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THE DETERMINANTS OF CARTEL SUCCESS: AN EMPIRICALAPPROACH

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Abstract

The collusive agreements between firms have been on the focus of empirical research because of the effects they produce on the society. However, it is challenging to determine which factors contribute the success of these agreements. There still several disagreements among economists regarding what determines the cartel success. This difficulty is partially attributable to the dearth of accessible data and limited number of indicators reflecting cartel performance.

This bachelor's thesis utilizes the Private International Cartels database to study what determines the success of cartels. To answer this question, we assess the influence of macroeconomic variables on cartel duration and overcharge. The analysis indicates that cartels are more likely to success in periods of lower economic growth. In addition, higher market concentration is associated with lower duration.

Keywords

Abbreviations

AT   Austria
BE   Belgium
BG   Bulgaria
CY   Cyprus
CZ   Czech Republic
DE   Germany
DK   Denmark
EE   Estonia
ES   Spain
EU   European Union
FI   Finland
FR   France
GR   Greece
HU   Hungary
IE   Ireland
IT   Italy
LV   Latvia
NL   Netherlands
PL   Poland
PIC   Private international cartels
PT   Portugal
RO   Romania
SE   Sweden
SI   Slovenia
SK   Slovakia
UK   United Kingdom
GDP   Gross Domestic Product
HICP   Harmonised Index of Consumer Prices
CRN   Concentration ratio
OLS   Ordinary Least Squares
EC   European Commission
Gov   Government
Euribor   Euro Interbank Offered Rate

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1. Introduction

In an economy, competition is essential to ensure the proper functioning of the market. Competition is also a way of promoting economic growth. It increases productivity, encourages innovation, and provides consumers with lower prices and a wider selection of products. However, corporations are typically tempted to engage in collusive agreements.

Cartels are agreements or concerted practices between two or more competitors with the intention of coordinating their competitive behavior on the market and influencing the relevant parameters of competition. They affect competition through practices such as the fixing of purchase or selling prices or other trading conditions, the allocation of production or sales quotas, the sharing of markets including bid-rigging, restrictions of imports or exports, or anti-competitive actions against other competitors. They generate market inefficiencies in markets where competition would otherwise exist.

A survey carried out by the OCED found that that cartel markup varies widely between cases but can reach 50 percent or more[1]. This indicates that the annual amount of consumer harm caused by cartels is several billion dollars. Due to the negative consequences, they have on the market, these sorts of actions are outlawed.

2. Theories of collusion

It is crucial to understand how cartels function. Cartelists cooperate to jointly maximize profits and determine production in a given industry collectively. This group of firms behave like a single monopolist and as a consequence, they rise prices above marginal costs, to their profit maximizing levels, restricting output below the optimal quantities. After maximizing earnings cooperatively, they distribute gains among themselves. In the event that businesses' marginal costs differ, and one has a cost advantage, the firm with the lowest marginal cost will create more output in equilibrium under the cartel solution.

Consider the case of the profit-maximization issue involving collusion between two enterprises. If the two firms collude to jointly maximize profits with two outputs (y_1, y_2), and two marginal costs (c_1, c_2), their maximization problem of industry profits will be as follows:

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[1] The publication on "Fighting Hard Core Cartels – Harm, Effective Sanctions and Leniency (OECD, 2002)"

$$\max p(y1 + y2) \, [y1 \; + \; y2] \; - \; c1(y1) \; - \; c2(y2)$$

With the following optimality conditions:

$$p(y_1^* + y_2^*) + \frac{\Delta p}{\Delta Y} [y_1^* + y_2^*] = MC_1(y_1^*)$$

$$p(y_1^* + y_2^*) + \frac{\Delta p}{\Delta Y} [y_1^* + y_2^*] = MC_1(y_2^*)$$

Imagine firm 1 wants to increase the output of good y_1. It will have to take into consideration the fact of having extra profits from selling more output and the reduction in the profit from lowering the price due to the increase in demand. However, since they are jointly maximizing, firm 1 must consider not just the reduced price on its own output ($y1$) but also that of the output of the other firm ($y2$). Eckbo (1976) finds that "efficient" cartels tend to consist of firms with similar costs, while Griffin finds that cartels that are made up of a small number of similar sized firms are more able to raise price[2]. In addition, Griffin (Griffin 1989) finds that more centralized cartels are more effective at raising price[3].

As has been already stated, cartels produce the monopoly quantities, which are lower than those in a totally competitive market. This results in a decline in the general welfare of the society, as well as a loss of consumer surplus. In addition, corporations have lower incentive to innovate and there is a reduction in the competition (Baumol, 1992).

In light of these effects, governments implement antitrust policies to combat collusion. However, it is frequently challenging to uncover and investigate collusive agreements. In order to encourage collaboration, governments enact antitrust laws known as Leniency Program. Since 1996 the European Commission is responsible for enforcing them. It enables cartel members to self-report and provide proof of the collusion. This collaboration is crucial to the identification of collusive agreements. This justifies why they are rewarded by receiving immunity from fines or a reduction which the Commission would have otherwise imposed of them.

The reason behind this practice is that the general welfare of customers surpasses the fines that will be imposed on the cartel's participants. It is in the European Commission's best interest to guarantee that these practices do not occur, and not to raise money through fines. In order to qualify for any of the two listed benefits, the companies have to comply with some specific requirements.

For being eligible for immunity from fine, among other requirements, the company must

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[2] Eckbo, P. (1976) *The Future of the World Oil Market*. Cambridge, MA: Ballinger.
[3] Griffin, J. (1989). *Previous Cartel Experience: Any Lessons for OPE*C? in Lawrence Klein and Jaime Marquez, eds. Economics in Theory and Practice: An Eclectic Approach. Academic Publishers.

be the first submitting information and evidence from the collusive agreement and provide the Commission with all relevant information and documentation[4]. Participants that do not meet the conditions for being exempted from the fine, they can benefit from a reduction of fine. In addition, participants that apply for leniency after the investigation has already started, they could meet the requirements needed for a reduction of fine.

In addition to the Leniency Program, the European Commission also encourages individuals to report any inside information or suspicions concerning a cartel. They can do so anonymously and in complete confidence using a "whistleblower" tool[5]. The effect of these policies has been proved to be significant. However, Auber (2006) revealed that positive rewards provide stronger tools than leniency programs in preventing of cartels[6]. Large benefits make collusion no longer sustainable and increases the incentive to break down.

3. Game theory of cartels

The main problem of the stability of cartels is that there is always a temptation to cheat. Suppose that the two firms from the previous example jointly collude to maximize industry profits and decide to produce a given amount of output (y_1^*, y_2^*). If firm 1 believes that firm 2 will keep its output fixed to the agreed quantity, then firm 1 has an incentive to deviate from this agreed quantity and produce a little more output Δy_1. By doing so, the firm will be able to increase its own profits by unilaterally expanding its output and taking advantage of the higher price (Varian, 2014).

However, imagine the case that firm 1 believes that firm 2 will increase its output even more. In this particular case, firm 1 will have an incentive to increase its output first and make profits as soon as it can. Nevertheless, if all firms have an incentive to increase the output produced, they will produce the contrary effect. If the quantity supplied in the market increases, the price of the output decreases to the competitive level. This show that there is always an incentive to cheat in the agreement. Therefore, to guarantee the stability of the cartel, they try to find ways of stabilizing the behavior. Firms threaten to punish each other for cheating on the cartel agreement. A firm will continue in the collusive agreement only if

$$\pi break < Loss\ punishment$$

where $\pi break$, stands for the additional profits that the firm expects to make from

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[4] See https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52006XC1208%2804%29 for more information about the requirements

[5] See https://ec.europa.eu/competition-policy/cartels/whistle-blower_en for more information about the whistleblower tool

[6] Aubert, C., Rey, P., & E. Kovacic, W. (2006). *The impact of leniency and whistle-blowing programs on cartels.* International Journal of Industrial Organization.

cheating and increasing the quantity of output sold above the agreement or decreasing the price. *Loss punishment* refers to the loss of profits in future periods that the firm expects if it breaches[7].

4. The determinants of cartel success

The aim of this report is to analyze the determinants of cartel success. However, it is difficult to measure when a cartel is successful or not. According to Margaret C. (2002) cartels are clandestine, so it is usually difficult to have accurate data about them. There are unobservable variables that cannot be controlled. In addition, we must take into account that the databases of cartels available, have information from cartels that have been detected. Undoubtedly, there is lack of data about undetected cartels. This may produce a bias in our sample, since there may be common characteristics of those detected cartels that we are leaving out.

As a result, it is interesting to know what detected cartels can tell us about undetected cartels, and this would help to fully understand how they work (E. Harrington, 2015). This would contribute to get rid of possible unobservable characteristics. Because of the lack of accurate data and different measurements tools, databases are plagued with measurement error, unobservable variables and sample bias (C. Levenstein & Y.Suslow, 2002).

In this report the success of a cartel is going to be represented by with two different response variables: the duration and the overcharge of the cartel. The duration is easier to measure, since the ending and beginning dates are stated in the judge sentence. Nevertheless, one should be aware of the imperfect proxy of duration for analyzing cartel success (I. Pekarskiene 2015). It should be noted that the collusive agreement can continue after the investigation, therefore it is never known with exact accuracy. In our sample, this variable will be in months and will represent the duration stated by the European Commission investigation.

When it comes to cartel overcharge, Bolotova et al., (2007) suggest that the overcharge is a direct measure of cartel success. The European Commission concluded that 93% of all cartel cases lead to an overcharge[8]. Nevertheless, overcharge is difficult to calculate because of the difficult accessibility to cartel data. What is more, it is a challenge to calculate what it would have been the market price in case that the collusive agreement didn't take place. To facilitate the calculation of cartel overcharges, the EC created a

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[7] Ayres, I. (1987) *How Cartels Punish: A Structural Theory of Self-Enforcing Collusion.*

[8] European Commission (2021) Cartel Statistics. See https://ec.europa.eu/competition-policy/cartels/statistics_en

guide to quantify them[9].

Barriers to entry

Stigler (1964) argues that the main challenge to cartel success is the possibility of incumbent firms' cheating on the agreement. One of the main challenges for cartels is the possibility of entry of new firms. When cartel takes place, the market price increases above the perfectly competitive market price. This is translated into a potential incentive for new firms to enter the industry. By doing so, their profits will considerably increase in comparison with operating in the perfectly competitive market. By this way, they can benefit from the collusive agreement without participating on it (ACCC, 2019).

Economic fluctuations

One might wonder whether cartels are more likely to make the agreement during an economic expansion or whether they have higher duration during this period. We should take into consideration that this might change depending on the country. Each country has different macroeconomic conditions, the degree of openness, degree of competition policy implementation, and external factors such as endogenous organizational level or corporate management culture.

The economists (Connor, 2011; Levenstein & Suslow, 2006; Zimmerman & Connor, 2005; Marquez, 1994) found that there is a relationship between the cartel longevity and the structure of the market, the cartel's organizational structure, the specifics of the industry, macro-economic conditions, and the antitrust laws. Other studies found that there is a correlation between the overcharge, economic fluctuations, and the probability of breaking a cartel[10].

It is expected that in times of economic expansion cartels charge lower prices because they have higher probability of violating a cartel agreement in good economic time. When it comes to the correlation between cartel profitability and economic fluctuations, it is difficult to analyze it.

The fact that cartels information is not easily accessible, explains why this may be difficult in measuring. The research carried out by F. Long (2018) analyzes the particular case of Lithuanian cartels. It shows that there is an interdependence between the number of cartels and GDP. It concludes that Lithuanian cartels are more likely to take place

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[9] See https://ec.europa.eu/competition/antitrust/actionsdamages/passing_on_en.pdf

[10] London Economics (2011) pg 4 article 7331

during economic growth rather than when the economy shrinks.

Higher profits restrict access to the market. Y.Suslow (2012) confirms that cartels are more likely to form during periods of falling prices, and the formation occurs in response to increase the intensity of competition. Firms may be responding to falling prices, but prices were often falling because of events in a specific market.

Number of firms and industry concentration

We might expect to have high correlation between the market concentration and the number of cartels. The lower the market concentration, the more competition in the market and more incentives to create cartels as a response to this competition. However, J.Siegried (2020) showed very minor role for this economic determinant in antitrust decisions.

In addition, as stated in the Australian report (2019) we might also expect that the number of suppliers in the market plays an important role. The more firms that take part in a cartel, the more difficult might be for them to communicate with each other and attempt to establish a cartel. As a result, those industries specialized or capital intensive, are more likely to set up a cartel, since it is costly for new firms to enter. On the other hand, industries where new firms regularly enter the market, have less likelihood to be cartel members. They will need to be scared off for a cartel to maintain its control[11].

Macroeconomics variables

It is an undeniable fact that cartels are directly affected by macroeconomic variables as it has been already proof. Interest rate impacts cartel stability in a non-linear fashion (Lenhard, 2021). In fact, it takes the form of a U. When interest rates are low, corporations are more patient, and these strengths cartels. Nonetheless, when interest rates are low, corporations have more investment options, and this creates incentives to deviate from the collusive agreement.

On the other hand, when interest rates are high, firms lack the investments to capture a large market share. Therefore, cartel stability is weakened when interest rates are low. The first effect dominates for relatively low interest rates; otherwise, the second effect dominates[12]. For sufficiently large interest rates, the second effect is exhausted, and only the first remains. For reasonable interest rates, stability is U-shaped in the interest rate.

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[11] See *page 5 Section "Barriers to entry"* for more information
[12] Lenhard, S. (2021). Cartel Stability in Times of Low Interest Rates. Universität Bern

Another important macroeconomic variable is government expenditure. The government plays an important role when providing public goods. As the economy grows, the government needs to meet the growing demand and increase the government expenditure to increase the provision of public goods. As a result, during times of high government expenditure, a lot of public goods will be supplied. Then, we might expect that this will increase the incentives for collusion in specific sectors. For example, construction. Firms might be tempted to take part in a collusive agreement in order to overcome the extra supply by the government.

<u>Nature of demand and type of product</u>

The type of product has been proofed to play an important role in the stimulation of the formation of cartels (ACCC, 2019). If in a given industry the buyer has a lot of choices, it will be more difficult for suppliers to control the market. If a product is relatively generic, and demand is stable and predictable, it is easier for suppliers to attempt to share markets and fix prices. A volatile market is far harder for a cartel to control. Clearly, if buyers lack expertise in an area of procurement, it is easier for suppliers to fix higher prices. Therefore, high elasticity will reflect more competitive environment as consumers would easily change for other products. In this case, it will be difficult for firms to increase their market share in the collusive agreement (Varian, 2014).

5. Empirical analysis

The aim of this report is to analyze the determinants of cartel success. For this purpose, we use a pooled-cross sectional database with almost 14.000 observations. We will carry out a descriptive analysis to see how the variables interact between them and this will give us an insight on how we should carry out the regression analysis. For the regression analysis, we are going to use two samples of the database. One sample including cartels, and one sample including the firms that participated in those cartels. We will execute all OLS regressions with and without outliers to see how influential these points are on the sample[13]. A fixed-effect model for countries and sector will be estimated. Since these models are subject to different econometric problems and biases, we will carry out different analysis (robustness analysis) to check multicollinearity, autocorrelation and heteroskedasticity in the model. The goal of these analysis is to guarantee that our model is consistent and unbiased so that solid conclusions can be drawn from the analysis. Finally, a Kaplan-Meier survival analysis will be carried out to have a better understanding of the probability of survival of cartels before and after the implementation of the leniency program in the European Union.

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[13] R-Studio is used for the whole econometric analysis

5.3 Description of data

This thesis uses the database called "*The Private International Cartels (PIC) Data Set*" created by John M. Connor[14]. This database contains cartels notified since 1902 in the period 1990-2017. This database is public and is continuously updated by the author. This sample is accompanied by a guide that describes all the variables included in the database, provides a descriptive analysis, and details the strengths and limitations of the data. At the end, it provides a descriptive analysis and offers advice for further research.

The database consists of a sample with 13917 observations with cartels notified in the period 1902-2017. It includes all cartels notified since 1902 (1307); the number of companies that participated in each cartel (11526); and companies that participated on death cartels (1084). These last ones were cartels that initially were judged as cartels, but finally ended up being a monopoly or merger cases. The database includes 417 variables describing the cartels[15]. This sample is a pooled-cross section database. In this kind of data, we take random samples in different time periods of different units. Therefore, each sample will be populated by different individuals. Each id appears one time and not several times across time (otherwise, panel data). The sample contains cartels judged by 80 anti-trust authorities, from 25 countries.

5.4 Descriptive analysis

With the objective of having a first approximation of the determinants of cartels success, we are going to analyze the different variables graphically. In Figure 1, we can appreciate that in the first years of our sample, the annual rate of discoveries was lower than during the first years of the 21st century. There may be several reasons explaining this behavior. It may be because after the implementation of the leniency program in the European Union, there has been more cartels detected. In addition, it could be that nowadays, governments are more concerned with the overall welfare of the society, especially with consumer welfare. Therefore, one of the priorities of the governments is to ensure that competition is respected in the market.

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[14] John M. Connor (2020). Private International Cartels Full Data 2019 edition. (Version 2.0). Purdue University Research

[15] Some of the variables: Continent, leading jurisdiction, market, sector, cartel share, concentration ratio, leader (dummy), type of buyers, beginning and ending date, penalty, overcharge, duration (months), affected commerce, etc...
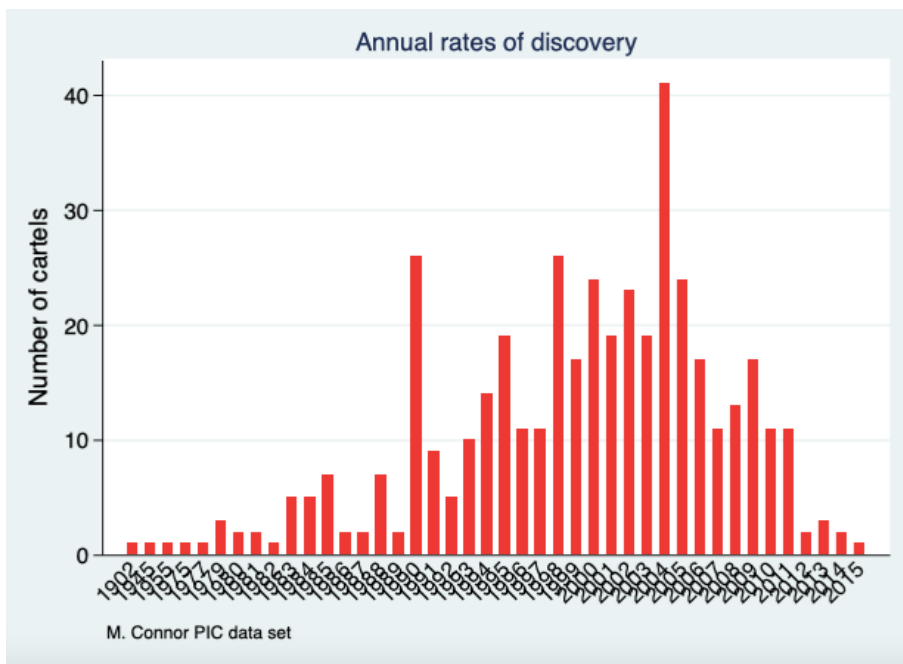
Figure 1: Annual rates of discovery

In Figure 2, we can clearly appreciate how after the implementation of the leniency program, there is a decreasing trend on the duration of cartels. The average duration of cartels is 85 months or 7 years and a half. There is a clear tendency of higher the duration in the past than nowadays.
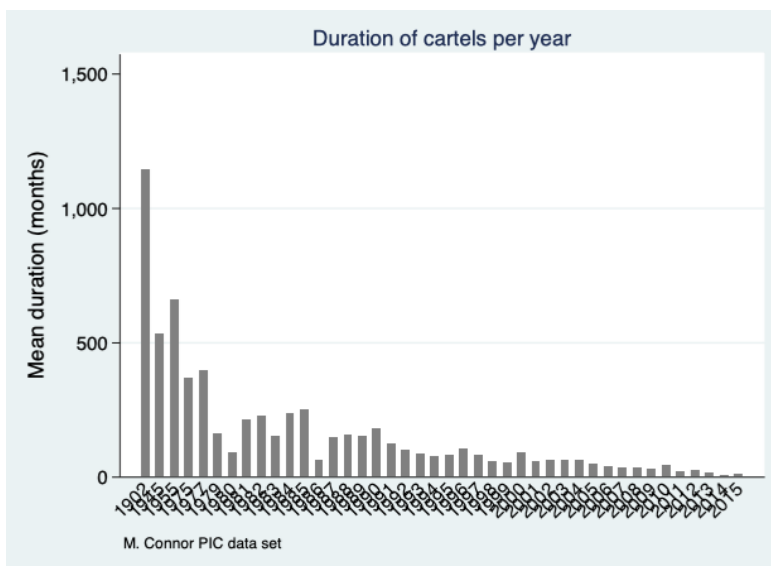

Figure 2: Duration of cartels per year

When it comes to cartel overcharges, the average overcharge is 16666 million of dollars. However, the overcharge doesn't follow any pattern overtime that could contribute to the analyze the determinant of cartel success.
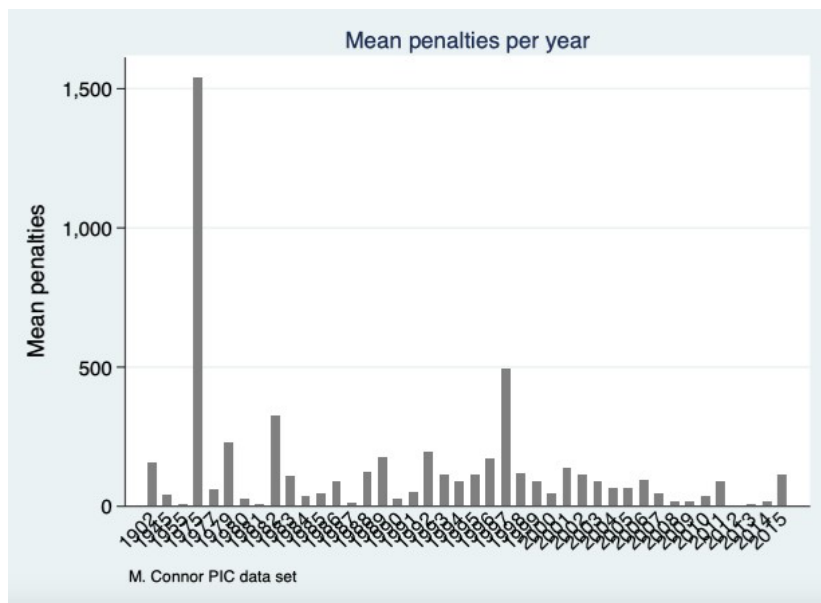
Figure 3: Mean penalties per year

Figure 4 describes the concentration ratio. We can see a slightly increasing trend in the last years of the sample. The average concentration ratio is around 0.2.
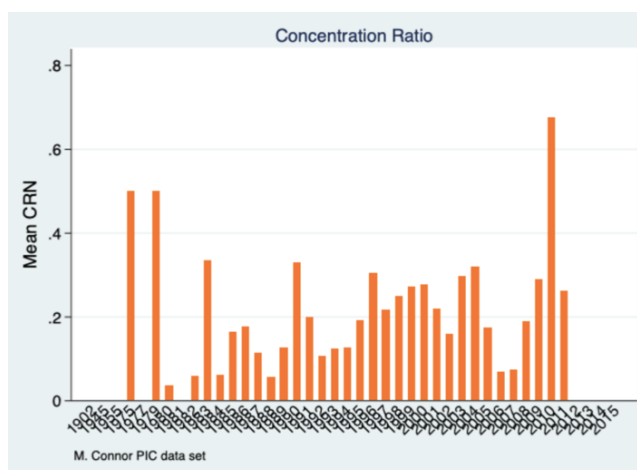
Figure 4: Concentration Ratio

5.5 Econometric analysis – The model

In order to carry out a proper regression analysis, it is necessary to clean the database in adequacy. For this purpose, we have used the software for data science called *Stata*. As mentioned before, the database includes death cartels and firms that are not of our interest

for the sample of cartels. Therefore, 12610 observations are deleted, and we have a sample of 1307 observations for cartels. As for the second sample, the one containing firms, we have a sample of 5309 observations.

In order to control for external factors affecting the macroeconomic market, the analysis is limited for the European Union common market. So, for the sample of cartels, we remove 6956 observations, and we are left with 565 cartels that took place in any country within the European Union. For the sample of firms, we delete 2482 observations. The PIC database doesn't include variables to analyze the macroeconomic factors affecting the cartel. With the aim of performing a more accurate analysis, external variables have been added to the data set. The value used in each variable is the average of the European Union taking into account United Kingdom since our sample is until 2017.

In this paper, we analyze the determinants of cartel success. As it has been already mentioned, our dependent variable "success" is going to be represented by two approaches. The first approach uses cartel duration as an indicator of cartel success. The second approach uses cartel overcharge.

As a result, we are going to carry out the models with the two data sets. Further, we are going to estimate two different fixed-effects regression models. The first one we are going to control for country and in the second one, for sectors. One country and one sector will be omitted and will be used as the reference. This kind of regression model will allow us to estimate effects for those variables that change across these observations. This fixed-effects specification absorbs factors in a particular country, at a particular time. The inclusion of these fixed effects allows to analyze within-country variation.

The model is estimated as follows;

$$Y_i = \alpha + X_i\beta + \epsilon_i$$

Where Y_i is the dependent variable (duration or overcharge), X_i is the vector of independent variables, β is the vector of parameters, and ϵ_i captures the error term. There are 11 independent variables included in the models[16]. Please note that not all independent variables are included in all models.

5.4 Kaplan-Meier survival analysis

Rey, P. (2006) concluded that the impact of the leniency program in the deterrence of cartels is effective. PIC database will be used to test whether this assumption holds or not.

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[16] See Appendix Table with summary statistics of the independent variables

For this purpose, a Kaplan-Meier survival analysis is performed. The Kaplan- Meier Product-Limit is often used to visualize the survival function. It shows the ordered time points at which some event happens. The aim of this analysis is to show that the probability of survival of a cartel before the implementation of the Leniency Program (1996) is higher than the probability of survival after the implementation of the Leniency Program. Thus, we need a censor variable that will define whether the cartel survived or not. It should be noted that all cartels are death in the sense that they have been notified. Therefore, the censor should equal 1 for all cartels, but this won't allow for a survival analysis.

In order to solve this problem, it has been assumed that, if the cartel started before 1996:

- Censor = 0 → if cartel notified before the Leniency Program

- Censor = 1 → if cartel notified after the Leniency Program

The problem arises with those cartels created after the threshold of 1996, since there is any benchmark to create the censor. As a result, the mean duration of cartels before and after 1996 has been analyze. After the threshold, the mean duration of cartels was 4 years, while before it was 12 years. This will serve as a cutoff value. Therefore, the censor variable for cartels after 1996 will be as follows:

- Censor = 0 → if cartel have a duration lower than 4 years

- Censor = 1 → if cartel have a duration higher than 4 years

Figure 5, represents the Kaplan-Meier survival function before and after the implementation of the leniency program. The lines represent survival duration for the interval. The shaded areas represent the associated confidence bands. It can clearly be appreciated that the probability of survival of a cartel before 1996 (red line) is considerably higher than after the program (blue line).
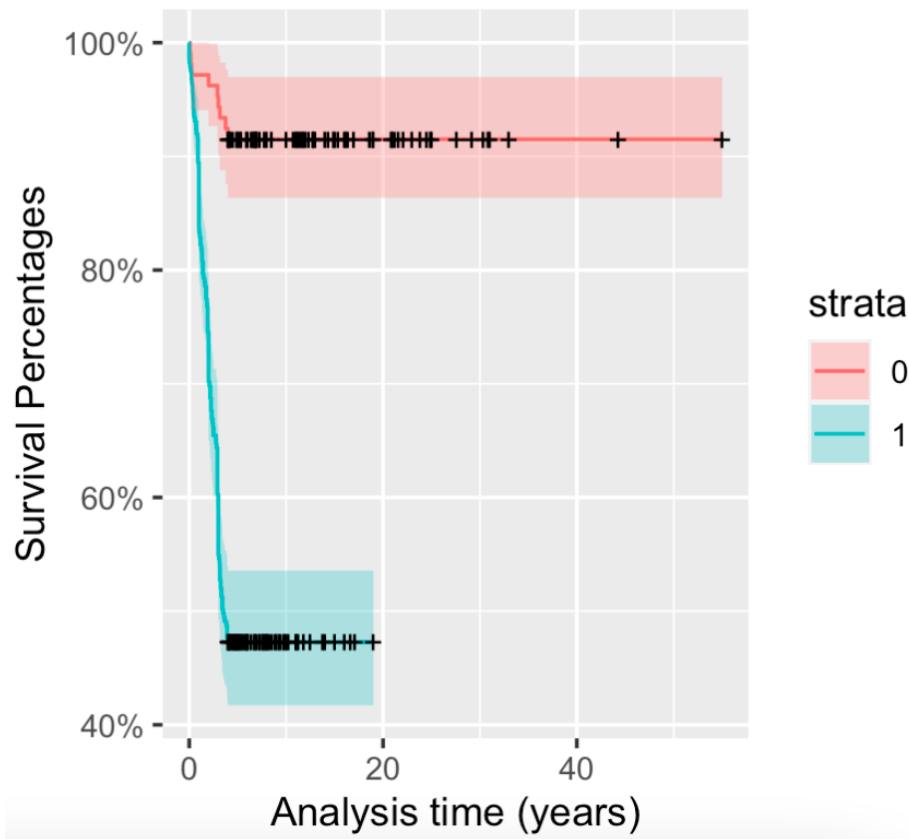
Figure 5: Kaplan-Meier Survival Analysis

The survival probability at 4 years were about 80% after the implementation of the leniency program, and 97% before the program. The p-value<0.0001 of the analysis means that there is a statistically significant difference in time-to-even between the independent groups. Approximately, 47% of cartels will survive more than 6 years after the leniency program, while before the program the probability was 97%. This shows that the implementation of the Leniency Program has played an important role. It may be other factors affecting this causality, but as has been already mentioned, these kinds of programs are effective for cartel deterrence.

6. Results and Discussion

The Appendix[17] shows the estimation results for the regressions with the two samples. There are 4 models, two simple OLS regression with two different indicators of cartel success: duration and cartel overcharge. In addition, there are two fixed-effects models one with country fixed effects and another one with sector fixed effects. Both fixed-effects models have duration as the dependent variable. The reason for not using fixed-effects model with overcharge as the dependent variable is that there are few observations with overcharge and the analysis is not significant. Thus, it is not a good proxy to

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[17] See Appendix page 24

determine cartel success with few observations out of a big sample. In model 1 we see that the adjusted R-square is 0.4064. This R-square is corrected for the number of independent variables included in the model. In this case, it means that 40% of the variability of cartel duration is explained by the fitting line of our model. There still a lot of variability in the model that can't be controlled. When it comes to the statistical significance of the independent variables, all of them are statistically significance at 5% of confidence level but government expenditure.

With the aim of increasing the percentage of variability of duration explained by our model, we analyze the model with country fixed effects (model 3). It can be seen that in this case, adjusted R-squared is 0.76, which is considerably higher than in the model without fixed effects. However, only two countries were statistically significant, and the difference between them is not significant to conclude that there may be external factors affecting the within-country variation. Apart from that, we see that in The Netherlands and United Kingdom, the effect on cartel duration is negative and significant.

It can be seen that in the model with country fixed effects (model 3) government expenditure is statistically significant and negative. An increase in government expenditure leads to a decrease in the duration of cartels. This contradicts our initial hypothesis that cartels might be tempted to participate in collusive agreements during the creation of more public goods.

As for affected commerce, in both models it positively influences the duration of cartels. Those cartels that have more market share and more affected commerce, might have more stability. When it comes to real GDP, it results on higher cartel duration. This supports previous research mentioned before. It indicates that cartels are more likely to form during periods of falling prices and more likely to break the agreement during periods of good economic conditions. When looking at the variable of buyers, we see that it is statistically significant but the difference between them is insignificant. This can't contribute to argue that having more or less buyers will affect the stability of cartels. When it comes to sector fixed effects (model 4), the adjusted R-squared increase up to 0.72. However, none of the sectors are statistically significant. Therefore, we can conclude that different sectors do not play an important role when explaining the variation of duration.

When we carry out the regression analysis with overcharge as the dependent variable (model 2), none of the independent variables are significant but Affected Commerce. We find that the correlation between both variables is high, and this might be one of the reasons explaining this significance. The Adjusted R-Squared is high 0.91. This model seems present some problems that bias our results and therefore is not appropriate for analyzing the cartel success. In addition, we have few observations with cartel overcharge, and this may partially explain the problem. What is more, we can see that the intercept is negative, and it doesn't make sense to have negative duration. This model will

not be considered for this analysis.

The same analysis is repeated for firms. The intuition is that the average duration of a firm in a cartel, the more successful the cartel is. In this case we find that the adjusted R-Squared of the simple regression is a bit higher (model 5). The independent variables mentioned before, have the same effect on duration in this sample. In addition, we find that big cartels have a positive impact on duration. This contradicts the hypothesis that bigger cartels might have difficulties when communicating between them. However, it has not been considered the inside organization that they might have. When it comes to market concentration (MKTCRn), it has a negative effect on cartel duration. Higher concentration seems to be related with lower duration. The lower the market concentration, the more competition in the market and more incentives to create cartels as a response to this competition. It can be seen that higher penalties (totsanc) are associated with higher duration. As expected, cartels with higher duration, will be charge higher sanctions. In the regression with country fixed effects, all countries are significant and have a negative impact on cartel duration. In addition, it can be seen that higher duration is associated with higher cartel overcharge. This might indicate that cartels that have higher duration, are better organized and can implement higher overcharge. With sector fixed effects, all sectors were insignificant on affecting the variability of cartel duration.

6.1 Limitations

There are some limitations of the study carried out. One of the main drawbacks of the database used, is that it lacks the necessary data to calculate the elasticity of demand. We will need excess profits or sales in order to calculate elasticity of demand. As it has been already mentioned, there are some limitations when using duration and overcharge as a proxy for cartel success[18]. What is more, J. Siegfried (1975) suggests that industry sales are the most important economic characteristic determining antitrust case bringing activities. However, the database used in this thesis do not include this data. Another point worth mentioning is the fact that undiscovered cartels are probably more durable than discovered cartels. Undiscovered cartels may have different economic characteristics than discovered cartels. In addition, we lack information about the inside organization of the cartel which is a very important determinant of cartel stability. As it has been already mentioned, the database contains few observations with overcharge and our analysis is very limited when using overcharge as the dependent variable.

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[18] See page 4

7. Conclusions

The antitrust activity has been on the edge of governments and researchers for the last century. The consequences that collusive agreements have on society, is one of the determinants for the increasing awareness of this kind of practices on governments and institutions. However, there is still discrepancies among economists of what factors determine cartel success.

This bachelor's thesis has studied the determinants of cartel success using a pooled cross-sectional database with almost 14.000 observations about cartels during 1902-2017. In order to represent the cartel success, this thesis uses two variables: cartel duration and overcharge. However, one should be aware of the limitations of both as a proxy for cartel success.

The thesis uses two different samples for the econometric analysis. One representing cartels and the other one with the firms involved in those cartels. A OLS regression was estimated for both samples with both dependent variables. What is more, with the aim of controlling within-country and within-sector variation, a fixed-effect regression was fitted for the dependent variable duration.

Although there still a lot of variation to be explained, the fitted models end up having considerably high adjusted R-squared values. In both samples, more cartel duration was associated with lower real GDP. This is consistent with previous research that confirms that there is higher probability of breaking the agreement in good economic conditions. It also confirmed that cartels are more likely to form during periods of falling prices, as a response to the increase of competition.

Also, the analysis confirmed that higher affected commerce positively contributed to higher cartel duration. This can be interpreted as a proxy of cartel stability, since the more affected commerce the more market share they may have, and the easier to avoid entry of new firms. What is more, the lower the market concentration, the more competition in the market and more incentives to create cartels as a response to this competition. Super cartels are also expected to have higher duration. This contradicts the hypothesis that bigger cartels have more difficulties to communicate between them that might affect their stability. Also, as expected, cartels with higher duration, will be charge higher sanctions. As for the fixed-effects models, the different sectors are not significant in explaining cartel success. When it comes for country fixed effects in cartel sample, only two countries were statistically significant, and the difference between them is not significant to conclude that there may be external factors affecting the within-country variation. In the firm's sample, it can be concluded that higher duration is associated with higher cartel overcharge.

In addition, with the Kaplan-Meier survival analysis it has been proved that the implementation of the Leniency Program has contributed positively to the deterrence of cartels. It indicates that the probability of cartel survival before the implementation of the leniency program was higher than after the implementation of the program.

However, as it has been already discussed, there are some limitations. One should be cautious when using duration and overcharge as a proxy for cartel success. Another important limitation of the analysis is the lack of data to calculate the elasticity of demand and cartel organization. In addition, we lack data regarding industry sales that have been proved to be an important determinant of cartel success (J. Siegfried, 1975).

Given these limitations, future empirical work should consider carrying out the analysis at a global level and not just limited to the European Union. In addition, it would be interesting to have a proxy of elasticity of demand given the important role that it plays determining cartel success. An analysis of the cartel organization should be considered in future research.

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9. Appendix

Table 1: Statics for Cartel Sample

Statistic	N	Mean	St. Dev.	Min	Max
Duration	401	85.354	97.891	0.032	1144
Cartel Overcharge	118	17087.01	119084.8	0	1260000
Super Cartel	505	-	-	0	1
Affected Commerce	359	79072.15	826905.7	0.084	1.53e+07
Penalty	364	16.188	158.7821	0	3012
Buyers	462	-	-	1	4
Inflation	300	82.825	7.950	71.74	105.06
Real GDP	230	24729.61	1103.598	23000	28690
Euribor	246	0.027	0.012	-0.003	0.049
Gov Expenditure	320	48.290	1.870	45.6	53.2
Sector	565	-	-	-	-

Table 2: Statics for Firms Sample

Statistic	N	Mean	St. Dev.	Min	Max
Duration	4976	81.296	192.407	0.0027	1144
Cartel Overcharge	2155	4376.281	41305.8	0	1260000
Super Cartel	5309	-	-	0	1
Affected Commerce	4388	44119.75	371024.3	0.003	1.53e+07
Penalty	4393	17.507	132.750	0	3012
Buyers	5195	-	-	1	4
Inflation	3845	80.037	7.236	71.74	100.23
Real GDP	2233	24602.5	1039.808	23000	27140
Euribor	2428	0.027	0.011	-0.002	0.049
Gov Expenditure	4072	48.311	1.680	45.6	53.2
Sector	2827	-	-	-	-

Table 3: Variables and Description

Variable	Variable description	Source	Range
Duration	The temporal endurance of cartels. The end usually coincides with the detection, the beginning is more difficult to Calculate.	The Private International Cartels (PIC) Data Set	1902 – 2015

Cartel Overcharge	The amount by which the cartel raised prices above the competitive market price.	The Private International Cartels (PIC) Data Set	1902 – 2011
Super Cartel	Cartels that are: (1) global in scope and (2) have a larger number of distinct products with partially overlapping corporate membership and (3) direct their price fixing at customers in one vertical production distribution channel	The Private International Cartels (PIC) Data Set	2009– 2015
Affected Commerce	Total amount of activity of buying and selling affected by the cartel. (Millions dollars)	The Private International Cartels (PIC) Data Set	1902 – 2013
Penalty	Amount fined for carrying out the collusive agreement. (M illions dollars)	The Private International Cartels (PIC) Data Set	1902 – 2013
Buyers	Govt major buyer= +50% of sales to government Many buyers= more than 100 buyers in the geographic market Mod buyers= 30 to 99 buyers in the geographic market Few buyers= less than 10 and usually less than 5 or 10 in the geographic market	The Private International Cartels (PIC) Data Set	1902 – 2015
HICP	The Harmonised Index of Consumer Prices (HICP). It measures the price change overtime of consumer goods and services acquired by households. The variable is used as a proxy for inflation.	EUROSTAT, EuropeanCommission	1996 – 2015
Real GDP	Gross Domestic Product per capita at market prices. Chain linked volumes (2010). It measures the value of total final output of goods and services produced by an economy within a certain period of time.	EUROSTAT, European Commission	2000 – 2015
Euribor	Euro Interbank Offered Rate. It is based on the average interest rates at which a large panel of European banks borrow funds from one another.	EUROSTAT, European Commission	1999-2015
Government Expenditure	General government expenditure as a percentage of gross domestic product (GDP). Average of the European Union	EUROSTAT, European Commission	1995 – 2015

Sector	R = Raw material I = Industrial intermediate inputK = Industrial capital good G = Generic final consumer D = Differentiated final consumer- ready packaged good or branded service S = Services, including	The Private International Cartels(PIC) Data Set	1902-2016

Table 4: List of countries

List of Countries			
1.	Austria	14.	Ireland
2.	Belgium	15.	Italy
3.	Bulgaria	16	Lithuania
4.	Cyprus	17.	Latvia
5.	Czech Republic	18.	Netherlands
6.	Germany	19.	Poland
7.	Denmark	20.	Portugal
8.	Estonia	21.	Romania
9.	Spain	22.	Sweden
10.	Finland	23.	Slovenia
11.	France	24.	Slovakia
12.	Greece	25.	United Kingdom
13.	Hungary		

8.1 Problems with the regression that I had

<u>Robustness analysis</u>

When fitting a linear regression model, one might encounter some problems that may bias our results. Therefore, it is important to check the assumptions of linear regression model: Normality, constant variance, linearity, and independence. In each of the models the robustness analysis has been carried out properly to ensure that our regression is consistent.

- <u>Detection of outliers</u>

The ordinary least square estimator is very sensitive for outliers. An outlier is a point with

a large residual, that often is an error in the database. An influential point is a point that has a large impact on the regression. Surprisingly, a point can be an outlier without being influential. We should be cautious with outliers, and for this purpose, we carry out an analysis for outlier and influential detection in the software program R-studio. We execute a cook's distance analysis, to assess the influence of the i_{th} observation on all the parameter estimates. Explain how we compute the process and select where hat>cv hat and why we do that. A dummy variable for outliers is created, and all regressions are carried out with and without outliers to see how they affect our fit.

As mentioned, not all outliers are influential and in some cases it's enough to delete them. However, we can conclude that in our sample they are not representative of the intended study population, and we delete them. When carrying out the regression with and without outliers we can see that they are influential since the output of the fit changes considerably. Therefore, it is more accurate to use the models without outliers for the final conclusions.

- <u>Multicollinearity</u>

Multicollinearity takes place when two or more of the independent variables of the regression model depend among them. In other words, they are highly correlated. This presents a problem on our analysis, because it increases the variance and as a consequence que have wider confident intervals. The marginal contribution of one variable in reducing the error sum of squares (remaining variability) depends on which other predictors are already in the model. We tested that when highly correlated variables are included in the same model, the standard error increases, and hence we have a less precise estimates of the parameters. In order to check multicollinearity in our model, we use the method called Variance Inflation Factor (VIF). This approach assesses the extent to which linear dependency among the regressors inflates the variance of the calculated regression coefficients. This method quantifies how much the variance of the estimated regression coefficients is inflated compared to when there is no linear dependence among the regressors. In our models, it is lower than 10 so we can conclude that we don't have multicollinearity. Highly correlated variables are eliminated from the model, and we run again the regression to check if we get rid of it.

- <u>Problems with the regression</u>

One of the main problems of the regression and in particular of the sample, is the fact that there are few observations containing data of all independent variables. The more independent variables included in the model, the less observations available for the analysis. In addition, most of the independent variables interesting to analyze, are not significance in our sample. This has limited the analysis considerably.

What is more, the sample used for the regression analysis is a pooled-cross sectional. This means that we cannot controlled for the time variability. As a result, to implement country

fixed effects in R, these have to be included as dummy variables. One country is omitted and represents the benchmark to the rest of countries. Since we can't control for time, we have to use the package of *lm* to include fixed effects as dummies. Given that in the sample there are 25 countries, this can lead to an overparametrized model.

R-Studio outputs

Model 1

```
Call:
lm(formula = duration ~ GDP_r + AffCommerce + buyers + Gov_exp,
    data = table18)

Residuals:
    Min      1Q  Median      3Q     Max
-48.609 -18.018  -2.024  16.111  57.023

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.228e+02  8.440e+01   5.009 1.46e-06 ***
GDP_r       -1.142e-02  1.982e-03  -5.761 4.29e-08 ***
AffCommerce  2.434e-04  5.426e-05   4.486 1.39e-05 ***
buyersMany   1.712e+01  4.544e+00   3.768 0.000232 ***
buyersMod    1.435e+02  2.444e+01   5.872 2.48e-08 ***
Gov_exp     -2.407e+00  1.522e+00  -1.581 0.115945
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 23.9 on 157 degrees of freedom
  (342 observations deleted due to missingness)
Multiple R-squared:  0.4247,    Adjusted R-squared:  0.4064
F-statistic: 23.18 on 5 and 157 DF,  p-value: < 2.2e-16
```

Model 2

```
Call:
lm(formula = carteloverchtotal ~ AffCommerce, data = table18)

Residuals:
    Min      1Q  Median      3Q     Max
-313268    1957    3771    4207  163447

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -4.243e+03  3.193e+03  -1.329    0.186
AffCommerce  5.824e-01  1.608e-02  36.224   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 34080 on 116 degrees of freedom
  (387 observations deleted due to missingness)
Multiple R-squared:  0.9188,    Adjusted R-squared:  0.9181
F-statistic:  1312 on 1 and 116 DF,  p-value: < 2.2e-16
```

Model 3

```
Call:
lm(formula = duration ~ GDP_r + AffCommerce + Gov_exp + buyers +
    factor(country) - 1, data = table181)

Residuals:
    Min      1Q  Median      3Q     Max
-55.297 -21.261  -2.235  13.832  81.757

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
GDP_r             -1.565e-02  2.764e-03  -5.661 8.30e-08 ***
AffCommerce        3.931e-05  1.541e-05   2.551  0.01183 *
Gov_exp           -4.320e+00  2.011e+00  -2.148  0.03345 *
buyersFew          6.438e+02  1.131e+02   5.692 7.16e-08 ***
buyersMany         6.566e+02  1.130e+02   5.811 4.05e-08 ***
buyersMod          6.866e+02  1.137e+02   6.041 1.33e-08 ***
factor(country)BE -9.619e+00  1.774e+01  -0.542  0.58851
factor(country)BG -2.972e+01  2.558e+01  -1.162  0.24725
factor(country)CY -4.488e+01  3.321e+01  -1.351  0.17884
factor(country)CZ -1.989e+01  2.110e+01  -0.943  0.34751
factor(country)DE -1.018e+01  1.537e+01  -0.662  0.50879
factor(country)DK  1.066e+00  2.561e+01   0.042  0.96686
factor(country)EE -1.322e+01  3.376e+01  -0.392  0.69595
factor(country)ES -1.076e+00  1.486e+01  -0.072  0.94241
factor(country)FR -2.862e+01  1.594e+01  -1.795  0.07481 .
factor(country)GR -2.171e+01  2.043e+01  -1.063  0.28969
factor(country)HU -2.840e+01  1.590e+01  -1.787  0.07616 .
factor(country)IE -3.982e+01  3.337e+01  -1.193  0.23485
factor(country)IT -1.349e+01  1.520e+01  -0.887  0.37636
factor(country)LT  2.859e+01  3.390e+01   0.843  0.40048
factor(country)LV  1.569e+01  3.336e+01   0.470  0.63895
factor(country)NL -4.805e+01  1.788e+01  -2.687  0.00809 **
factor(country)PL -2.334e+01  2.302e+01  -1.014  0.31225
factor(country)PT -2.294e+01  2.580e+01  -0.889  0.37545
factor(country)RO -7.702e+00  1.621e+01  -0.475  0.63549
factor(country)SE -1.326e+01  2.243e+01  -0.591  0.55536
factor(country)SI  2.107e+01  3.365e+01   0.626  0.53223
factor(country)SK -4.123e+01  3.376e+01  -1.221  0.22410
factor(country)UK -3.862e+01  1.745e+01  -2.214  0.02848 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 30.21 on 139 degrees of freedom
  (289 observations deleted due to missingness)
Multiple R-squared:  0.8016,    Adjusted R-squared:  0.7602
F-statistic: 19.36 on 29 and 139 DF,  p-value: < 2.2e-16
```

Model 4

```
Call:
lm(formula = duration ~ GDP_r + SuperCartel + buyers + factor(sector) -
    1, data = table181)

Residuals:
    Min      1Q  Median      3Q     Max
-81.777 -24.097  -4.819  16.230 123.739

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
GDP_r            -0.017625   0.002355  -7.483 2.19e-12 ***
SuperCartel0    472.762636  58.074854   8.141 3.99e-14 ***
SuperCartel1    487.824836  59.580902   8.188 2.98e-14 ***
buyersMany       13.580114   5.671041   2.395 0.017550 *
buyersMod        43.287956  11.443701   3.783 0.000204 ***
factor(sector)G  -7.744335  11.280112  -0.687 0.493155
factor(sector)I  -0.177808   7.765311  -0.023 0.981754
factor(sector)K  20.988898  13.089585   1.603 0.110391
factor(sector)R   1.816440  25.139509   0.072 0.942471
factor(sector)S   0.868173   6.963985   0.125 0.900912
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 34.45 on 202 degrees of freedom
  (245 observations deleted due to missingness)
Multiple R-squared:  0.734,     Adjusted R-squared:  0.7208
F-statistic: 55.73 on 10 and 202 DF,  p-value: < 2.2e-16
```

Model 5

```
Call:
lm(formula = duration ~ carteloverchtotal + MKTCRn + totsanc +
    Gov_exp + SuperCartel, data = table16)

Residuals:
    Min      1Q  Median      3Q     Max
-66.876  -1.180  -1.180  -0.462  81.503

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)       -3.189e+02  1.919e+01 -16.615   <2e-16 ***
carteloverchtotal  2.931e-04  2.413e-05  12.147   <2e-16 ***
MKTCRn            -7.126e-01  5.024e-02 -14.185   <2e-16 ***
totsanc            8.689e-02  3.474e-02   2.501   0.0125 *
Gov_exp            8.769e+00  3.916e-01  22.392   <2e-16 ***
SuperCartel1       5.692e+01  2.264e+00  25.139   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 11.73 on 1125 degrees of freedom
  (4221 observations deleted due to missingness)
Multiple R-squared:  0.6378,    Adjusted R-squared:  0.6362
F-statistic: 396.2 on 5 and 1125 DF,  p-value: < 2.2e-16
```

Model 6

```
Call:
lm(formula = duration ~ carteloverchtotal + totsanc + Gov_exp +
    MKTCRn + factor(country) - 1, data = table16)

Residuals:
    Min     1Q  Median     3Q     Max
-54.636  -0.607  -0.607   1.088  30.904

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
carteloverchtotal  5.085e-04  1.175e-05  43.262  < 2e-16 ***
totsanc           -1.866e-01  2.259e-02  -8.261 4.07e-16 ***
Gov_exp            8.281e+00  2.301e-01  35.995  < 2e-16 ***
MKTCRn             1.155e-01  3.946e-02   2.928  0.00348 **
factor(country)BE -3.413e+02  1.258e+01 -27.137  < 2e-16 ***
factor(country)DE -3.621e+02  1.103e+01 -32.820  < 2e-16 ***
factor(country)ES -3.134e+02  1.139e+01 -27.510  < 2e-16 ***
factor(country)EU -3.685e+02  1.153e+01 -31.950  < 2e-16 ***
factor(country)FR -3.306e+02  1.117e+01 -29.590  < 2e-16 ***
factor(country)HU -3.608e+02  1.186e+01 -30.421  < 2e-16 ***
factor(country)IT -3.805e+02  1.099e+01 -34.624  < 2e-16 ***
factor(country)LV -3.133e+02  1.118e+01 -28.030  < 2e-16 ***
factor(country)NL -3.793e+02  1.136e+01 -33.401  < 2e-16 ***
factor(country)PL -2.772e+02  1.140e+01 -24.312  < 2e-16 ***
factor(country)PT -3.325e+02  1.147e+01 -28.976  < 2e-16 ***
factor(country)RO -3.678e+02  1.152e+01 -31.941  < 2e-16 ***
factor(country)SK -3.876e+02  1.128e+01 -34.360  < 2e-16 ***
factor(country)UK -3.777e+02  1.121e+01 -33.684  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 5.732 on 1113 degrees of freedom
  (4221 observations deleted due to missingness)
Multiple R-squared:  0.9832,    Adjusted R-squared:  0.983
F-statistic:  3625 on 18 and 1113 DF,  p-value: < 2.2e-16
```