weights. The geographical coverage of the surveys includes all Member States as well as the candidate countries, although we do only use Member States results. The harmonized surveys are carried out at national level by national institutes and offices. The sample size for each survey varies across countries according to the heterogeneity of their economies and their population size. The sample of the industry survey includes more than 38,000 units that are surveyed every month, in the first two-three weeks of each month. The industry survey is largely qualitative.

The survey questions of interest for our study admit three possible responses: increase, remain unchanged and decrease. Answers obtained from the surveys are aggregated in the form of balances, which are constructed as the difference in the percentage of positive and negative answers. The information provided allows the use of a range of variables to monitor cyclical dynamics.

We have used non-seasonally adjusted data for *business evolution* and *price expectations*, and data adjusted by working days in the case of *production EU*. The variable *production EU* has been obtained from Eurostat. The time series corresponds to monthly data of the volume index of production in industry (manufacturing sector), at European level (EU18) and where 2010=100. The variable *high production growth* takes value 1 if the growth rate of the production index is above the average yearly growth rate. The descriptive statistics of these variables are shown in Table 3.

Table 3: Summary statistics (1997-2012)

Variable	N	Mean	Std. Dev.	Min	Max
Formed Cartels	192	0.099	0.363	0	3
Broken Cartels due to Internal Reasons	192	0.260	0.583	0	4
Business Evolution	192	0.312	12.013	-49	19
Price Expectations	192	4.562	7.917	-14	23
Active Cartels	192	16.885	14.745	0	44
Sanctioned Cartels	192	0.443	0.817	0	6
High Production Growth	192	0.471	0.500	0	1
Production EU	192	101.181	10.381	68.1	123.2

Source: own elaboration

Finally, we computed the variable *active cartels* as the stock number of detected and sanctioned cartels that were alive in each month given their respective startup and breakup date to control for the level of finally discovered and sanctioned colluding activity across time.

4. Empirical strategy

The purpose of this paper is to study the drivers of cartel formation and breakup. We analyze which is the role of managers' perception about the evolution of their business and expectations they have regarding the selling price, and also the effect of the industry production on the dependent variables of interest. Our empirical strategy uses Poisson model estimations. This type of model is used when the dependent variable is a count variable, as it is in our case. It means that the variable to be explained takes on nonnegative integer values; so even the value zero has positive probability of occurrence in both cases (formed and broken cartels).

The basic Poisson model assumes that y given x has a Poisson distribution, and the density of y given x is completely determined by the conditional mean. That is: $f(y|x) = \exp[-m(x)][m(x)]^{y}/y!$, where $m(x) \equiv E(y|x)$. Given a parametric model for the conditional mean and a random sample, the parameters of interest are obtained by Maximum Likelihood Estimation. The log-likelihood for observation *i* is: $\ell_i(b) = y_i \exp(x_i b) - \exp(x_i b)$.

Another assumption imposed by Poisson distribution is that the conditional variance is equal to the conditional mean. However, since this assumption it not usually satisfied in the data, there are alternative characterizations of the model such as the Negative Binomial Regression, which is estimated by Maximum Likelihood Estimation. It is used when there

is over-dispersion. We have tested whether this is the case in our data, but the test concludes that there is no over-dispersion,[15] so we can estimate a Poisson regression. Nevertheless, even if it was the case, according to Cameron and Trivedi (2009) the Poisson panel estimators rely on weaker distributional assumptions than the negative binomial model, so that it would be more robust to use the Poisson panel estimators with cluster-robust standard errors to resolve the usual over dispersion.

We should also note that working with information regarding cartels means that we can only know characteristics of the uncovered cartels. Therefore, if the variables *formed* or *broken cartels* take the value of zero it could be because no cartel was formed or broken that specific month or because it was formed or broken but it hasn't been discovered. Unfortunately, we cannot distinguish between these two types of selection, as it is also the case in the Zero Inflated Poisson (ZIP) regression. However, this model tries to capture which are the relevant variables that cause the count to be zero. Therefore, we have also worked with this alternative model specification, but results are not shown in the paper since Voung (1989) test[16] of ZIP vs Poisson does not favor the former model.

Summing up, the equation of the full model estimated in order to estimate the relationship between formed cartels and expectations is the following one[17]:

$$\begin{aligned}\log\left(E\left(formed\_cartels_t \mid x\right)\right) = {} & b_0 + b_1 business\_evolution_t + b_2 price\_expectations_t \\ & + b_3 sanctioned\_cartels_t + b_4 formed\_cartels_{t-1} \\ & + b_5 high\_production\_growth_t + b_6 production\_EU_t\end{aligned} \qquad [1]$$

where x denotes the vector of independent variables. We estimate different specifications of the model by introducing gradually some variables. We consider the simplest baseline estimation.

Regarding the estimation of the equation to explain why cartels break internally, the empirical strategy is the same than in equation [1], but substituting the variable of formed

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[15] We test $H_0 : a = 0$ in $\text{var}\left(y \mid x\right) = m(x) + a m(x)^2$.

[16] It tests the null hypothesis that the two models fit the data equally well.

[17] The error term does not appear in equation [1] because the model is expressed in terms of the conditional expectation.

cartels by broken cartels as dependent variable, and the lag of formed cartels by the lag of active cartels as regressor.

$$\log\left(E\left(broken\_cartels_t|x\right)\right) = b_0 + b_1 business\_evolution_t + b_2 price\_expectations_t + b_3 sanctioned\_cartels_t + b_4 active\_cartels_{t-1} + b_5 high\_production\_growth_t + b_6 production\_EU_t \quad [2]$$

As previously mentioned, we will gradually introduce covariates in both estimations in order to control for different effects by groups of exogenous variables. Results are included in the following section.

5. Results

The results of the Poisson regression model for equation [1] are shown in Table 4. As stated above, we have considered alternative specifications of the model. The results shown in the table are the point estimates of the beta coefficients.[18]

Table 4: Poisson estimation results. Formed cartels (1997-2012)

	(1)	(2)	(3)	(4)	(5)
Business Evolution	0.060**	0.053**	0.058**	0.061**	0.067**
	(0.028)	(0.027)	(0.026)	(0.029)	(0.030)
Price Expectations	-0.072**	-0.064**	-0.068**	-0.084***	-0.089***
	(0.031)	(0.032)	(0.031)	(0.029)	(0.028)
Sanctioned Cartels		-1.064*	-1.089*	-1.082*	-1.110*
		(0.583)	(0.582)	(0.592)	(0.591)
Formed Cartels (-1)			-14.486***		-15.514***
			(0.421)		(0.461)
High Production Growth				-0.312	-0.370
				(0.605)	(0.625)
Production EU	-0.017	-0.008	-0.012	0.008	0.004
	(0.020)	(0.020)	(0.020)	(0.024)	(0.025)
Constant	-0.417	-1.132	-0.534	-2.568	-2.062
	(1.992)	(1.978)	(1.991)	(2.352)	(2.436)
Observations	192	192	192	191	191
Pseudo-R^2	0.038	0.070	0.106	0.079	0.115
Chi^2	11.495	12.701	1261.457	17.360	1350.645
p-value	0.009	0.013	0.000	0.004	0.000

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance test. Robust standard errors within brackets.

[18] They tell us that one unit increase in the independent variable will increase the average number of the dependent variable by β percent.

First of all, we can observe how regardless of the model specification the managers' perceptions of the evolution of the firm's business in the last 3 months affects positively and significantly the number of cartels formed. An increase of the *business evolution* index in one unit will increase the average number of formed cartels by around 5.3-6.7%. This suggests that cartel formation is strongly pro-cyclical with respect to firm growth: the likelihood of cartel set up is related to firm growth in the near past.

Secondly, the higher the prices are expected to be at the beginning of the month for the next three months, the lower the number of cartels formed that month. The effect of an increase of one unit in price expectations is that the formation of cartels is reduced between 6.4% and 8.9%. On the other way round, collusion is more likely when firms expect a decline in prices in the near future: collusion is more likely with expected declining pricing.

It is also remarkable that the number of total sanctioned cartels (in the manufacturing and the other industries) in the same period influences negatively cartels formation. Since the decision of the European Commission is public, seeing that more cartels are being sanctioned seems to be an effective deterrent because it could increase the perceived probability of being caught.

Moreover, the number of cartels formed in the previous period also affects negatively the number of cartels formed. This can be explained by the fact that, if the sector is already highly cartelized, there are fewer incentives to collude, since the outsiders can free ride from higher selling prices and less competition in the market. An alternative explanation could be that firms prefer to join existing cartels rather than forming new ones.

Finally, we cannot draw any conclusion regarding the effect of the industry real production index at the EU level, nor from the dummy variable considering high production growth in the sector on cartel setting up. It seems that cartel startup is more related to firms-specific perceived business cycles rather than industry-wide real production cycles.

In our results for the post-leniency period, the *business evolution* has a positive effect on cartel set up. Moreover, if firms' managers expect that prices will increase in the current and next two months, then fewer cartels are formed. Therefore, in this baseline model, what matters for cartel formation is the perception that businessmen have about the

evolution of their own production and the prices at which they expect to be selling their products in the market the following months.

Empirical results regarding cartel set up appear to show that collusion is pro-cyclical, these results are robust to the ones obtained in the strand of the theoretical literature started by the seminal paper of Haltiwanger and Harrington (1991) who showed that it is easier to collude during booms and more difficult to collude during recessions, as also in the paper by Bagwell and Staiger (1997), and in the case of non-binding capacity constraints studied by Fabra (2006).

Table 5 presents the results of the estimations of equation [2] concerning the explanatory variables of the breakup of cartels.

Table 5: Poisson estimation results. Internally broken cartels (1997-2012).

	(1)	(2)	(3)	(4)	(5)
Business Evolution	0.019	0.019	-0.015	0.020	-0.017
	(0.014)	(0.014)	(0.022)	(0.014)	(0.022)
Price Expectations	-0.013	-0.013	0.030	-0.016	0.028
	(0.029)	(0.029)	(0.037)	(0.029)	(0.035)
Sanctioned Cartels		-0.055	0.003	-0.090	-0.039
		(0.244)	(0.201)	(0.247)	(0.199)
Active Cartels (-1)			0.041***		0.046***
			(0.015)		(0.015)
High Production Growth				-0.449	-0.621*
				(0.325)	(0.321)
Production EU	-0.002	-0.001	0.023	0.006	0.035**
	(0.015)	(0.016)	(0.016)	(0.017)	(0.017)
Constant	-1.081	-1.137	-4.615***	-1.669	-5.686***
	(1.550)	(1.614)	(1.786)	(1.640)	(1.814)
Observations	192	192	192	191	191
Pseudo-R^2	0.005	0.006	0.049	0.014	0.067
Chi^2	2.096	2.110	15.814	4.317	22.502
p-value	0.553	0.715	0.007	0.505	0.001

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance test. Robust standard errors within brackets.

Contrary to equation [1], the Poisson estimations of the relationship between managers' appraisal of past production and selling price expectations and the breakup of cartels by internal reasons yield several less conclusive results. The number of cartels broken does not appear to be related neither with the business evolution in the last three months, nor with the level of prices expected by firms' managers, nor with the number of sanctioned cartels in the same or the previous months. However, we will see later on that we can extract some conclusions regarding cartel breakup when we include lags of the independent variables in the specification of our model.

One of the conclusions that model 5 of Table 5 hints at is that the breakup of the cartel is more likely to occur the higher the real production of the industry is, although this effect is less severe when the production is growing at a high rate (the impact of EU production growth at the mean is equal to 3.54 that results from multiplying the estimated coefficient [0.035] times its sample average value [101.18], while at the high production growth months, this impact is reduced by the estimated coefficient [-0.621], and therefore, the impact of EU production growth is 16% lower at high production growth rate months). There is weak evidence in favor of counter-cyclical collusion: collusion is more difficult to sustain in demand booms, cartels are more likely to break down when the industry real production is high. This is more consistent with the seminal paper by Rotemberg and Saloner (1986) of unexpected demand booms breaking collusion, and the case of binding capacity constraints studied by Fabra (2006), where also demand booms break collusion.

Summing up, all these results combined tell us that there are asymmetries in the effect of economic cycles on cartel setup and breakup: if the firm is doing well in terms of their own production and the managers expect their selling price to decrease in the next periods, then firms will get involved in a cartel to get larger profits (pro-cyclical cartel setup). On the other hand, if the real industry production is high then it is more likely the collapse of the cartel (counter-cyclical cartel breakup). Booms bring about a turnover of new cartels forming and old cartels collapsing.

6. Robustness Checks

In this section, we carefully deepen the analysis of our time series and check whether our results are robust to different model specifications. We follow the procedures explained below both for cartel formation and cartel breakup. We will also double check to what extend the relationship between economic cycles and collusion has remained stable in the post-leniency period (1997-2012) with respect to the pre-leniency period (1991-1996) in the EU.

6.1. Autocorrelation and Endogeneity

First of all, we are interested in studying the existence of autocorrelation in the residuals of the models presented above. In order to do so, we start by performing the Durbin-Watson test in the estimation of the models shown in Table 3 and Table 4 by OLS. The reason why we use OLS is because the Durbin-Watson test assumes that the residuals are distributed according to a normal distribution in order to compute the critical values. Additionally, we

include in our tables of results the Durbin's alternative[19] test for autocorrelation. Even though in most of the cases there is no autocorrelation, we show the estimation of our model by GLS correcting for autocorrelation, to check that our results are robust and do not change.

Alternatively, we analyze the residuals of the Poisson estimations themselves to double check whether the results found are due to the use of OLS or if they are similar in the case of Poisson. Therefore, after estimating the model, we predict the residuals and then estimate an AR(1) process for the mentioned residuals. We will see that there is no problem of first-order autocorrelation neither in the case of cartel formation nor in the case of cartel breakup.

The second step we follow, in order to obtain more robust and reliable results, is to consider lagged variables in our specifications. There are two reasons why we proceed this way: first, in any market we do only observe quantity and prices in equilibrium, and they may depend on previous period's values; second, the market expansion in the sector may be endogenous to cartel existence and price evolution. Moreover, the study of the correlograms shows that the series are autocorrelated. Therefore, as robustness check we have estimated the models presented in Section 4 and 5 changing the number of lags of the covariates. We will see that results hold. It should be pointed out that we have studied the existence of autocorrelation in the residuals also in this case, but results are not shown due to space limitations since the problem of autocorrelation is not present.

Finally, we consider another potential problem as robustness check. There are grounds for the suspicion that the variable *price expectations* may present endogeneity problems, since the expectations expressed by the firm's manager may reflect the fact that the firm has recently decided to join a cartel (decision which may or may not be observed by the econometrician later on). Therefore, we instrument *price expectations* using covariates that could explain these expectations but that are exogenous to the cartel formation.[20] By using a model of Instrumental Variables, we manage to capture only the exogenous part of this variable, this is to say, to capture the underlying variance in price expectations independently from being

[19] We show the statistic Chi^2 and its p-value. Null hypothesis: no first-order autocorrelation.

[20] This idea has been obtained from Perdiguero (2010), although the procedure is slightly different in our case.

cartelized or not. As excluded instruments we use one lag of the dependent variable[21], the evolution of the price index in other sectors (Construction and Electricity, gas, steam and air conditioning supply) and time fixed effects. We conclude that results do not change when this model is used and according to the test of endogeneity, it is not necessary to treat the variable *price expectations* as endogenous.

6.1.1. Cartel Startup

As explained above, we start by showing the results of the OLS estimation in Table 6. Since our dependent variable takes positive integer values from 0 to 3, we are not interested in the interpretation of the coefficients. What we are interested in is the sign and the significance of the coefficients, which agree with the results shown in Table 4. Apart from obtaining that the Durbin-Watson test is close to 2 in all the specifications, the Durbin alternative also tells us that the residuals of the different specification are not first-order autocorrelated at a significance level of 10%.

Table 6: OLS estimation results. Formed cartels (1997-2012)

	(1)	(2)	(3)	(4)	(5)
Business Evolution	0.005**	0.005**	0.005**	0.005**	0.006**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Price Expectations	-0.006*	-0.006*	-0.007**	-0.007**	-0.008**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Sanctioned Cartels		-0.045**	-0.048**	-0.045**	-0.048**
		(0.018)	(0.019)	(0.020)	(0.020)
Formed Cartels (-1)			-0.107***		-0.102***
			(0.036)		(0.036)
High Production Growth				-0.024	-0.023
				(0.061)	(0.061)
Production EU	-0.002	-0.001	-0.001	0.000	0.000
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
Constant	0.298	0.254	0.294	0.112	0.153
	(0.236)	(0.233)	(0.235)	(0.237)	(0.238)
Observations	192	192	192	191	191
R^2	0.018	0.028	0.039	0.030	0.040
Durbin-Watson	2.151	2.143	1.941	2.165	1.972
Durbin Alternative Chi^2	1.599	1.458	1.379	1.271	0.654
Durbin Alternative p-value	0.206	0.227	0.240	0.260	0.419

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance test. Robust standard errors within brackets.

Even though there is no problem of existence of autocorrelation in the estimation of the OLS model, we estimate the Prais-Winsten and Cochrane-Orcutt regression which estimates the parameters in a linear regression model assuming that the errors follow a

[21] Results do not change if the lag of the instrumented variable is not used as instrument.

first-order autoregressive process in order to obtain more robust results. These results are shown in Table 7, and we can see that they are very similar to the ones obtained in the case of OLS.

Table 7: GLS (correcting for autocorrelation) estimation results. Formed cartels (1997-2012)

	(1)	(2)	(3)	(4)	(5)
Business Evolution	0.005**	0.005**	0.006**	0.005**	0.006**
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)
Price Expectations	-0.007**	-0.006**	-0.007**	-0.008***	-0.009**
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
Sanctioned Cartels		-0.042**	-0.053***	-0.042**	-0.054**
		(0.017)	(0.020)	(0.019)	(0.021)
Formed Cartels (-1)			-0.190***		-0.186***
			(0.033)		(0.033)
High Production Growth				-0.013	-0.034
				(0.060)	(0.060)
Production EU	-0.002	-0.001	-0.001	0.000	0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Constant	0.297	0.253	0.322	0.125	0.171
	(0.230)	(0.228)	(0.234)	(0.234)	(0.236)
Observations	192	192	192	191	191
R^2	0.021	0.030	0.061	0.032	0.063
Rho	-0.092	-0.088	0.091	-0.085	0.095
Durbin-Watson (transformed)	1.978	1.978	1.960	2.009	1.992
Durbin-Watson (original)	2.151	2.143	1.941	2.165	1.972

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance test. Robust standard errors within brackets.

Now we check whether the residuals of any specification follow a first-order autoregressive process when we work with the Poisson model. We compute the residuals from the models estimated in Table 4 and we estimate an AR(1) process for the residuals of each specification. Results are summarized in Table 8. We can conclude that the coefficient of the first lag is not significantly different from zero in any of the specifications, so we should not worry about the existence of first-order autocorrelation.

Table 8: OLS (of Poisson's residuals) Estimation Results. Formed cartels (1997-2012).

	(1)	(2)	(3)	(4)	(5)
Residual (-1)	-0.088				
	(0.072)				
Residual (-1)		-0.095			
		(0.072)			
Residual (-1)			0.003		
			(0.073)		
Residual (-1)				-0.084	
				(0.073)	
Residual (-1)					0.015
					(0.073)
Constant	-0.000	-0.000	-0.000	0.000	-0.000
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Observations	192	192	192	190	190
R^2	0.008	0.009	0.000	0.007	0.000

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance test. Robust standard errors within brackets.

Once we have made sure that the residuals are not autocorrelated, we estimate an alternative Poisson model in which we include lagged values of the independent and dependent variables. Results are shown in Table 9. First note that the conclusions obtained from Table 4 still hold: *business evolution* affects cartel formation positively and significantly and *price expectations* affect cartel formation negatively and significantly in some specifications. However, the effect of *price expectations* is picked up by the first lag of the variable. Also the fifth lag of the variable *business evolution* and the third lag of the variable *production EU* have a positive and significant effect on the dependent variable. These effects could be reflecting the fact that the process of making the decision of forming a cartel takes some time and it is related to lags of firm level business evolution and production at EU level.

Table 9: Poisson estimation results. Formed cartels (1997-2012).

	(1)	(2)	(3)	(4)	(5)
Business Evolution	0.279*** (0.075)	0.261*** (0.088)	0.243*** (0.090)	0.259*** (0.092)	0.231** (0.104)
Business Evolution (-1)	-0.231*** (0.069)	-0.183** (0.081)	-0.095 (0.099)	-0.179** (0.087)	-0.077 (0.113)
Business Evolution (-2)	-0.009 (0.125)	0.039 (0.130)	0.051 (0.117)	0.046 (0.141)	0.067 (0.138)
Business Evolution (-3)	0.066 (0.158)	0.009 (0.140)	-0.056 (0.147)	0.008 (0.142)	-0.061 (0.148)
Business Evolution (-4)	-0.111 (0.097)	-0.120 (0.123)	-0.103 (0.166)	-0.126 (0.119)	-0.119 (0.165)
Business Evolution (-5)	0.221*** (0.070)	0.309*** (0.104)	0.320** (0.131)	0.311*** (0.106)	0.328** (0.148)
Business Evolution (-6)	-0.009 (0.063)	-0.111 (0.125)	-0.113 (0.156)	-0.108 (0.124)	-0.111 (0.162)
Price Expectations	0.227* (0.133)	0.149 (0.138)	0.018 (0.195)	0.156 (0.132)	0.025 (0.187)
Price Expectations (-1)	-0.389* (0.215)	-0.315** (0.138)	-0.210 (0.205)	-0.324** (0.135)	-0.221 (0.199)
Price Expectations (-2)	-0.165 (0.222)	-0.096 (0.170)	-0.097 (0.211)	-0.086 (0.180)	-0.081 (0.229)
Price Expectations (-3)	0.169 (0.203)	0.091 (0.185)	0.033 (0.191)	0.070 (0.180)	-0.009 (0.187)
Price Expectations (-4)	0.350* (0.180)	0.235 (0.209)	0.196 (0.278)	0.247 (0.199)	0.221 (0.264)
Price Expectations (-5)	-0.313 (0.243)	-0.253 (0.248)	-0.214 (0.272)	-0.253 (0.246)	-0.215 (0.266)
Price Expectations (-6)	-0.185 (0.170)	-0.151 (0.217)	-0.182 (0.202)	-0.161 (0.214)	-0.200 (0.188)
Sanctioned Cartels		-2.580*** (0.968)	-2.951** (1.321)	-2.650*** (1.004)	-3.129* (1.640)
Sanctioned Cartels (-1)		0.578** (0.253)	0.490* (0.297)	0.587** (0.248)	0.505* (0.292)
Sanctioned Cartels (-2)		-0.109 (0.507)	0.182 (0.908)	-0.094 (0.507)	0.248 (0.942)
Sanctioned Cartels (-3)		-0.129 (0.691)	-0.078 (0.783)	-0.172 (0.671)	-0.217 (0.889)
Sanctioned Cartels (-4)		-0.017 (0.385)	-0.126 (0.411)	-0.032 (0.385)	-0.154 (0.410)
Sanctioned Cartels (-5)		-2.094* (1.191)	-2.301 (1.679)	-2.094* (1.205)	-2.301 (1.773)
Sanctioned Cartels (-6)		0.096 (0.473)	0.108 (0.636)	0.108 (0.475)	0.161 (0.636)
Formed Cartels (-1)			-14.505*** (1.755)		-14.877*** (2.011)
Formed Cartels (-2)			-0.707 (0.725)		-0.857 (0.851)
Formed Cartels (-3)			0.538 (0.401)		0.490 (0.390)
High Production Growth				-0.330 (1.053)	-0.628 (1.238)
Production EU	-0.037 (0.056)	-0.002 (0.043)	-0.006 (0.042)	0.009 (0.049)	0.015 (0.059)
Production EU (-1)	0.064* (0.038)	0.094 (0.078)	0.112 (0.127)	0.083 (0.072)	0.091 (0.110)
Production EU (-2)	-0.057* (0.031)	-0.111*** (0.036)	-0.117*** (0.041)	-0.119*** (0.044)	-0.134** (0.056)
Production EU (-3)	0.032 (0.046)	0.068* (0.039)	0.095** (0.040)	0.076 (0.050)	0.111* (0.066)
Production EU (-4)	0.130** (0.063)	0.088 (0.078)	0.083 (0.076)	0.088 (0.079)	0.079 (0.079)
Production EU (-5)	-0.054 (0.034)	-0.013 (0.078)	-0.005 (0.112)	-0.004 (0.072)	0.012 (0.098)
Production EU (-6)	-0.026 (0.045)	-0.005 (0.029)	0.014 (0.036)	-0.008 (0.031)	0.011 (0.036)
Constant	-8.186 (5.995)	-14.477*** (5.443)	-19.555*** (6.624)	-14.725*** (5.494)	-20.090*** (6.865)
Observations	186	186	186	186	186
Pseudo- R^2	0.362	0.463	0.484	0.464	0.485
Chi^2	172.706	145.043	1614.493	150.621	1584.195
p-value	0.000	0.000	0.000	0.000	0.000

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance test. Robust standard errors within brackets.

Finally, we analyze the results obtained from the IV estimation, which are summarized in Table 10. Note that the estimated coefficients are very close to the ones obtained when we estimated our model by OLS. The partial R^2 is high, which tells us that the additional instruments are highly correlated with the potentially endogenous variable after partialling out the effect of the other independent variables. Also the Shea's adjusted partial R^2 is high, which shows that the component of *price expectations* that is orthogonal to the other regressors can be explained by the component of the predicted value of *price expectations* that is orthogonal to the predicted values of the other regressors in the model. As hinted above, we are interested in analyzing whether the variable *price expectations* can be treated as exogenous, in which case the OLS estimation would be more efficient than the IV estimation. We test the null hypothesis, that the variable can be treated as exogenous, with Wooldridge's score test (Robust Score) and the regression-based test (Robust Regression). The difference between these tests is that the former assumes that the variables being tested are exogenous when estimating the error term's variance, while the latter assumes that the variables being tested are endogenous. According to the results of Table 10, the null hypothesis cannot be rejected.

Table 10: IV estimation results. Formed cartels (1997-2012)

	(1)	(2)	(3)	(4)	(5)
Business Evolution	0.005**	0.005**	0.005**	0.005**	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Price Expectations	-0.007**	-0.007**	-0.007**	-0.008**	-0.009***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Sanctioned Cartels		-0.045**	-0.048***	-0.045**	-0.048**
		(0.018)	(0.019)	(0.019)	(0.020)
Formed Cartels (-1)			-0.107***		-0.102***
			(0.035)		(0.035)
High Production Growth				-0.025	-0.023
				(0.059)	(0.059)
Production EU	-0.002	-0.001	-0.001	0.001	0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Constant	0.289	0.246	0.290	0.102	0.148
	(0.234)	(0.230)	(0.232)	(0.231)	(0.233)
Observations	192	192	192	191	191
R^2	0.018	0.028	0.039	0.030	0.040
Robust Score Chi^2	0.654	0.568	0.189	0.543	0.160
Robust Score p-value	0.419	0.451	0.664	0.461	0.689
Robust Regression F	0.646	0.555	0.183	0.528	0.154
Robust Regression p-value	0.423	0.457	0.670	0.468	0.696
Overident. Score Chi^2	19.509	19.876	20.410	18.744	19.269
Overident. Score p-value	1.000	1.000	1.000	1.000	1.000
Partial R^2	0.940	0.941	0.940	0.941	0.941
Shea's Adjusted Partial R^2	0.916	0.915	0.915	0.915	0.914

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance test. Robust standard errors within brackets.

6.1.2. Cartel Breakup

We follow the same procedure used for the robustness check of cartel formation for the case of cartel breakup. In Table 11 we can see the results of the OLS estimation. As in the case of cartel formation, the conclusions obtained from the Poisson model of cartel breakup summarized in Table 5 still hold. Also in this case, the Durbin alternative test of first-order autocorrelation of the residuals is not significant. When we estimate the model correcting for autocorrelation (Table 12) we obtain the same results.

Table 11: OLS estimation results. Internally broken cartels (1997-2012).

	(1)	(2)	(3)	(4)	(5)
Business Evolution	0.005	0.004	-0.003	0.005	-0.004
	(0.003)	(0.003)	(0.005)	(0.003)	(0.005)
Price Expectations	-0.003	-0.003	0.007	-0.004	0.007
	(0.007)	(0.007)	(0.010)	(0.007)	(0.010)
Sanctioned Cartels		-0.013	-0.005	-0.024	-0.018
		(0.055)	(0.050)	(0.054)	(0.048)
Active Cartels (-1)			0.010**		0.011***
			(0.004)		(0.004)
High Production Growth				-0.116	-0.163*
				(0.085)	(0.088)
Production EU	-0.001	-0.000	0.004	0.002	0.008**
	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)
Constant	0.329	0.316	-0.377	0.171	-0.658*
	(0.418)	(0.432)	(0.348)	(0.447)	(0.366)
Observations	192	192	192	191	191
R^2	0.005	0.005	0.049	0.014	0.067
Durbin-Watson	1.975	1.973	2.060	1.992	2.103
Durbin Alternative Chi^2	0.027	0.030	0.191	0.002	0.523
Durbin Alternative p-value	0.870	0.862	0.662	0.963	0.469

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance test. Robust standard errors within brackets.

Table 12: GLS (correcting for autocorrelation) estimation results. Internally broken cartels (1997-2012)

	(1)	(2)	(3)	(4)	(5)
Business Evolution	0.005	0.005	-0.003	0.005	-0.004
	(0.003)	(0.003)	(0.005)	(0.003)	(0.005)
Price Expectations	-0.003	-0.003	0.007	-0.004	0.007
	(0.007)	(0.007)	(0.009)	(0.007)	(0.009)
Sanctioned Cartels		-0.014	-0.004	-0.024	-0.019
		(0.054)	(0.050)	(0.054)	(0.049)
Active Cartels (-1)			0.010**		0.012***
			(0.004)		(0.004)
High Production Growth				-0.116	-0.172*
				(0.085)	(0.089)
Production EU	-0.000	-0.000	0.004	0.002	0.008**
	(0.004)	(0.004)	(0.003)	(0.005)	(0.004)
Constant	0.322	0.308	-0.378	0.169	-0.663*
	(0.419)	(0.433)	(0.343)	(0.448)	(0.360)
Observations	192	192	192	191	191
R^2	0.005	0.005	0.052	0.014	0.074
Rho	0.012	0.013	-0.032	0.003	-0.054
Durbin-Watson (transformed)	2.000	2.000	1.995	1.999	1.995
Durbin-Watson (original)	1.975	1.973	2.060	1.992	2.103

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance test. Robust standard errors within brackets.

After having checked the residuals obtained from the OLS estimation, we are interested in studying the potential existence of autocorrelation in the residuals obtained from the Poisson estimation too. The results of the AR(1) process estimation from the Poisson residuals of the model shown in Table 5, are summarized in Table 13. The coefficient of the first lag is not significant, and therefore, we should not worry about the existence of first-order autocorrelation.

Table 13: OLS (of Poisson's residuals) estimation results. Internally broken cartels (1997-2012).

	(1)	(2)	(3)	(4)	(5)
Residual (-1)	0.015				
	(0.073)				
Residual (-1)		0.015			
		(0.073)			
Residual (-1)			-0.019		
			(0.072)		
Residual (-1)				0.006	
				(0.073)	
Residual (-1)					-0.057
					(0.073)
Constant	0.000	0.000	-0.000	0.001	0.002
	(0.042)	(0.042)	(0.041)	(0.042)	(0.041)
Observations	192	192	192	190	190
R^2	0.000	0.000	0.000	0.000	0.003

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance test. Robust standard errors within brackets.

As explained above, we estimate the Poisson model including more lags of the independent variables to check the robustness of the results obtained in the baseline model. The model presented in Table 14 is slightly more informative than the baseline case considered in Table 5. The first lag of *business evolution* is negative and significant. This means that the evolution of the business in the previous 3 months affects negatively and significantly the number of cartels broken in a given month. In fact, broken cartels increase by around 14.9-23.1% if the *business evolution* index decreases by one unit. This is some weak evidence of pro-cyclical collusion with respect to cartel breakups when economic cycles are measured using firm-specific business evolution.

This result is in line with the one obtained in the case of cartel formation: when the production faced by an individual firm has evolved positively in the last months it is more likely to form a cartel, and if the firms are already in a cartel, then it is easier to sustain collusion since it is less likely that a cartel breaks up. The number of cartels broken does not appear to be related nor with level of prices expected by firms' managers nor with the number of sanctioned cartels in the same or the previous months.

Moreover, as shown before, the breakup of the cartel is more likely to occur the higher the production of the sector is, although this effect is reduced when the production is growing at a very high rate and also when we introduce the fourth and the sixth lags. This is like what was found previously, collusion seems to be counter-cyclical with respect to cartel breakups when economic cycles are measured using industry wide real EU production.

Table 14: Poisson estimation results. Internally broken cartels (1997-2012).

	(1)	(2)	(3)	(4)	(5)
Business Evolution	0.023 (0.044)	0.005 (0.044)	0.041 (0.053)	0.008 (0.038)	0.055 (0.052)
Business Evolution (-1)	-0.151*** (0.058)	-0.159*** (0.061)	-0.225*** (0.068)	-0.149** (0.060)	-0.231*** (0.073)
Business Evolution (-2)	0.021 (0.044)	0.056 (0.050)	0.036 (0.051)	0.066 (0.055)	0.044 (0.054)
Business Evolution (-3)	0.100* (0.051)	0.095* (0.051)	0.104** (0.049)	0.065 (0.052)	0.089* (0.049)
Business Evolution (-4)	0.055 (0.056)	0.076 (0.056)	0.121** (0.060)	0.066 (0.056)	0.113* (0.058)
Business Evolution (-5)	-0.008 (0.049)	0.003 (0.049)	-0.001 (0.051)	0.008 (0.051)	0.002 (0.052)
Business Evolution (-6)	-0.018 (0.035)	-0.039 (0.036)	-0.110** (0.048)	-0.021 (0.036)	-0.094* (0.049)
Price Expectations	-0.080 (0.070)	-0.100 (0.075)	-0.021 (0.086)	-0.119 (0.073)	-0.058 (0.084)
Price Expectations (-1)	0.054 (0.087)	0.068 (0.099)	-0.009 (0.105)	0.077 (0.098)	0.015 (0.100)
Price Expectations (-2)	-0.047 (0.093)	-0.027 (0.099)	-0.055 (0.097)	-0.003 (0.108)	-0.024 (0.108)
Price Expectations (-3)	0.242** (0.102)	0.210** (0.101)	0.282** (0.122)	0.185* (0.107)	0.239* (0.129)
Price Expectations (-4)	-0.085 (0.112)	-0.081 (0.109)	-0.121 (0.118)	-0.090 (0.114)	-0.133 (0.123)
Price Expectations (-5)	-0.193* (0.113)	-0.232** (0.111)	-0.196* (0.104)	-0.188 (0.116)	-0.138 (0.114)
Price Expectations (-6)	0.032 (0.076)	0.042 (0.068)	0.050 (0.071)	0.004 (0.067)	0.006 (0.074)
Sanctioned Cartels		-0.342 (0.356)	-0.395 (0.301)	-0.351 (0.346)	-0.403 (0.291)
Sanctioned Cartels (-1)		-0.502* (0.270)	-0.321 (0.228)	-0.556* (0.296)	-0.341 (0.239)
Sanctioned Cartels (-2)		-0.057 (0.184)	0.031 (0.171)	-0.079 (0.181)	-0.001 (0.170)
Sanctioned Cartels (-3)		0.028 (0.230)	0.119 (0.204)	0.112 (0.233)	0.199 (0.216)
Sanctioned Cartels (-4)		0.171 (0.152)	0.140 (0.135)	0.165 (0.156)	0.148 (0.147)
Sanctioned Cartels (-5)		0.104 (0.140)	0.224* (0.131)	0.185 (0.147)	0.321** (0.138)
Sanctioned Cartels (-6)		0.117 (0.141)	0.135 (0.142)	0.143 (0.138)	0.180 (0.143)
Active Cartels (-1)			-0.027 (0.211)		-0.026 (0.202)
Active Cartels (-2)			-0.047 (0.264)		-0.021 (0.265)
Active Cartels (-3)			0.159 (0.164)		0.134 (0.182)
High Production Growth				-1.184** (0.520)	-1.206** (0.557)
Production EU	0.063* (0.036)	0.061* (0.035)	0.074** (0.034)	0.094** (0.047)	0.104** (0.043)
Production EU (-1)	0.017 (0.022)	0.035 (0.026)	0.053** (0.025)	-0.001 (0.032)	0.021 (0.033)
Production EU (-2)	0.071*** (0.022)	0.097*** (0.031)	0.120*** (0.042)	0.090*** (0.032)	0.115*** (0.043)
Production EU (-3)	0.018 (0.017)	0.026 (0.019)	0.049** (0.025)	0.040** (0.019)	0.065*** (0.024)
Production EU (-4)	-0.071*** (0.026)	-0.071*** (0.024)	-0.068*** (0.022)	-0.070*** (0.026)	-0.066*** (0.024)
Production EU (-5)	-0.020 (0.026)	-0.028 (0.027)	0.005 (0.025)	-0.020 (0.026)	0.017 (0.024)
Production EU (-6)	-0.060*** (0.022)	-0.061*** (0.023)	-0.044* (0.026)	-0.079*** (0.028)	-0.062** (0.031)
Constant	-3.256 (3.944)	-7.146* (4.211)	-22.539*** (6.229)	-6.276 (4.383)	-22.574*** (6.516)
Observations	186	186	186	186	186
Pseudo-R^2	0.153	0.187	0.267	0.201	0.279
Chi^2	43.799	58.844	81.524	62.375	77.379
p-value	0.002	0.001	0.000	0.000	0.000

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance test. Robust standard errors within brackets.

Finally, we look at the results of the IV estimation. Also in this case both the partial R^2 and the Shea's adjusted partial R^2 are high. Still, our test of interest is the potential endogeneity of the variable *price expectations*. At the 10% level of significance we cannot reject the null

hypothesis of the variable being exogenous according to both the statistic of the Robust Score and the statistic of the Robust Regression.

Table 15: IV estimation results. Internally broken cartels (1997-2012).

	(1)	(2)	(3)	(4)	(5)
Business Evolution	0.004	0.004	-0.005	0.004	-0.006
	(0.003)	(0.003)	(0.005)	(0.003)	(0.005)
Price Expectations	-0.001	-0.001	0.010	-0.002	0.010
	(0.008)	(0.008)	(0.010)	(0.007)	(0.010)
Sanctioned Cartels		-0.014	-0.005	-0.024	-0.018
		(0.054)	(0.049)	(0.054)	(0.047)
Active Cartels (-1)			0.011**		0.012***
			(0.004)		(0.004)
High Production Growth				-0.114	-0.162*
				(0.084)	(0.086)
Production EU	-0.001	-0.001	0.004	0.001	0.008**
	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)
Constant	0.349	0.337	-0.395	0.193	-0.668*
	(0.417)	(0.430)	(0.345)	(0.444)	(0.361)
Observations	192	192	192	191	191
R^2	0.005	0.005	0.048	0.013	0.067
Robust Score Chi^2	1.195	1.374	2.561	0.815	1.942
Robust Score p-value	0.274	0.241	0.110	0.367	0.163
Robust Regression F	1.158	1.329	2.506	0.776	1.860
Robust Regression p-value	0.283	0.250	0.115	0.380	0.174
Overident. Score Chi^2	41.180	42.182	40.999	43.717	44.838
Overident. Score p-value	0.860	0.833	0.864	0.786	0.749
Partial R^2	0.940	0.941	0.929	0.941	0.930
Shea's Adjusted Partial R^2	0.916	0.915	0.898	0.915	0.898

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance test. Robust standard errors within brackets.

6.2. Pre-leniency program period

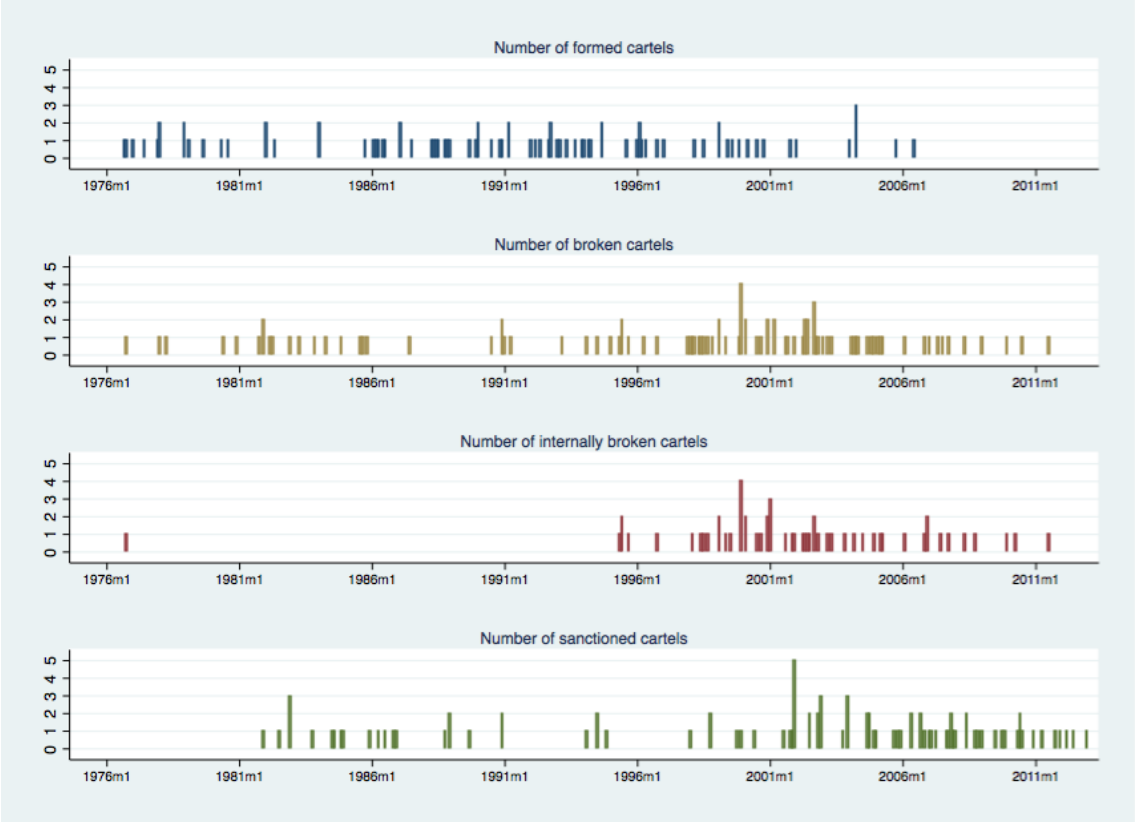
So far, we have only analyzed the cartel cases formed or broken in the manufacturing sector during the period January 1997 to December 2012. However, both the formation and breakup of these cartels have been affected by the existence of the leniency program, which was introduced in July 1996 in the European Union. This program could produce two opposite effects in the dynamics of cartels birth and death. On the one hand, the members of a discovered cartel case could benefit from a fine reduction under certain circumstances. Therefore, the ex-ante profits from collusion are higher than in the case in which the sanctioned firm has to pay the full fine, for a given probability of detection, which means that the likelihood of cartel formation increases. On the other hand, the incentives to deviate and break up the cartel are higher under the leniency program, since the first member revealing the existence of the illegal collusive agreement could get a higher or even a full fine reduction. Thus, we should see that the probability of breakup is higher.

Summing up, the introduction of the leniency program may have affected the way in which the independent variables affect our dependent variables of interest. For this reason, we focus in this section in the period from January 1991 to December 1996. Following the methodology explained in Section 4, we will study how do the business evolution, the price expectations, the sanctioned cartels and the production at the European level affect the formation and breakup of cartels during this period.

At Table 2, we can also see how the number of cartels formed in the period 1991-1996 (33 cartels) is higher than the number of cartels formed after 1997 (29 cartels), while the number of broken and internally broken cartels is significantly lower in the period 1991-1996 (21 and 7 respectively) than in the period 1997-2012 (80 and 59 respectively).

In Figure 2 we can observe the formation, breakup and sanction distribution of the discovered cartels over time the whole time period 1976 to 2012. The number of internally broken cartels explodes since 1997, and the number of sanctioned cartels clearly increases since 1997 onwards.

Figure 2: Number of monthly formed, broken, sanctioned and broken by internal reasons cartels in the manufacturing sector (1976-2012)



Source: Own elaboration

We estimate the same equations than before, now for the cartels startups and breakups between 1991 and 1996, in the pre-leniency period using the monthly data described in table 16.

Table 16: Summary statistics (1991-1996)

Variable	N	Mean	Std. Dev.	Min	Max
Formed Cartels	72	0.347	0.585	0	2
Broken Cartels due to Internal Reasons	72	0.069	0.306	0	2
Business Evolution	72	-4.194	10.954	-26	19
Price Expectations	72	8.389	8.187	-3	32
Active Cartels	72	37.681	4.776	29	43
Sanctioned Cartels	72	0.181	0.422	0	2
High Production Growth	71	0.465	0.502	0	1
Production EU	72	85.278	8.611	57.1	94.46

Source: own elaboration

In Table 17 and 18 we can see the results of the Poisson model estimation of cartel formation and breakup, respectively. Analogously, the OLS estimation results of our dependent variables of interest are presented in Table 19 and 20.

Again, for the period before the leniency program (1991-1996), we find that collusion seems to be pro-cyclical when looking at cartel setup, while collusion appears to be counter-cyclical when looking at cartel breakup. This is similar to the results obtained for the post-leniency program period 1997 to 2012.

However, in the pre-leniency period, the drivers of cartel setup and break up are different with respect to the post-leniency period. The driver of cartel setup in the pre-leniency period is the industry-wide production growth at the EU level (Table 17), while the drivers of cartel setup in the post-leniency period are the firm-level business evolution and price expectations (Table 4).

Table 17: Poisson estimation results. Formed cartels (1991-1996).

	(1)	(2)	(3)	(4)	(5)
Business Evolution	-0.016	-0.017	-0.018	-0.015	-0.015
	(0.025)	(0.025)	(0.025)	(0.020)	(0.020)
Price Expectations	-0.019	-0.016	-0.016	-0.006	-0.008
	(0.024)	(0.025)	(0.025)	(0.023)	(0.023)
Sanctioned Cartels		-0.837	-0.827	-0.551	-0.496
		(0.639)	(0.652)	(0.679)	(0.712)
Formed Cartels (-1)			-0.045		-0.148
			(0.328)		(0.347)
High Production Growth				1.094**	1.127***
				(0.429)	(0.427)
Production EU	0.020	0.023	0.023	-0.008	-0.008
	(0.027)	(0.026)	(0.027)	(0.026)	(0.027)
Constant	-2.677	-2.866	-2.899	-0.939	-0.975
	(2.404)	(2.320)	(2.363)	(2.257)	(2.269)

Observations	72	72	72	71	71
Pseudo-R2	0.018	0.034	0.034	0.081	0.082
Chi2	2.163	4.835	5.522	9.442	11.195
p-value	0.539	0.305	0.356	0.093	0.083

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance test. Robust standard errors within brackets.

The drivers of cartel breakup in the pre-leniency period seem to be mostly the business evolution and price expectations at the firm level (Table 18) and also somehow the EU industry real production growth, while in the post-leniency period it appears to be exclusively EU industry real production growth (Table 5). Note that this last statement should be considered carefully, given that the number of cartels broken due to internal reasons is very low during the period January 1991-December 1996.

Table 18: Poisson estimation results. Internally broken cartels (1991-1996).

	(1)	(2)	(3)	(4)	(5)
Business Evolution	0.425***	0.445***	0.580***	0.407***	0.557***
	(0.142)	(0.164)	(0.207)	(0.152)	(0.169)
Price Expectations	-0.262**	-0.270**	-0.349**	-0.253**	-0.345***
	(0.102)	(0.108)	(0.138)	(0.103)	(0.116)
Sanctioned Cartels		0.389	0.989	1.215*	2.081**
		(0.649)	(0.817)	(0.624)	(0.934)
Active Cartels (-1)			-0.328		-0.370*
			(0.220)		(0.191)
High Production Growth				1.208	1.532*
				(0.736)	(0.845)
Production EU	0.397**	0.391***	0.417***	0.411**	0.470**
	(0.159)	(0.152)	(0.148)	(0.173)	(0.189)
Constant	-38.772***	-38.413***	-27.639*	-41.156**	-32.049*
	(14.734)	(14.018)	(15.498)	(16.240)	(18.316)
Observations	72	72	72	71	71
Pseudo-R^2	0.454	0.457	0.472	0.466	0.486
Chi^2	16.812	17.456	24.946	18.554	40.519
p-value	0.001	0.002	0.000	0.002	0.000

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance test. Robust standard errors within brackets.

We double-checked as previously whether these results for the pre-leniency period were robust to the presence of auto-correlation or endogeneity of price expectations, and we found that they indeed are robust. Results from these robustness checks are available upon request from the authors.

7. Conclusions

In this paper we shed some light about the impact of economic cycles on cartel formation and cartel breaks up. Our results show that the average number of cartels formed increases when the firm-level perceived business has evolved positively in the last three months and managers expected in the previous period that their selling price would decrease in the next three months. Regarding the underlying reasons for cartels break up, the number of

ruptures increases when there is real industry production growth at the EU level. We also find some weak evidence that cartel breakups are also driven by past positive perceptions of firm-specific business evolution.

In conclusion, our results show that cartels are more likely to be formed in upturns, but also that cartels tend to breakup also in booms. Cartels are more prone to be created when managers consider that their firm production has evolved positively in the last three months (growing firms) and when they expect a decrease in prices in the near future (with expected declining prices). Cartels are more likely to collapse when firms face upturns in real demand at the EU level. Upturns in economic cycles appear to cause cartel turnovers: existing cartels collapse while new ones are set up.

Collusion appears to be pro-cyclical with respect to cartel creation when cycles are measured using firm-specific perceived business evolution (and also somehow with respect to cartel breakup when cycles are measured by such firm-specific booms), while collusion seems to be counter-cyclical with regard to cartel demise when cycles are measured by industry-wide EU production.

These results should be considered as a first approach to answer the question of interest as there is some scarcity of data and we are just relying on the time series of cartel startups, cartel breakups, cartels sanctioned and a set of business cycle variables. Ideally, the missing data problem should be overcome working with a panel data including more industries and territorial units.

New theoretical analysis should also be developed in line with the ones of Fabra (2006) as the results we have obtained are consistent with the result that collusion might be pro-cyclical when there is not capacity constraints, firms find it easier to collude during booms, while collusion is counter-cyclical when capacity constraints are sufficiently tight, firms find it more difficult to collude during booms. It might be the case that capacity constraints are on average not binding in industries still not colluding (before collusion), so demand booms are driving the startup of cartels. After having the cartels functioning, collusion might be the driver not only of price hikes but also of coordinated reductions in the colluding industries capacities. As capacity constraints get tight, collusion might become counter-cyclical, and cartels might finally breakup also during booms.

In addition, important further research would be the study, from a theoretical and empirical point of view, of the determinants and characteristics that make some cartels reach the screen of the Antitrust Authority while other don't. Finally, the impact of successive reforms of the Community leniency program in the dynamics merits some further research.

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