DOES EUROPEAN COMPETITION POLICY REALLY STIMULATE COMPETITION?

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Abstract

In 2006, an updated version of the European Leniency Program came into effect. It has the goal to stimulate competition by being more effective against cartels. Theoretical work has shown that Leniency Programs are effective in deterring and detecting cartels. Empirical work has shown that after the implementation of such policies, the number of detected cartels increases. However, this is no valid proof the Leniency Program really stimulates competition since the cartels that are not detected are not taken into account. This research investigates the direct relationship between the 2006 Leniency Program and competition by using a proxy for competition. This study uses data from 25 European countries and 30 industries. Results from OLS regressions, Fixed effects estimations, Regression Discontinuity design and the average treatment effect reveal the 2006 Leniency Program really stimulates competition.

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Introduction

Competition is regarded as an important aspect for economic growth since it increases consumer welfare and it can be defined as "a market situation in which firms or sellers independently strive for the patronage of buyers in order to achieve a particular business object, e.g. profits, sales, and/or market share" (OECD, 2008, pp. 122). A large body of literature is written about product market competition and its relation with corporate governance (Amman et al., 2011; Januszweski et al., 2002; Byun et al., 2014), management incentives (Bloom & van Reenen, 2007; Besley & Ghatak, 2005) and capital structure (Chevalier, 1995; Zhibiao et al., 2003). The European Commission ('Commission') acknowledges the importance of product market competition and has created competition policy in the field of antitrust and cartels, mergers and state aid. Its goal is to promote a competitive culture in the European Union (European Commission, 2014). However, is the competition policy really effective in reaching this goal? This question is important since the Commission tends to expand the antitrust policy by introducing a new directive that makes national competition authorities enforcers that are more effective.

The Commission encourages companies to be more efficient and innovative which results in offering consumer goods and services at the most favourable terms (European Commission, 2014). However, there is a lack of academic research into the relationship between the competition policies and competition itself within the European Union. To my knowledge, there is little evidence that affirms that competition policy, especially in the field of antitrust, really stimulates competition in Europe. The research that is done in the field of antitrust, aims at getting more insights in the effectiveness of the antitrust policies, such as the Leniency Program of the Commission. (Brenner, 2009; Chen & Harrington, 2007; Harrington & Chan,

2015; Hoang et al., 2014; Marvao, 2016; Spagnolo, 2015;). This is done by getting more insights in the duration of cartels, the determinants of firms to self-report to the Commission and the total fines paid to the Commission by law infringers. These papers conclude that, after the implementation of a Leniency program, the duration of cartels is lower, firms have more incentives to self-report and there is an increase in total fines paid to the Commission.

However, this is no convincing evidence that the competition within the European Union has increased since these papers have a selection bias because only cartels that are identified by the Commission are taken into account. The cartels that are not identified are not included in the research since they operate in secrecy (Harrington & Chang, 2012). Therefore, based on previous research no conclusions can be made about the relationship between the Leniency Program and its effect on competition and previous research acknowledges this problem.

This research investigates the direct relationship, hereby avoiding the selection bias, between the Leniency Program and competition by determining the effect of the Leniency Program on a proxy of competition in 25 EU-countries and 30 industries.

At first, it gives background information about the Leniency Program and the current academic literature about the Leniency Program and competition is reviewed. Subsequently, the methodological framework is presented where is explained which variables and analysis are used in this research. After that, the results are presented and this research ends with a discussion and conclusion.

Background and literature review

2.1. The EU Leniency Program

Competition policy focusses on free competition in markets. One of the policies implemented by the Commission to enhance competition is the Leniency Program, which is first implemented in 1996. The Leniency Program is revised in 2002 and 2006 to improve its efficiency. The Leniency Program tries to enhance competition by offering law infringers, i.e. participants of illegal cartels, incentives to self-report to the responsible authority. These incentives are either a reduction of fines or full immunity if the infringer (fully) cooperates with the investigation of the Commission and discloses enough information about the cartel (European Commission, 2006b).

The conditions for leniency were first drafted in the 'Commission Notice on the non-imposition or reduction of fines in cartel cases' in 1996. The 1996 Leniency Program played an important role in detecting and punishing cartels. However, due to a lack of transparency, the Leniency Program is revised in 2002. The new policy should have increased the legal certainty since it was more transparent and predictable (European Commission, 2002). After four years of experience in applying the 2002 Leniency Program, a new step to uncover cartels was taken by adopting the revision of the Leniency Program in 2006. This revision, again, increased the transparency of the procedure by clarifying which information the applicant needs to provide and by clarifying the conditions for immunity and reduction of fines (European Commission, 2006a).

Regarding the 2006 Leniency Program, an undertaking can receive immunity from fines when it is a whistle-blower, i.e. it is the first to submit information and evidence to the Commission. When the applicant is not the first to submit information, it can still receive a reduction of fines if it discloses information that has an added value in respect to the evidence already in the Commission's possession. The first undertaking to provide significant added value receives a reduction of 30-50% of the imposed fine. The second undertaking receives a reduction of 20-30% and all other applicants receive a reduction of up to 20% (European Commission, 2006b).

2.2. Effects of leniency

2.2.1. Measuring effectiveness of the Leniency Program

Since the Commission claims its Leniency Program has a positive effect on cartel detection, scholars have done theoretical and empirical research on this matter. Theoretical literature provides insights in the 'effectiveness' of Leniency Programs by investigating the effect on cartel deterrence. Spagnolo (2005) uses a static model to identify determinants of an efficient Leniency Program. The author finds that a Leniency Program that rewards the whistle-blower with a reduction of fines paid by the fines of the other cartel members has the strongest cartel deterrence effect. Furthermore, moderate Leniency Programs that reduce sanctions also destabilize and deter cartels. This is because the risk for the firms engaging in a cartel is increased. In addition, the firms that report are protected from punishments from other cartel members and receive a reduction of fines (Spagnolo, 2005).

A Leniency Program supposedly lowers the cartel rate. However, in an environment where penalties are low and the costs of enforcement for the competition authority are high, the

Leniency Program can have the opposite effect and increase the cartel rate. This is because the resources of the competition authority are shifted from non-leniency cases to leniency cases. This means that the competition authority has fewer resources to detect the non-leniency cases. In this situation, cartel forming can flourish and increase the cartel rate. If the competition authority increases the penalties, fewer cartels are formed. This indicates that there is a trade-off between the height of fines and cartel forming (Harrington & Chang, 2015).

The latter is in line with the research from Chen and Harrington (2007). They conclude that a Leniency Program, which grants a full reduction of fines for whistle-blowers, makes collusion less attractive. In addition, the incentives of cartel members to self-report are lower when the Leniency Program is less strict and even if the Leniency Program does not deter cartel formation, it can still lower the prices charged by the firms (Chen and Harrington, 2007).

Leniency Programs get more effective when the reduction of fines increases when a firm reports it participated in a cartel. In addition, increasing the amount of the fines for violating the antitrust law enhances the effectiveness of the Leniency Program. This indicates that high penalties and lenient enforcement of antitrust laws go hand in hand. (Hinloopen, 2003).

2.2.2. Empirical research

There is empirical research that investigates the efficiency of the Leniency Program by focusing on an increase of cartel detection and deterrence of cartels. Brenner (2009) uses a sample of 61 cartel cases that were investigated and prosecuted by the Commission between 1990 and 2003. The author concludes that under the Leniency Program, more information is revealed, in the first three years after cartel detection, and this is accompanied by a reduction of investigation and prosecution costs. However, these findings are not strong enough to

conclude the Leniency Program deters future cartel activity and destabilizes cartels (Brenner, 2009).

Moreover, firms can learn how to 'play the leniency game' and this has an ambiguous impact on the incentives of the firms and has implications for policy makers (Marvao, 2016). Firms have the temporary incentive to play the leniency game, by colluding and then be the first reporter. The results show the number of repeat offenders in a cartel have a significant positive effect on the predicted individual leniency reduction and suggests the fines for repeat offenders should be more severe (Marvao, 2016).

Research is done into the determinants of self-reporting of firms under the European corporate Leniency Program, i.e. how whistle-blowers differ from other cartel members (Hoang et al., 2014). The authors use a dataset that covers 80 cartels between 2000 and 2011 and find that the revision of the 2002 Leniency Program had a significant positive effect on the incentives of repeat offenders to self-report and become a whistle-blower. Furthermore, a higher basic fine and an increased degree of multinationalism of the firm increase the probability to self-report to the Commission (Hoang et al., 2014).

However, the success of a Leniency Program cannot be validly measured by the amount of leniency applications, the number of cartels detected or prosecution costs, as more applications and higher costs do not necessarily translate into fewer cartels. This is due to the selection bias that occurs. The empirical research only takes cartels into account that are identified by the Commission and not the cartels that are not identified. This is impossible, since these cartels operate in secrecy, but it is a major problem in this field of research

(Harrington & Chang, 2012). Klein (2011) recognizes this problem and is the first to test the efficiency of Leniency Programs by empirically test the impact on competition intensity. The author uses the price cost margin as the outcome variable and bases the econometric estimations on OECD data from 23 countries in a period of 20 years. The results show a positive and significant effect of the 1996 Leniency Program and the revised 2002 Leniency Program on competition intensity. The author concludes that the 1996 Leniency Program and 2002 Leniency Program were an effective policy to increase competition. In the next section, the literature about the measurement of competition is described.

2.3. Competition

Analogous empirical research into product market competition could be difficult due to data unavailability on the key variables of competition or because of the different proxies that are used in the literature. Competition lowers sales prices, however information about those sales prices is often not available for all firms in an industry. Therefore, proxies are used that look at the changing market structure due to competition. In this section, these different proxies are being described and the advantages and disadvantages of each proxy are given.

2.3.1. Number of firms

A straightforward way to measure the intensity of competition in an industry, is to count the number of firms in that industry (Du and Chen, 2010; Polder et al., 2009). A higher number of firms relates to more intense competition. However, in the long run and with a competitive market, it can be assumed that inefficient firms will be outcompeted since they cannot survive under intense competition (Boone et al., 2007). One drawback is that this proxy ignores the

differences in firm size but it is useful since the data is widely available for most industries in most countries.

2.3.2. Market concentration

Market concentration is, ceteris paribus, an important element of market structure and can be used as a proxy for competition (Rhoades, 1993). Market concentration can be calculated by the market share of a firm's sales as percentage of total sales of the industry. As a robustness check, the concentration ratio can be determined by the company's total assets or added value. There are different ways to measure market concentration.

Concentration ratios

A proxy that is often used to measure competition is the n-firm concentration ratio. This measure sums up the market shares of the largest firms, often the 3, 4, 5 or 8 largest firms, in an industry. A higher concentration value implies industries that more concentrated. However, the concentration ratio does not give information about the structure of the industry and about the size inequality between the firms. Therefore, it cannot give insights in the market power of the firms and it only gives an estimate of the competition level in the industry (Du and Chen, 2010).

Herfindahl-Hirschman Index

The Herfindahl-Hirschman index ('HHI') is a statistical measure of concentration and is used in various contexts. It is used to measure the concentration of wealth in household but it is also a widespread tool to measure market concentration at industry level (Amman et al., 2011; Cheng et al., 2013; Chou et al., 2011; Rhoades, 1993). The HHI has benefits over concentration

rations since the HHI takes the number of firms in a market and the relative size of all firms in a market into account, which concentration ratios do not. In this way, the influence of smaller firms is lessened and of larger firms is emphasized (Dobre, 2012). The HHI can be computed by summing up the squared market shares of all firms in a given industry and then dividing it by the square of the sum of all market shares (Amman et al., 2011; Rhoades, 1993). The Commission uses the HHI in order to determine the degree of competition in the market and it outperforms the n-firm concentration ratio (Stigler, 1964).

However, the n-firm concentration ratio and the HHI both assume that market structure is exogenous and depends on supply and demand. This implies that when the concentration decreases, prices also decrease and that competition increases. However, research indicates that when market structure is assumed to be endogenous, it is not clear whether the decrease of concentration reflects a decrease of competition, especially in cross-industry analyses (Karuna, 2007). This critique, of one-way causality, is also addressed by Vesala (1995) and Bos (2002).

Another issue that arises with the use of concentration ratios is the definition of the relevant product market. Market shares can only be computed if the product and geographic market is well defined. This can be extensive and complex (Dobre, 2012). Especially since it is difficult to precisely define the relevant market due to product differentiation. Authors often make use of industry classifications, such as the ISIC-code or NACE classification for industries, to define the relevant market. However, this combines a wide range of product markets and may therefore not reflect the competition the firms face in reality. Moreover, the definitions and

classifications vary across time, which results in more difficulties for the researchers (Du & Chen, 2010).

Furthermore, a problem with concentration ratios is the availability of data. A widely used database to retrieve market shares is Thomson Reuters EIKON, Compustat or the U.S. Economic Censes which has data from (mainly) listed companies listed worldwide. A problem is these databases only have information from listed companies. As listed companies only reflect a small proportion of the actual industry, computing the n-firm concentration ratio or the HHI will not be representative for the entire industry (Ali et al., 2009). Authors enrich their sample by using the Orbis database in addition to overcome this problem (Amman et al., 2011). Orbis contains business and financial information on about 275 million companies worldwide (Bureau van Dijk, 2018). These companies are mostly non-listed companies and authors therefore use the database to get a representative sample. However, this does not imply that Orbis contains all the non-listed companies of each industry in each country. Moreover, the data is not completely representative for the entire industry and it is questionable if it is useful to use the n-firm concentration ratio or the HHI as a proxy for competition.

2.3.3. Profit margins

Measures of profit margins capture the industries' or firms' profit margin and has a negative relationship with competition. This implies that if competition increases, the profit margins decrease (Du and Chen, 2010). The most used measure of profit margins is the Lerner index and is often referred to as the price cost margin.

The Lerner index

The Lerner index gives insights in market power from firms and is first introduced by Lerner (1934). Klein (2011) is the first author to use it in his research into the effectiveness of the 1996 and 2002 Leniency Program.

The advantage of the Lerner Index over the concentration ratios is that the definition of the product market does not have to be strict (Du & Chen, 2010). In essence, the Lerner index is computed with the price of a good and the firm's marginal cost of production. This makes it difficult to compute the Lerner index since the marginal costs of firms are not publically available and assumptions have to be made. Small differences in these assumptions can lead to diverse estimates. Therefore, the Lerner index is not viable as a practical tool (Dobre, 2012; Roberts, 2014). Despite this fact, authors modify the Lerner index so it is more applicable (Du & Chen, 2010). However, the Lerner index does not take exogenous economic factors as shift in cost of inputs into account, which can lead to misleading changes (Dobre, 2012).

Furthermore, Boone et al. (2012), emphasizes the fact that the price cost margin has problems with other exogenous factors such as a fall in entry barriers and more aggressive firms. Due to a reallocation effect, where efficient firms increase their market shares at the cost of the inefficient firms, the price cost margin can indicate the competition has increased while it actually has decreased. The authors state that the price cost margin only can be used when the research uses industry aggregate information. When the research uses firm level information, the profit elasticity indicator is a better proxy (Boone et al., 2012).

Profit elasticity

The profit elasticity indicator is first introduced by Boone et al. (2007) and its idea is that profits shift from less efficient firms to more efficient firms. The more efficient firms are assumed to have lower marginal costs and "an increase of this elasticity indicates an increase in competition because firms are punished more harshly (in terms of profits) for losing efficiency" (Boone et al., 2007, pp. 37). This proxy, equal to the concentration ratios, requires a definition of the relevant market and it faces the same problems as concentration ratios. In addition, the profit elasticity indicator makes use of marginal costs, which are not publically available (Amador & Soares, 2018). This makes it, as with the Lerner index, a difficult proxy to use in practice. Furthermore, the profit elasticity model is empirically tested and it can be concluded it is not viable as a practical tool (Schiersch & Schmidt-Ehmcke, 2010).

2.3.4. Import penetration

As a robustness check, import penetration can be used as a proxy to measure competition (Bertrand, 2004; Morellec et al., 2013). The authors define import penetration as "total value of imports divided by imports plus domestic production" (Morellec et al., 2013, pp. 19). The advantage of this proxy is that it considers competition pressure related to the international market while the above described proxies merely take the domestic market into account. However, it is not a reflection of the actual competition in the domestic market since it only measures the impact of imports (Du & Chen, 2010).

2.4. Policy changes

When policies change, it is desirable to know whether the policy had the intended effects. In the academic literature, there are models that can be used to examine the effects of a policy change. The difference-in-difference analysis and the Regression Discontinuity design are described.

Difference-in-difference analysis

A widely used method to determine the effects of a policy change is the difference-in-difference method (Dimick & Ryan, 2014). This method is only valid if there are no time-dependent trends in the outcomes which are not related to the policy change. The difference-in-difference analysis compares groups before and after a policy change, with one group exposed to the policy change and one group without exposure. If the difference-in-difference estimate is zero, the policy implementation has no relation with the investigated effect. To apply difference-in-difference analysis, panel data and a shock that affects one group but not the other group is needed. This is a big limitation since a control group has to be found where the policy change is the only difference between the group and the control group. This is, in practice, hard to find (Dimick & Ryan, 2014).

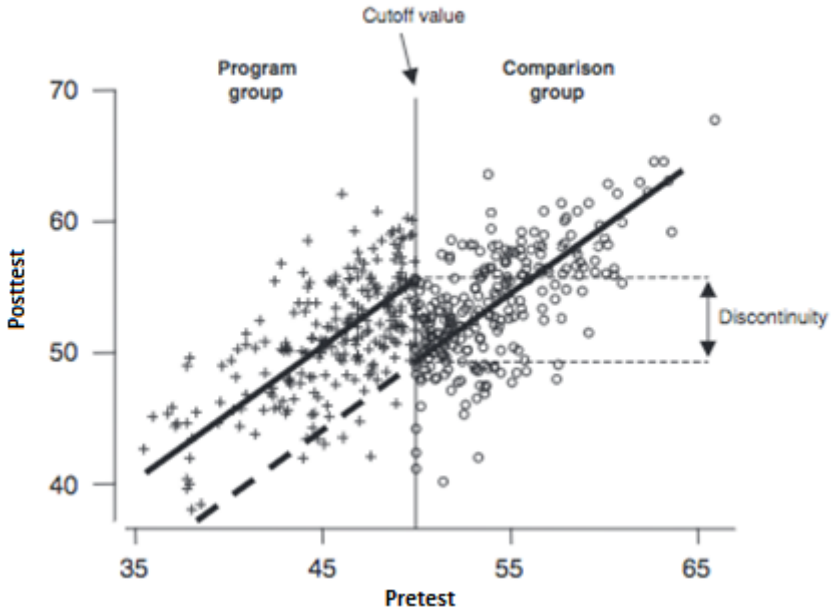
Regression Discontinuity designs

A different method that is used to determine the effect of a policy change is the Regression Discontinuity design (Jacob & Zhu, 2012). With this method, a treatment effect from a policy change can be estimated by comparing the outcomes before and after a cut-off point. Since the 1990s, the Regression Discontinuity design became a popular method to estimate the effects from policy changes and is used to evaluate, among others, the impact of class size reduction in primary and secondary education (Angrist & Lavy, 1999), anti-discrimination laws

(Hahn et al., 1999) and social assistance programs (Lemieux & Milligan, 2004). Also, the effects of unionization on employment and wages and the labor supply effect on welfare are investigated with the Regression Discontinuity design (Lee & Lemieux, 2010).

A basic Regression Discontinuity design, which shows a positive effect, looks like figure 1 (Cappelleri & Trochim, 2015).

Figure 1 Basic Regression Discontinuity design with a positive effect (Cappelleri & Trochim, 2015, pp. 153)



In this model, the solid lines represent the regression of the posttest on the pretest scores. The treatment effect is indicated with the discontinuity between the regression lines at the cut-off point. If the treatment has no effect, the comparison group's regression line will continue as the dashed line. However, in this example, the treatment effect has a positive effect and this is indicated by the discontinuity at the cut-off point (Cappelleri & Trochim, 2015). In practice, the Regression Adjustment function in STATA can be used to estimate the average treatment effect (StataCorp, 2013a).

Hypotheses

As the Leniency Program has the goal to improve competition within the European Union by offering incentives for cartel participants to self-report to the Commission, it is expected the competition within the European Union has increased since the adoption of the Leniency Program. It is found the 2002 revision of the Leniency Program increased the competition intensity (Klein, 2011). The revision of 2006 of the Leniency Program had the goal to be more efficient against cartels by improving the transparency of the Leniency Program and therefore the following hypothesis is drafted:

H1: *The 2006 Leniency Program has increased competition within the European Union.*

As stated before, a more intense competition is due to an increase of firms in that market. As the 2006 revision of the Leniency Program offers cartel members more incentives to self-report to the Commission, the detection of cartels, and competition, should increase after the implementation. However, in a competitive market, the inefficient firms will be outcompeted and the number of firms should decrease (Boone et al., 2007). The model that Boone introduced is empirically tested and it can be concluded that the competition intensity increases in the first three years after a cartel is detected (Schiersch & Schmidt-Ehmcke, 2010). Therefore, this research assumes that the short-run effect of the Leniency Program is visible up to three years after its implementation. Hence, the following hypotheses are drafted:

H2: *After the increase of the number of firms in the short-run, the number of firms has decreased.*

Data and Method

4.1. Data and descriptive statistics

4.1.1. Data source

The data for the dependent variable is from the OECD SBDS structural business statistics and the data from 2002 until 2007 is downloaded with the ISIC Rev. 3 classification. From 2008 onwards, the industry classification system changed to the ISIC Rev. 4 classification system. In response, correspondence tables have been used to convert the data from 2008 onwards to the ISIC Rev. 3 classification in order to have comparable data.

The PMR index is downloaded from the OECD's Indicators of Product Market Regulation and the 'starting a business' statistics are downloaded from the World Bank's Doing Business project.

4.1.2. Dependent variable

The dependent variable to identify the effect of the 2006 Leniency Program on competition is the logarithm of number of firms in an industry. A firm is a legal entity that conducts business on its own. The number of firms is chosen, in line with Huang and Lee (2013), since competition intensity can be measured. The drawback that the differences in firm size are ignored is taken into account and the choice for this proxy, as measure for competition, is justified since the data is widely available. Moreover, the other proxies also have disadvantages. As described earlier, the data for the concentration ratios and profit margins may not reflect the entire industry or are not viable due to the assumptions that have to be made. Since the literature is not conclusive that one proxy is the best, the logarithm number of firms in an industry is used.

4.1.3. Main independent variable

The main independent variable is the effectuation of the 2006 Leniency Program. The variable is constructed as a dummy variable to indicate whether the Leniency Program was implemented at that time.

To test hypothesis 2, a dummy variable is constructed labelled as long-run. This variable makes a distinction between the short-run period and the long-run period after the implementation of the 2006 Leniency Program. The short-run period is from the years 2007-2009 and the long-run period is from 2010-2015.

4.1.4. Control variables

Barriers to competition have an influence on the number of firms within a country. Regulation of markets are considered a barrier to competition and the PMR index is used to control for this country specific intensity on product market regulation (Bento, 2017; Klein, 2011). The PMR index is drafted with the answers from more than 700 survey questions asked to national governments in the OECD Regulatory Indicator Questionnaires of 1998, 2003, 2008 and 2013. The PMR index indicates how restrictive the regulations are for competition in 47 countries and has a range from 0 to 6. A higher value indicates the competition environment is more restrictive (Bento, 2017).

The number of firms is also influenced by other institutional factors (Bento, 2017). The Doing Business project from the World Bank "records all procedures officially required, or commonly done in practice, for an entrepreneur to start up and formally operate an industrial or commercial business, as well as the time and cost to complete these procedures and the paid-in minimum capital requirement" (World Bank, 2017). A measure is constructed for the variable 'starting a business' and it ranges from 0 till 100 and the higher the score, the easier

it is to start a business. Since these two factors have a potential influence on the number of firms in a country, they are added as control variables in the empirical model.

Furthermore, there are more factors that influence the number of firms in a country. In practice, it is difficult to consider all those factors and the chance the results are biased due to omitted variables is present. Therefore, the fixed effects model is used to determine the results. The fixed effects model controls for the average differences across countries, industries and time in the unobservable predictors which reduces the treat of the omitted variable bias. The omitted variable bias refers to factors that are not taken into the model but have an effect on the dependent variable. Models with country and industry data can have many unobservable factors that are time-invariant and the fixed effects model eliminates these factors (Allison, 2011; Blumenstock, n.d.).

It is found that in certain industries, more cartels are formed and that in certain industries cartel duration is longer than in other industries. This can be due to industry specific aspects which increase the chance of detection (Abrantes-Metz et al., 2009). Alawi (2012) found that cartels were colluding in 46 industries and that most cartels were formed in the chemical industry, manufacture of basic pharmaceutical products and the wholesale industry. Furthermore, cartels are not evenly spread among countries. In certain countries firms collude more often than in other countries (Connor & Helmers, 2006)

Therefore, a country-industry fixed effects model is conducted that controls for the size of specific industries in specific countries and for industry specific aspects. This model is crucial for insulating the causal effect of the Leniency Program on competition (De Mooij & Liu, 2018). In addition, time dummies are added to control for unobserved time factors, such as the changed industry classification in 2008.

4.1.5. Missing values

The dataset is not complete for all industries in every country each year. These missing values can be estimated with imputation, be deleted or not estimated. There is a range of imputation methods available and all have their advantages and disadvantages (Donders et al., 2006).

Number of firms

The dataset for number of firms is not complete. For several industries in several years and countries data is missing. The total amount of missing values for the dependent variable is 456 and this is 4.34% of the total observations.

At first, the missing values are not treated with imputation and the analysis is performed with only the available data. This is known as the 'complete data approach' and it can be used if the percentage of missing values is under ten percent (Hair et al., 2014). Since the latter is the case, the complete data approach is used in this paper. However, this approach is affected by any non-random missing since the cases with missing data are deleted from the analysis (Hair et al., 2014). Therefore, a robustness check is performed where the multiple imputation method is used. A multiple imputation strategy replaces the missing value with a variety of plausible values that represent the uncertainty about the right value to impute. These imputed data sets are analysed and the results are combined (Yuan, 2010).

The imputation method that is used is the regression imputation method (Hair et al., 2014). This method uses regression analysis to predict the missing values based on the existing relationship with other variables in the dataset. This may be a disadvantage, since it reinforces the relationship that already exists in the data. However, since the observations in the data have a relationship, it holds promise and it will not affect the generalizability of the results

(Hair et al., 2014). The regression imputation method is preferred over the popular mean substitution method since the latter reduces the variance of the distribution, depresses observed correlations and distorts distribution of the data (Hair et al., 2014).

PMR index

As stated, the PMR index only comes out once every five years. Therefore, there are always four missing years in between and these missing values are treated with linear interpolation. This method renders a straight line between the known values and the points between these known values receive an interpolated value. The result is that interpretation of this variable is hard, but it remains a proper, but imprecise control variable (Klein, 2011).

Starting a business

The doing business project from the World Bank started in 2004 and therefore there is no data for the years 2002 and 2003. When the missing values are not treated with imputation, a large amount of data will be lost. Therefore, as robustness check, the values for the years 2002 and 2003, and the missing values in the years 2004 – 2015, are estimated with the TREND function in Excel (Microsoft, n.d.).

4.2. Empirical model

Three estimates are used to research the effect of the 2006 Leniency Program on competition in the European Union. The basic empirical model is formulated in the following estimating equation:

$$LnF_{ict} = \beta_0 + \beta_1 LP_t + \varepsilon_{ict}$$

Where LnF is the logarithm of the number of firms in industry i in country c, at time t, LP_t is the 2006 Leniency Program dummy variable and ε is the error term. Here, the 2006 Leniency Program equals zero before the implementation and one after the implementation.

In addition to the pooled OLS regression, the fixed effects model is used to control for unobserved heterogeneity. As stated, the fixed effects model controls for the average differences across countries, industries and time which reduces the treat of the omitted variable bias. Furthermore, the time-invariant factors are removed which estimates the net effect of the Leniency Program on competition. The fixed effects model is formulated in the following estimating equation:

$$LnF_{ict} = \beta_0 + \beta_1 LP_t + \beta_2 PMR + \beta_3 Business + D_{ci} + \delta_t + \varepsilon_{ict}$$

Where LnF is the logarithm of the number of firms in industry i in country c, at time t, LP_t is the 2006 Leniency Program dummy variable, PMR is the value from the PMR index, Business is the starting a business statistic, D represents a dummy variable and ε is the error term. Here,

the 2006 Leniency Program equals zero before the implementation and one after the implementation.

Furthermore, the Regression Discontinuity design is used to determine the effects of the 2006 Leniency Program. With this method, the treatment effect from the policy can be estimated by comparing the outcomes before and after a cut-off point. The cut-off point is the year 2007, since the revision is introduced in December 2006. The Regression Discontinuity Design is formulated in the following estimating equation:

$$LnF = \alpha + \beta_0 T_i + \beta 1(t-t_c) + \varepsilon_{ict}$$

Where LnF is the logarithm of the number of firms, t is time variable, t_c is the cut-off point and ε is the error term. LP equals 1 if the observation i is assigned to the treatment group and 0 otherwise (Jacob & Zhu, 2012).

Moreover, two estimates are used to determine the effect after the short-run period. The basic empirical model is formulated in the following estimating equation:

$$LnF_{ict} = \beta_0 + \beta_1 LR_t + \varepsilon_{ict}$$

Where LnF is the logarithm of the number of firms in industry i in country c, at time t, LR_t is the long-run dummy and ε is the error term. Here, the long-run dummy equals zero between 2007 - 2009 and one between 2010 – 2015.

Moreover, the fixed effects model is used to determine the effect after the short-run period and is formulated in the following estimating equation:

$$LnF_{ict} = \beta_0 + \beta_1 LR_t + \beta_2 PMR + \beta_3 Business + D_{ci} + \delta_t + \varepsilon_{ict}$$

Where LnF is the logarithm of the number of firms in industry i in country c, at time t, LR_t is the long-run dummy variable, PMR is the value from the PMR index, Business is the starting a business statistic, D represents a dummy variable and ε is the error term. Here, the long-run dummy equals zero between 2007 - 2009 and one between 2010 – 2015.

Empirical Results

5.1. Descriptive statistics

The total observations for the period 2002 – 2015 are 10,500. The Country and Industry observations are given in more detail in Tables A1 and A2 in Appendix A.

As stated, the time path in this research is from 2002 – 2015 and the research includes 25 countries and 30 industries. Furthermore, the average number of firms in an industry in a country in a given year is 31,758.

Table 1 Summary statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Year	10,500	2008.5	4.031	2002	2015
Country	10,500	13.36	7.616	1	25
Industry	10,500	15.5	8.656	1	30
Firms	10,142	31,758.32	76256.61	0	806,290
Logarithm of firms	10,044	8.512	2.281	0	13.6
Leniency Program	10,500	0.643	0.479	0	1
Doing business	8,760	136.853	75.480	1	258
Product Market Regulation	10,500	55.82	25.255	1	116
Long-run	6,750	0.667	0.471	0	1

Table A1 provides information on the countries for which sufficient data is gathered. It can be observed that the distribution of observations among countries is more or less similar. However, smaller countries as Belgium, Cyprus, Ireland and Luxembourg have less observations. Table A2 provides information on the industries that are taken into account in this research and it can be observed that the distribution among industries is equally distributed and there is no dominant industry present in the dataset.

5.2. Baseline results

Pooled OLS

Table 2 reports the pooled OLS regression and fixed effects regression results of the Leniency Program on competition. The pooled OLS estimation, column (1), shows a positive and significant, at 1% level, relationship between the 2006 Leniency Program and the logarithm of the number of firms. The coefficient of the Leniency Program is 0.681, which indicates that the Leniency Program had a positive effect on competition in the European Union.

Fixed effects

The fixed effects model is used to control for endogeneity between the predictors and the error terms due to unobserved characteristics of the variables. The results are given in Table 2. A regression with country-industry fixed effects is given that controls for the average differences across specific industries in specific countries.

The fixed effects estimation of the Leniency Program increases to 0.751 and is significant at 1% level. The coefficient has increased which means that unobserved heterogeneity has an effect. The coefficient increases to 1.006 when time dummies are taken into account. This means that unobserved time factors also have an effect on the relationship between the Leniency Program and competition.

When the control variables are added, the size of the coefficients of the Leniency Program decreases to 0.879 and remains significant at the 1% level. The control variables are both insignificant. Furthermore, the explanatory power of the fixed effects estimation is very high due to the inclusion of the dummy variables and the overestimation of the model.

In addition, a Hausman test is conducted and it indicates that the fixed effects model is preferred over the random effects model. Therefore, the random effects estimations are not given.

Table 2 Overview Pooled OLS and Fixed Effects

	Ln(f) Pooled OLS (1)	Ln(f) Fixed Effects (2)	Ln(f) Fixed Effects (3)	Ln(f) Fixed Effects (4)	Ln(f) Fixed Effects (5)	Ln(f) Fixed Effects (6)
Leniency Program	0.681***	0.751***	1.006***	0.922***	0.906***	0.879***
	(19.04)	(24.14)	(24.05)	(12.54)	(16.19)	(11.81)
PMR				-0.002		-0.001
				(-1.14)		(-0.52)
Business					0.0004	0.0003
					(1.16)	(0.92)
Time dummies			Yes	Yes	Yes	Yes
Country-Industry dummies		Yes	Yes	Yes	Yes	Yes
Constant	8.072***	5.390***	5.316***	5.441***	5.282***	5.339***
	(95.85)	(269.53)	(222.65)	(51.01)	(209.80)	(49.58)
R^2	0.020	0.949	0.956	0.956	0.959	0.959
Observations	10,044	10,044	10,044	10,044	8,474	8,474

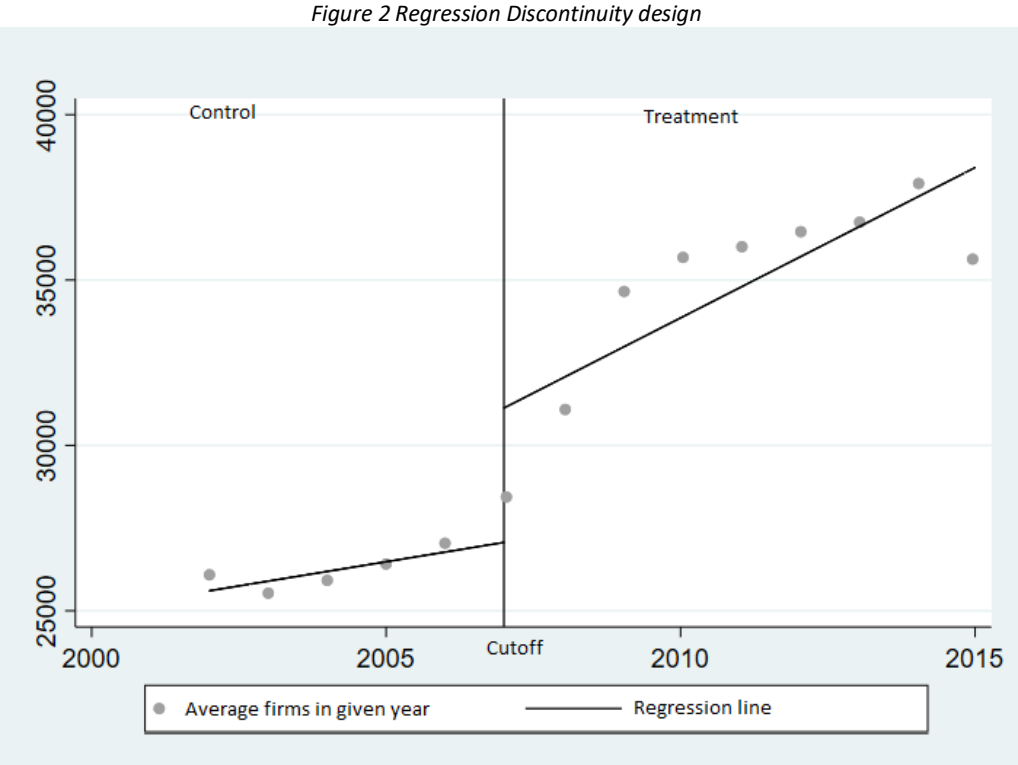
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
t statistics in parentheses
Robust standard errors clustered by Country-Industry

The results from the fixed effects estimations are all positive and significant at 1% level. This indicates that hypothesis 1 can be accepted. In addition, hypothesis 1 is also tested with the Regression Discontinuity design and the average treatment effect is computed.

Regression Discontinuity design

As stated, the Regression Discontinuity design is used to determine the effects of the 2006 Leniency Program. The treatment effect from this policy is estimated by comparing the outcomes before and after the cut-off point, the year 2007. At first, the Regression Discontinuity design is graphically presented in Figure 2.

Figure 2 Regression Discontinuity design



The y-axis indicates the average number of firms from all the industries from all the countries and the x-axis indicates the years that are investigated in this research. There is a discontinuity at the cut-off point. This is indicated by the gap between the control and

treatment regression lines and indicates that the 2006 Leniency Program had a positive effect on the average number of firms in the European Union.

In addition, the average treatment effect is calculated with Regression Adjustment and is controlled for the PMR index and the starting a business statistic, see Table 3.

Table 3 Average treatment effect

	f
Treatment effect	9,186.96*** (3.91)
Mean (before implementation Leniency Program)	25,839.41*** (12.08)
Observations	8,560

z statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This indicates that the Leniency Program causes the number of firms to increase, by an average, of 9,262 firms. The average of firms before the implementation of the Leniency Program is 25,765. Interpreting the results from the fixed effects estimation and the average treatment effect, and by eyeballing the graphical representation of the Regression Discontinuity design, hypothesis 1 is accepted. Therefore, it can be concluded that the 2006 Leniency Program had a positive effect on competition in the European Union.

Hypothesis 2 is also tested with a pooled OLS regression and a fixed effects estimation. The coefficient of the long-run variable in column (7) of Table 4 is positive and highly significant. This indicates that competition in the years 2010-2015 has increased relative to the base variable, which is a dummy variable for the years 2007-2009. The coefficient for the long-run dummy variable is also positive and highly significant with the fixed effects estimation, see column (8) – column (12) of Table 4. It was expected that the long-run dummy coefficient had a negative sign because the inefficient firms should have been outcompeted in the long-run. This is not the case and hypothesis 2 cannot be accepted.

Table 4 Overview pooled OLS and Fixed Effects long-run effect

	Ln(f) Pooled OLS (7)	Ln(f) Fixed Effects (8)	Ln(f) Fixed Effects (9)	Ln(f) Fixed Effects (10)	Ln(f) Fixed Effects (11)	Ln(f) Fixed Effects (12)
Dummy 2007-2009	Base	Base	Base	Base	Base	Base
Long-run	0.363***	0.345***	0.817***	0.772***	0.779***	0.761***
	(15.89)	(18.44)	(21.36)	(16.61)	(18.61)	(15.41)
PMR				-0.002		-0.001
				(-1.14)		(-0.62)
Business					0.0006	0.0005
					(2.09)	(1.92)
Time dummies			Yes	Yes	Yes	Yes
Country-Industry dummies		Yes	Yes	Yes	Yes	Yes
Constant	8.509***	5.645***	5.239***	5.320***	5.211***	5.258***
	(104.02)	(452.40)	(167.84)	(72.88)	(158.71)	(70.79)
R^2	0.0058	0.971	0.976	0.977	0.977	0.977
Observations	6,496	6,496	6,496	6,496	6,445	6,445

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

t statistics in parentheses

Robust standard errors clustered by Country-Industry

5.3 Robustness checks

It is important to consider if the results are robust. Perhabs the deletion of data due to the use of the complete data approach somehow effects the findings. Therefore, multiple imputation for the logarithm of the number of firms is used as a robustness check for the results. In this research, 20 imputations are used to reduce the sampling error (StataCorp, 2013b). In addition, the control variables are also estimated with imputation.

The results for the pooled OLS regression and fixed effects estimation are stated in Table 5. When comparing column (13) and column (1), there can be concluded that the results are robust since the coefficient in column (1) is 0.681 and the result in column (1) is 0.684. They are both singificant at 1% level. The fixed effects estimations, column (14) – column (18) of Table 5, are all positive and highly significant. The coefficients are smaller than the coefficients of the original regressions, column (2) – column (6). However, they are still positive and it be concluded that the results from the fixed effects estimations are robust.

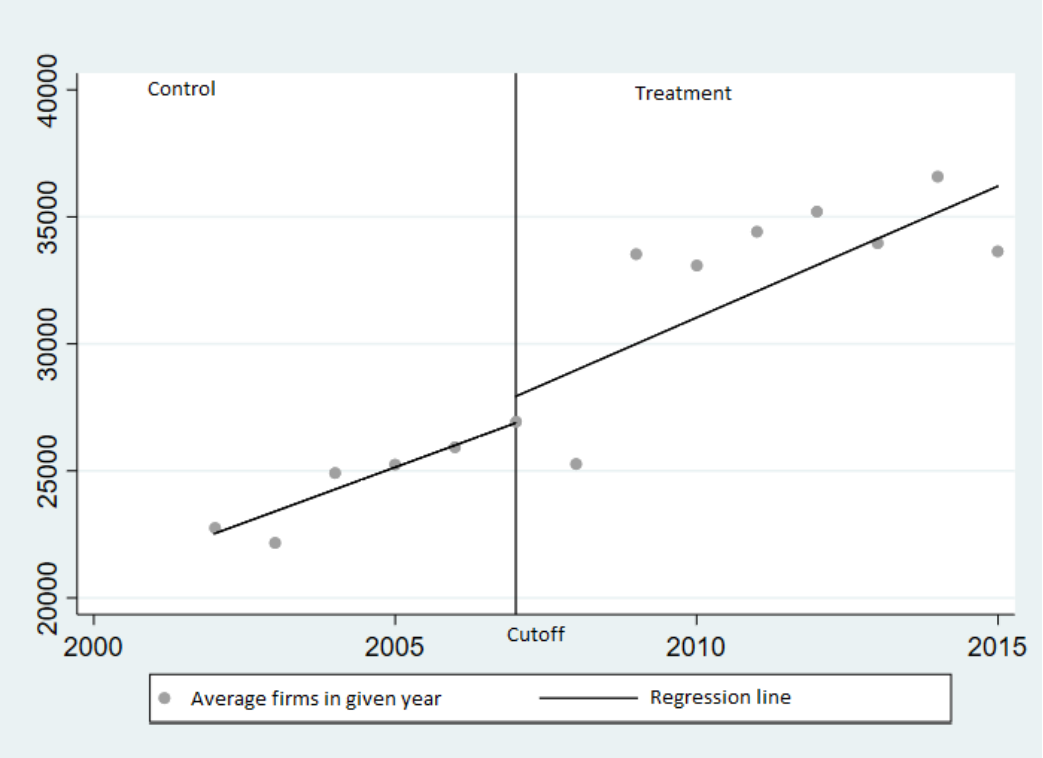
Table 5 Overview Pooled OLS and Dummy Fixed Effects with imputed data

	Ln(f) Pooled OLS (13)	Ln(f) Fixed Effects (14)	Ln(f) Fixed Effects (15)	Ln(f) Fixed Effects (16)	Ln(f) Fixed Effects (17)	Ln(f) Fixed Effects (18)
Leniency Program	0.684***	0.684***	0.803***	0.651***	0.664***	0.586***
	(18.38)	(17.77)	(9.27)	(5.23)	(6.32)	(4.49)
PMR				-0.004*		-0.003
				(-1.91)		(-1.34)
Business					0.001***	0.0009**
					(2.87)	(2.32)
Time dummies			Yes	Yes	Yes	Yes
Country-Industry dummies		Yes	Yes	Yes	Yes	Yes
Constant	8.064***	5.432***	5.450***	5.684***	5.412***	5.587***
	(99.87)	(219.44)	(85.37)	(40.23)	(84.43)	(38.74)
R^2						
Observations	10,500	10,500	10,500	10,500	10,500	10,500

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
t statistics in parentheses
Robust standard errors clustered by Country-Industry

The Regression Discontinuity method and treatment effect are both conducted with the sample that includes imputed data. The graphical representation of the Regression Discontinuity indicates that the treatment effect is still present but smaller, see Figure 3.

Figure 3 Regression Discontinuity design with imputed data



Furthermore, the treatment effect is still present as the number of firms has increased by an average of 10,134 firms, see Table 6. Therefore, these results are robust and it can be concluded that the 2006 Leniency Program stimulated competition in the European Union.

Table 6 Treatment effect with imputed data

	f
Treatment effect	10,134.21*** (6.98)
Mean (before implementation Leniency Program)	21,898.69*** (17.87)
Observations	17,302

z statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7 shows the results of the pooled OLS regression and fixed effects estimations for the long-run effect with the sample that includes imputed data. Column (19) shows a positive and highly significant result and it can be concluded that the result in column (7) of Table 4 is robust. Moreover, the coefficients of the fixed effects estimation in column (20) – column (24) are all positive and significant at 1% level. It can be concluded, when comparing these results with the results of column (8) – column (12), that the results of Table 4 are robust and hypothesis 2 cannot be accepted.

Table 7 Overview pooled OLS and Fixed Effects long-run effect with imputed data

	Ln(f) Pooled OLS (19)	Ln(f) Fixed Effects (20)	Ln(f) Fixed Effects (21)	Ln(f) Fixed Effects (22)	Ln(f) Fixed Effects (23)	Ln(f) Fixed Effects (24)
Dummy 2007-2009	Base	Base	Base	Base	Base	Base
Long-run	0.369***	0.369***	0.719***	0.727***	0.684***	0.702***
	(13.34)	(12.71)	(10.88)	(8.76)	(8.89)	(8.04)
PMR				0.0004		0.001
				(0.16)		(0.47)
Business					0.0004	0.0005
					(1.36)	(1.63)
Time dummies			Yes	Yes	Yes	Yes
Country-Industry dummies		Yes	Yes	Yes	Yes	Yes
Constant	8.502***	5.629***	5.303***	5.288***	5.281***	5.231***
	(106.75)	(290.15)	(124.68)	(52.73)	(126.76)	(50.27)
R^2						
Observations	6,750	6,750	6,750	6,750	6,750	6,750

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

t statistics in parentheses

Robust standard errors clustered by Country-Industry

Discussion and Conclusion

The main conclusion of this study is that the 2006 Leniency Program from the European Commission stimulates competition in the European Union. This research uses the number of firms as a proxy for competition and empirical analysis shows that the revision of the Leniency Program in 2006 has a positive impact on the number of firms in a sample of 25 countries of the European Union. At first, the empirical analysis uses a pooled OLS regression to determine the effect of the 2006 Leniency Program on competition. Secondly, a country-industry fixed effects model is conducted to control for endogeneity between the predictors and the error terms due to unobserved characteristics of the variables. Moreover, time-dummies are added to control for unobserved time factors and the treat of the omitted variable bias is reduced due to the use of the fixed effects model.

In addition, the Regression Discontinuity design and the average treatment effect are conducted. Imputation techniques are used to estimate missing values and to determine whether the initial results were robust. It can be concluded the 2006 Leniency Program stimulates competition and that the results are robust.

This result is in line with the goal the Commission has for its competition policy. Previous empirical research indicates that a Leniency Program stimulates competition but these results are not conclusive since they suffer from a selection bias. This research does not suffer from this selection bias since it investigates the direct relationship between the Leniency Program and competition and it can be regarded as valid evidence that the policy from the Commission is effective in stimulating competition. However, it does not directly investigate whether the competition is stimulated due to the deterrence or detection of cartels.

Besides the main finding, the research found that the number of firms, in the long-run, keeps increasing. This is not in line with the existing literature since it is expected that inefficient firms will be outcompeted under intense competition and the number of firms will decrease in the long-run (Boone et al., 2007). One possible explanation could be that the Leniency Program does not stimulate competition to the point where the market for firms is 'saturated' and not all inefficient firms are forced to exit the market. Another explanation is that the inefficient firms are forced to exit the market but they are 'replaced' by new, more efficient firms. Moreover, the definition for the long-run period could not be accurate. In this research, the long-run is assumed to be from three years onward. However, if the long-run is defined in a different way, the results could differ.

This research has limitations. Probably firms knew and anticipated on the effectuation of the Leniency Program. If this is the case, the results are underestimated since the firms could have ended their participation before the implementation of the 2006 Leniency Program. On the other hand, cartel participants could have reinforced their relationship and this would made it harder for the Commission to detect the cartel. It cannot be excluded that this is the case for some cartels but the results do not indicate that this is the case for all the cartels since the net effect of the Leniency Program on competition is positive.

One could argue that the number of firms is not the appropriate proxy to measure competition since it is a straightforward measure and does not take firm size into account. However, all the proxies for competition have its advantages and disadvantages. Therefore, a valuable extension of this research could be to iterate this research with other proxies. This could function as a robustness check for this research.

Future research could focus on specific industries and specific countries since cartels are not evenly spread among industries and countries (Alawi, 2012; Connor, 2006). This research could investigate whether the Leniency Program had a bigger effect in industries or countries where more cartels are detected. By this, the effect of the Leniency Programs on specific industry factors becomes clearer and the Commission could use it to keep improving their antitrust policy.

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Appendix A: Descriptive statistics

Table A1 Countries and Observations

Country	Observations	Missing values	Total observations
Austria	420	0	420
Belgium	366	54	420
Bulgaria	415	5	420
Cyprus	373	47	420
Czech Republic	398	22	420
Denmark	420	0	420
Estonia	420	0	420
Finland	419	1	420
France	405	15	420
Germany	419	1	420
Greece	379	41	420
Hungary	418	2	420
Ireland	357	63	420
Italy	420	0	420
Latvia	420	0	420
Luxembourg	385	35	420
Netherlands	420	0	420
Poland	413	7	420
Portugal	418	2	420
Slovak Republic	392	28	420
Slovenia	418	2	420
Spain	420	0	420
Sweden	410	10	420
United Kingdom	407	13	420
Total	10,142	358	10,500

Table A2 Industries and observations

Industry	Observations	Missing values	Total observations
10_14: Mining and quarrying	336	14	350
15_16: Food products, beverages and tobacco	340	10	350
17_18: Textiles and textile products	340	10	350
19: Tanning and dressing of leather, luggage, handbags, saddlery, harness and footwear	325	25	350
20: Manuf. of wood and of products of wood and cork, except furniture, straw and plaiting	340	10	350
21_22: Paper, paper products, printing and publishing	338	12	350
23_25: Energy products, chemicals and plastic products	316	34	350
26: Manuf. of other non-metallic mineral products	342	8	350
27_28: Basic metals and fabricated metal products	337	13	350
29: Manuf. of machinery and equipment n.e.c.	343	7	350
30_33: Electrical and optical equipment	344	6	350
34_35: Transport equipment	344	6	350
36_37: Manufacturing nec, recycling	337	13	350
40: Electricity, gas, steam and hot water supply	320	30	350
41: Collection, purification and distribution of water	329	21	350
45: Construction	343	7	350
50: Sale, maint. and repair of motor vehicles/cycles, retail sale of fuel	345	5	350
51: Wholesale trade and commission trade, except of motor vehicles and motorcycles	343	7	350
52: Retail trade, except of motor vehicles and motorcycles, repair of personal and household goods	344	6	350
55: Hotels and restaurants	345	5	350
60: Land transport, transport via pipelines	345	5	350
61: Water transport	323	27	350
62: Air transport	326	24	350
63: Supporting and auxiliary transport activities, travel agencies	340	10	350
64: Post and telecommunications	341	9	350
70: Real estate activities	345	5	350
71: Renting of machinery without operator and of household goods	345	5	350
72: Computer and related activities	338	12	350
73: Research and development	343	7	350
74: Other business activities	345	5	350
Total	10,142	358	10,500