

Snitches get stitches

An empirical study of the probability to self-report and cartel stability under the European Commission leniency program



LUNDS UNIVERSITET
Ekonomihögskolan

Lund University
Department of Economics
Bachelor Thesis

Authors:
Jakob Stockman Burg
Karl Johan Tegnér

Supervisor:
Jerker Holm

Abstract

In an effort to combat illegal cartel activities taking place in the European Union, in 1996 the European Commission decided to implement a leniency program for self-reporting firms who, in return for information about their cartel, could receive a substantial reduction, or a total exemption from any fines that would have otherwise been imposed on them. The wellbeing and survival of cartels is dependent on the trust and dynamics between the members, and a leniency program strives to upset the balance between them. This thesis aims to empirically assess which factors affect the probability for a firm to self-report, as well as which factors affect cartel stability in general, when they are operating under a leniency program. This is done by looking at data on detected cartels between 2001 and 2016 from press releases, official case summaries and publicly available case documents gathered from the European Commission's website and on this data run a binary probit regression on the probability for a firm to self-report, and a multivariate regression on the duration of cartels. Our results show that the individual members' expected shares of the cartel fine, if detected, has a positive effect on the probability of self-reporting, while the extent to which firms want to avoid uncertain situations has a negative effect. On a cartel level we find that both the number of firms in a cartel, and differences in size among cartel members, has positive effects on cartel duration, whereas the presence of a repeat offender amongst the cartel members has a negative effect on cartel duration, if the cartel was sentenced under the European Commission's revised leniency program from 2006.

Keywords: *cartels, European Commission, leniency program, self-reporting, cartel stability*

Contents

- 1. Introduction** 4
- 2. Cartels** 6
 - 2.1. Theory of cartels..... 6
 - 2.2. Stabilizing factors..... 8
- 3. Leniency programs**..... 11
 - 3.1. What is a leniency program? 11
 - 3.2. What is the purpose of a leniency program? 12
 - 3.3. Theoretical properties:..... 12
 - 3.3.1. Review of theoretical research 12
 - 3.4. Previous empirical studies..... 14
- 4. The European Commission’s leniency program** 16
 - 4.1. Cartels..... 16
 - 4.2. Leniency program..... 16
 - 4.3. Conditions for leniency 16
 - 4.3. Basic fine 1996..... 17
 - 4.4. Updates of the leniency guidelines..... 18
 - 4.5. Settlement..... 19
- 5. Hypotheses and Variables**..... 19
 - 5.1. Snitches 20
 - 5.1.1. Fines before reduction 20
 - 5.1.2. Relative length of cartel participation 21
 - 5.1.3. Repeat offender 21
 - 5.1.4. Country quota..... 22
 - 5.1.5. Uncertainty avoidance 23
 - 5.2. Duration..... 24
 - 5.2.1. Number of firms 24
 - 5.2.2. Multinationalism 24
 - 5.2.3. Repeat offender 25
 - 5.2.4. Leniency program of 2006 26
 - 5.2.5. Uncertainty avoidance 27
 - 5.2.6. Size differences among cartel members 27
- 6. Data and Descriptive statistics** 29
 - 6.1. Data gathering process 29

6.2. Processing errors	29
6.3. Data limitations	29
6.4. Descriptive statistics.....	30
7. Econometric models	31
7.1. Probability model	31
7.2. Stability model	32
7.3. Econometric issues	33
7.3.1. Heteroscedasticity	33
7.3.2. Multicollinearity.....	34
8. Results	35
8.1. Snitches	35
8.1.1. Share of expected fine	36
8.1.2. Relative duration	36
8.1.3. Repeat offender	36
8.1.4. Country quota.....	36
8.1.5. Uncertainty avoidance.....	36
8.2. Duration.....	37
8.2.1. Number of firms	38
8.2.2. Herfindahl–Hirschman Index on nationalities.....	38
8.2.3. Repeat offender	38
8.2.4. Leniency program of 2006	38
8.2.5. Repeat offender after 2006 leniency notice.....	39
8.2.6. Standard deviation of uncertainty avoidance index.....	39
8.2.7. Normalized Herfindahl–Hirschman Index on fines imposed	39
9. Discussion of key results	39
9.1 Snitches	39
9.2 Stability	41
10. Summary and Concluding remarks	43
11. Future research	44
12. References	45
13. Appendix A	48

1. Introduction

Groups of firms that cross the threshold of what is regarded as fair cooperation and, by doing so, limit competition in their respective markets are referred to as cartels. Cartels can cooperate in many different ways such as price fixing, market sectioning and geographical divisions. By cooperating instead of competing, cartels are able to charge higher prices and offer a lesser quantity, which increases their combined profits. When firms stop competing in a market, it causes the usual innovations and improvements normally inspired by competition to decrease. It is usually the consumers who suffer because of this, since they will have to pay a higher price for a lower quality *and* a lesser quantity of the supplied good. The society therefore suffers a total welfare, because the increase in profits for the cartel firms is smaller than the decrease in consumer surplus generated by the cartel activities.

Cartels are therefore illegal in most countries and most of them have authorities that work to detect cartels and deter them from forming. In the EU this work is carried out by the European Commission (hereafter referred to as the EC). Since 1990 the EC has managed to make decisions in over 120 cartel cases in which more than 20 billion euro in fines have been imposed (European Commission, 2016). Detecting and proving the existence of cartels is however a difficult task. As cartels are illegal, it is of utmost importance for the involved firms to hide their actions from the authorities. To look at high prices, stable market shares, or other publicly available information as a mean to detect and prove illegal cartel behavior is seldom enough, as it usually does not provide sufficient evidence (Brenner, 2009, p 639). In an effort to combat cartels, the EC introduced a leniency program in 1996 (European Commission, 1996). This program affects the incentives for firms to cease their cartel activities by offering full immunity or reduction in fines to firms that expose cartels that they are, or have been, part of.

The implementation of the leniency program changed the environment cartels are subjected to. A cartel need now not just worry about being detected by the authorities' regular criminal investigations, but also about the possibility of being exposed by one of its own members. Therefore this paper performs an empirical analysis to see if it is possible to determine if the firms that are first to apply for leniency, and thus snitches on the cartel, have any certain characteristics that separates them from the other cartel members.

To expand our paper we examine how different factors can affect cartel stability as well. Since cartel stability is hard to quantify, we measure it by looking at cartel duration, assuming

that a more stable cartel will last longer than an unstable one. In this analysis, we use the firm specific characteristics and apply them on a cartel basis, as well as some well-known variables on cartel stability from economic literature. We therefore hope to be able to see how both internal factors, such as the composition of the cartel, as well as external factors, such as the leniency program, affect cartel stability.

Leniency programs create incentives for firms to report and hand over evidence of cartels to the authorities which destabilizes cartels (European Commission, 2013). Our hope is therefore to be able to combine our results and see if, and if so, how our probability analysis and our stability analysis relate to each other. There have been other studies and articles who have analyzed cartels and the effects leniency programs have on them. What separates our paper from previous studies is the inclusion of *both* a probability and a stability analysis which, to our knowledge, is something that has not been done before.

We analyze a data set consisting of cartels that have been detected and found guilty by the EC. The cartels in our sample were detected between the years 2001 – 2016 and the information about these cartels and their member firms have been gathered by us by going through press releases, official case summaries and publicly available case documents posted on the EC's website. We are aware that our sample might be problematic as these cartels might not reflect the true population of cartels since this population is unobservable. Also, as we only examine cartels that were found guilty of cartel behavior in the EU, it is not certain that the same results would be found if we analyze cartels which were detected in other parts of the world.

This paper starts out by providing a theoretical discussion about the internal dynamics of cartels and what factors facilitate collusion. In section three the theoretical properties of leniency programs are discussed as well as previous empirical studies. Section four provides an overview of the EC's leniency notice and their fine setting policy. In section five we discuss our hypotheses and the variables used to measure them. The sixth section provides some relevant descriptive statistics as well as a discussion regarding some data limitations. The seventh section presents our econometric models. In section eight we present our results and in section nine we provide a discussion about them. Section ten summarizes our study and makes a few closing remarks. In section eleven we give some suggestions for future possible research in the field.

2. Cartels

2.1. Theory of cartels

In a one-shot market game cartel cooperation is seldom a Nash Equilibrium. Since there are profits to be made when the price exceeds the marginal cost, firms have incentives to cheat on the agreed upon cartel price (Stigler, 1964). This means that two firms competing in a duopoly market with homogenous products face a payoff structure as follows;

$$\pi^D > \pi^M > \pi^N > \pi^L$$

where π^D is the payoff for a firm who deviates from the agreement while the other firm cooperates, π^M is the payoff for each firm if they both cooperate, π^N is the payoff if neither firms chooses to cooperate and π^L is the payoff for a firm that chooses to cooperate while the other firm deviates from the agreement (Pepall, Richards and Norman, 2014, p 359). In such a situation the dominant strategy for each firm is to deviate from the agreement and therefore the Nash Equilibrium will result in the π^N -payoff even though the firms would have been better off if they had cooperated and ended up with the π^M -payoff.

To help understand how cartels manage to stay sustainable we can turn to the repeated game literature. The cartel game is not a one-shot market game but is played an indefinite number of times; and according to De (2010) the repeated game literature suggests that “when punishment strategies are credible and subgame perfect equilibrium at every stage” (p 34), cooperation might be a Nash Equilibrium. If we think of the game being played in a Bertrand setting, where firms compete with prices, a punishment strategy would be that, if a firm deviates from the agreement, all other firms will then set a competitive price forever, resulting in all the firms making the π^N -payoff forever. This means that if the firms interact repeatedly, the cartel agreement can stay sustainable, if the short term gains from deviating are lower than the forgone future profits from continuing to cooperate (De, 2010). According to De (2010, p 34-35), the current and expected future gains from colluding can be expressed as:

$$\text{Collusion: } V_i^C = \pi_i^M + \delta V_i^M \quad i = 1, 2 \dots n \quad (1)$$

Here δ is the discount factor and is equal to $\delta = \frac{1}{(1+r)}$, where r is the interest rate, which is identical for all firms in the industry. If a firm deviates it will receive the gain in one period and receive the subsequent lower profit due to the punishment strategy in all following periods:

$$\text{Deviation: } V_i^D = \pi_i^D + \delta V_i^N \quad i = 1, 2 \dots n \quad (2)$$

So for the cartel agreement to remain sustainable this would mean that:

$$\pi_i^M + \delta V_i^M \geq \pi_i^D + \delta V_i^N \quad i = 1, 2 \dots n \quad (3)$$

The last equation (3) is known as the incentive compatibility constraint (ICC) and if it is violated it would cause the cartel agreement to become unstable, which could cause the cartel to break down.

The equations above, however, do not account for external factors which affect the expected profit from colluding. Pepall, Richards and Norman (2014) notice that factors such as market stability and the risk of detection by the authorities are factors that the firms also need to account for and that these factors affect the probability of the game being played another round. By adding a variable, p , which measures this probability, they get the following equations (2014, p 359-360):

$$\text{Collusion: } V_i^C = \pi_i^M + p\delta V_i^M \quad i = 1, 2 \dots n \quad (4)$$

$$\text{Deviation: } V_i^D = \pi_i^D + p\delta V_i^N \quad i = 1, 2 \dots n \quad (5)$$

These equations can be rewritten as:

$$V_i^C = \frac{\pi_i^M}{1-p\delta} = \frac{\pi_i^M}{1-\rho} \quad (6)$$

$$V_i^D = \pi_i^D + \frac{p\delta\pi_i^N}{1-p\delta} = \pi_i^D + \frac{\rho\pi_i^N}{1-\rho} \quad (7)$$

Here δ is the the discount rate and p is the probability of the game being played one more time. ρ is therefore the probability-adjusted discount factor in a firm's expected profit function. Using the ICC and equation (6) and (7) they derive an expression for the value that ρ must exceed in order for the cartel to remain sustainable (2014, p 360).

$$\rho > \rho^* = \frac{\pi_i^D - \pi_i^M}{\pi_i^D - \pi_i^N} \quad (8)$$

What this equation tells us is that for a cartel to hold, the probability-adjusted discount factor cannot exceed the quota between the difference in profits between a deviating firm and the agreed cartel outcome, and between a deviating firm and the competitive profit. We know that $\rho < 1$ since we had from earlier that $\pi^D > \pi^M > \pi^N$. What we can conclude from this

discussion is that cartel stability increases when ρ increases. This means that a lower interest rate and a high probability of future interactions between the cartel firms work to facilitate collusion (Pepall, Richards and Norman, 2014).

In the next subsection we go through a number of factors that facilitate collusion and affect cartel stability.

2.2. Stabilizing factors

A cartel that wishes to be stable and durable faces both internal and external difficulties. As we mentioned before there are internal struggles for cartels with profit maximizing member firms since the firms might have incentives to deviate from the cartel agreement in order to increase their own profits. Firms try to change their cost-benefit analysis continuously in an effort to keep up with changes in technology, new market entrants, wrongful future demand anticipations or imperfect information between firms (Hoang et al., 2014).

According to economic theory there are certain market specific factors that can facilitate collusion and make cartels more stable and sustainable. One example of this is the market's concentration, where a smaller number of firms is preferred (Pepall, Richards and Norman, 2014). This would make it easier to cooperate, and make cartel agreements easier to coordinate. Similarly, it is easier to decide where to go to dinner if there are only two people compared to ten people trying to agree on what to eat, how much it should cost and how long it should take. Since cartel members strive to share a monopoly profit, a larger number of firms in the cartel would decrease the individual firms' profits (Levenstein and Suslow, 2006), which would make the ICC harder to sustain.

Shapiro (1989) shows that when there is symmetry among firms, increases in the number of cartel members puts pressure on the probability-adjusted discount factor and by doing so, makes collusion more difficult to sustain. Shapiro (1989, p 370-371) assumes that if firms compete in a Bertrand setting a punishing strategy would be to set $P = MC$ resulting in $\pi_i^N = 0$, and he uses this to rewrite equation (8) as:

$$\pi_i^D < \frac{\pi_i^M}{1-\rho} \quad (9)$$

In a Bertrand setting, he notices that if a firm just slightly undercuts the price and cheats on the agreement, this firm will receive the entire monopoly profit π^M , which means that π^D can

be expressed as the sum of the individual cartel profits: $\sum_{i=1}^n \pi_i^M$. As he assumes symmetry among the firms this can be written as $n\pi_i^M$. Substituting this into (9) he finds that.

$$n(1 - \rho) < 1 \quad (10)$$

Or in other terms:

$$\rho > \frac{n-1}{n} \quad (11)$$

What this tells us is that when the number of firms increases, the critical value which ρ has to take in order for the cartel to remain sustainable increases as well, which makes the cartel less stable and more difficult to sustain.

However, Brock and Sheinkman (1985) show that cartels that operate in markets with capacity constraints can be positively affected by an increase in the number of membership firms. They explain this by noting that when a cartel consists of a small number of members, the output the members would produce in a competitive setting might be just slightly larger than the cartel output. This means that the cost of deviating, the forgone profits from continuing to collude, is not sufficiently high to deter firms from deviating. If the number of membership firms increases, so does the difference between the cartel output and the competitive output, which increases the cost of deviating, thereby stabilizing the cartel. Brock and Sheinkman (1985) however notice that when the number of members increases, the cartel profits per capita will decrease, thereby lowering the gains from the cartel agreement, which would destabilize the cartel. They therefore manage to show that when a cartel consists of a small number of members, an increase in membership firms might initially have a positive effect on cartel stability, but when the number of membership firms becomes too large, cartel stability will be negatively affected by further increases in membership firms.

Another factor that makes it easier for cartels to form and survive is if the market has large entry barriers, like large initial startup investments. The high initial costs can prevent new firms from entering the market and therefore stabilize the cartel since they do not have to worry about any outside competition by firms that might be tempted to enter the market and undercut the cartel price (Pepall, Richards and Norman, 2014). When firms consider colluding by, for example, setting a price above marginal cost, there will be additional profits to be made in the market. In a market with low entry barriers it is easier for new firms to enter the market and undercut the cartel price to get a piece of these profits. Therefore a cartel

in this type of market would likely never form in the first place (Levenstein and Suslow, 2006).

Companies with similar technological levels, market shares and cost structures are also theoretically more likely to collude than those who are not. This because it is easier for them to divide up the market or decide on a mutual price if they all make similar profits in the end (Pepall, Richards and Norman, 2014). Therefore similar firms should have smoother negotiations during the establishing of a cartel and subsequent meetings. If everyone gets an equal share, the question of what is fair is handled easier. Other research shows that the opposite effect might be true instead. Bertrand and Lumineau (2016) argue that due to their illegality there is no legal authority that can control the cartel members' activities, and they are therefore in need of a strong leader firm, which actions the other firms can follow. This means that if all firms are of similar size, there might be a power struggle when forming a cartel and deciding on how the agreement should be arranged which should result in a weaker cooperation all together. Eswaran (1997) also emphasize the need for differences in size amongst cartel members. In a recession, some less efficient cartel members might be facing bankruptcy due to the production limitations caused by the drop in demand. Eswaran then argues that, for a cartel to survive a recession, they need at least one low-cost producer that can decrease their production even further, so that other members of the cartel can keep producing at a sufficiently high level and thereby stay in the market.

Companies from the same country who share the same language, currency and culture might find it easier to cooperate (Levenstein and Suslow, 2011). Imagine two companies from the same country who have been dealing with each other for years and the employees might be familiar with each other. It is easier to imagine that these two companies would conspire to some extent to increase both companies' profits, and that they would have more trust that neither of them would break their agreement as opposed to two firm from different countries which might lack these characteristics. Hugo Van Driel (2000) studies non-economic factors that can affect collusion such as group dynamics and social characteristics of the executives of the firms involved. Similarly to Levenstein and Suslow (2011), he finds corresponding social and cultural values to be important factors for the trust and stability of a cartel.

In a similar way, when companies operate in several different markets together they are more likely to build up a relationship of trust with one another and might therefore be more inclined to start a cartel. The multi-market contact also helps to facilitate collusion in the way that if a

firm cheats on a cartel agreement in one market, the other firm might break their agreement in another market, making it more costly for a cartel member to deviate from a mutual strategy (Pepall, Richards and Norman, 2014).

We have in this section seen that cartel stability is affected by several different factors, both positively and negatively. Cartels both have to worry about how to remain profitable as well as sustainable. Most of this discussion has however not accounted for the illegality of cartels and the means that antitrust authorities are taking in order to prevent them. The possibility of getting caught by an Antitrust Agency affects the firms' incentives to enter and to remain in a cartel, as heavy fines are imposed on those firms which are found guilty of illegal anti-competitive behavior.

3. Leniency programs

Detecting and proving the existence of cartels is a difficult task for the Antitrust Agencies around the world. Being aware of the factors which help facilitate collusion and using this knowledge to monitor markets in order to detect and uncover cartels can help the authorities, but this is not always enough. The authorities are at a disadvantage as the cartel members have the true information regarding such factors as market demand and, transportation and production costs (Pepall, Richards and Norman, 2014). Extensive evidence of actual colluding is needed to be able to prove the existence of, and to sentence a cartel. Although cartel existence is difficult to prove it is not impossible as shown by the fact that the authorities have managed to detect numerous cartels and have been able to impose fines and sentences on the firms involved. One of the tools that is used by Antitrust Agencies to combat cartels is what is known as a leniency program.

3.1. What is a leniency program?

Even though most leniency programs differ in their characteristics and details, depending on which countries' or regions' leniency programs you choose to look at, there are certain characteristics that are found in most of them. Pepall, Richards and Norman (2014) provide a generalization of the form of most leniency programs as: "The first member of a cartel to provide evidence that leads to successful prosecution of the cartel receives lenient treatment. Everybody else is subjected to heavy fines" (p 375). Lenient treatment in this case usually means getting your fine removed entirely or significantly reduced. It should be noted that in

some countries more than one firm can be entitled to lenient treatment. It is however usually only the first firm to expose the cartel that can receive full immunity.

3.2. What is the purpose of a leniency program?

The objectives of a leniency program can be separated into two parts; ex-ante deterrence, meaning to deter firms from entering into cartel agreements, and ex-post deterrence, which includes the detection and prosecution of existing cartels (Klein, 2010). These two objectives are related in the way that the more effective the competition authorities become in detecting and prosecuting cartels, the more reluctant should firms be from entering into cartel agreements which should be the ultimate goal of any effective competition authority (De, 2010).

3.3. Theoretical properties

Knowing the objectives of leniency programs, the next step is to discuss how, in theory, leniency programs hope to achieve these objectives, and how leniency programs affect the dynamics of cartel agreements.

3.3.1. Review of theoretical research

As discussed earlier, cartel stability is affected by the expected payoff from colluding versus the expected payoff from deviating from the cartel. On the basis of this, several authors have tried to map out optimal leniency programs and the effects these have on cartels.

According to Harrington (2008), when a leniency program is in place the cartel members have the possibility not only to deviate from the agreement but also at the same time report the cartel and by doing so receive a reduction in fines. He calls this the *Deviator Amnesty Effect* and it works to destabilize cartels as it makes the payoff from cheating greater. Increasing the payoff from cheating creates a situation where the ICC is more easily violated and therefore makes cartels more difficult to sustain. Similar reasoning can be found in Spagnolo (2005).

Leniency programs might however also increase the payoff from colluding as the colluding firms know that they have the possibility to enter into a leniency program and by doing so get a reduction in fines. Naming this the *Cartel Amnesty Effect*, Harrington (2008) argues that this will reduce the expected penalties from detection. This means that the expected payoff from continuing to collude increases, which should stabilize the cartel. The increase in expected payoff could also cause more cartels to form than would be the case if a leniency program was

not present. That leniency programs may encourage pro-collusive behavior since they may reduce the expected fines facing the cartel members is also found by Motta and Polo (2003) and they therefore argue that leniency programs should not be used by Antitrust Agencies if they have sufficient resources to prevent collusion using full fines. Leniency programs, they argue, is therefore a second best solution and should be used when the Antitrust Authorities have limited resources as it raises the probability of firms to reveal information. Leniency programs thereby increase the probability of ex-post deterrence while saving Antitrust Agencies resources, and by doing so, also increases welfare.

To what degree a leniency program offers reductions in fines or immunity can have an effect on its destabilizing properties. A more lenient program that offers large reductions in fines can accordingly to Harrington (2008) create what he calls *The Race to the Courthouse Effect*. Why it is important to distinguish between different types of leniency programs is as he explains it; when minimal leniency programs are offered (low reductions in fines) there can be equilibrium for no firm in the cartel to apply for amnesty. He means that offering a more lenient program increases the willingness to apply for amnesty and can turn the cartel game into a Prisoners' Dilemma by making applying for leniency the firms' dominant strategy. The firms therefore face a situation where the probability of getting reported and caught has increased, and thereby an increased probability of having fines imposed as well. Since the cartel members know that the expected reduction of fines is larger for the first firm to report than it is for subsequent firms, this causes the importance of being the first firm to report to increase, thus spurring a race to the authority's door. This destabilizes the cartel by making the expected payoff from colluding decrease and thus making collusion more difficult.

Similar to Harrington (2008), Spagnolo (2005) writes about how leniency programs can increase the expected payoff of a firm that defects and reports, to a level above that of a firm that only defects, which makes the cartel less stable. He argues that the most effective leniency programs limit the lenient treatment to the first firm to report. He means that leniency programs may have a deterring effect on cartels since cartel members now have the possibility to cheat and report to avoid fines which would cause entry into, and continued cooperation in cartels to become more risky. Spagnolo (2005) continues to argue that for a cartel to be sustainable it is necessary that the members trust that no one will cheat on their arrangement. Leniency programs may cause breakdowns in trust between the cartel members and can create a situation close to the *Race to the Courthouse Effect* by increasing the probability that a firm will cheat on the cartel and contact the authorities. If lenient treatment

is offered to more than one cartel firm, the members of a cartel may feel safer as they know that it is possible for them to wait and see if one firm decides to cheat. If this happens they know that even if they are not first to report they can still cooperate and get their fines reduced (Spagnolo, 2005). Therefore if more than one firm is eligible for leniency it may mitigate the *Race to the Courthouse Effect*.

Although different authors differ in their beliefs of what constitutes an optimal leniency program, the theoretical research suggests that leniency programs do indeed change the cartel members' incentives to cheat and report the cartel to the authorities which should make cartel agreements less stable.

3.4. Previous empirical studies

In reviewing the theoretical properties and its effects, Brenner (2009) evaluates the European Commission's leniency program using data from 61 cartel cases between the years 1990 and 2003. As the leniency program was implemented in 1996 he tries to evaluate the efficiency of the program. He differentiates between short-run effects (information revelation and reductions in investigation and prosecution costs) and long-run effects (the deterrence of collusive behavior). He manages to show that the EC's leniency program has provided some significant short-run effects but that it is not possible to show that it yet has had any long run effects.

Nathan H. Miller (2009) conducted another study in which he evaluates the leniency program that was introduced in USA in 1993. For this study he uses cartel data gathered from the Department of Justice which covers a 20 year period (1985-2005). He finds that after the introduction of the leniency program, the number of detected cartels initially increased and then fell to pre-lenieny levels. Using this finding he argues that the initial increase in cartel detection can be attributed to the program's capabilities to enhance detection. The following decrease in detected cartels, he argues, can be attributed to the leniency program's ability to deter firm from colluding.

Similar to us, Hoang et al. (2014) try to determine what factors impact the probability of firms to self-report. This is done by using a probit-model with publicly available case data from the EC between the years 2000 and 2011. What they find is that the size of the basic fine, which they use as a proxy for the expected fine, positively impacts the probability of becoming a snitch. Furthermore they find that other variables that increase the probability of becoming a

snitch includes if the firm is a repeat offender, how many countries are active in one group and the size of the group's market share.

Two articles that have used cultural factors as part of their analyzes of cartels are Brenner (2011) and Bertrand and Lumineau (2016). These two papers include a variable called uncertainty avoidance. This variable is defined as “the extent to which a society feels threatened by uncertain and ambiguous situations” (Hofstede cited in Brenner, 2011, p 225) and is part of a set of six indexes measuring cultural dimensions developed by Geert Hofstede to describe differences in culture among different countries.

In his article, Brenner (2011) hypothesizes what variables may cause firms to self-disclose information to the European Commission. His focus lies on organizational and cultural factors. He looks at whether multinational enterprises are more likely to reveal information and how the heterogeneity in cultural factors in the countries in which the firms are based can explain the heterogeneity in which firms decide to cooperate with the authorities. He does this by using a logit-model and a two-step analysis. In the first step he looks at cartel-level variables and investigates how these may impact the decision of a firm to report the cartel. On this level his main question becomes how the cartel structure may cause any firm in the cartel to report it to the authorities. On the second level he looks at firm specific data in order to determine what factors may have caused the specific firm to report the cartel. He finds support for his hypothesis that multinational enterprises are more likely to cooperate with the authorities due to the large legal resources they have at their disposal. He does not however find any decisive evidence that the cultural factors; uncertainty avoidance and collectivism, have a significant impact on which firm will report the cartel.

Bertrand and Lumineau (2016) conduct a study in which they analyze the longevity of cartels using data from the European Commission. Their main focus is to analyze how the variety in different firm characteristics relates to how long cartels survive. They develop a theoretical framework within which they hypothesize that variety in age-based experience and power disparity should be positively related to the longevity of cartels. Furthermore they argue that separation in uncertainty avoidance should affect the longevity in a negative way. Their findings support their hypotheses, which mean that diversity among cartel members seems to be an important factor when it comes to explaining cartel stability and duration.

4. The European Commission's leniency program

As our data set is gathered from the EC and due to us wanting to evaluate what factors may cause a firm to snitch on their cartel agreement and how certain variables might explain the duration of sentenced cartels by the EC we will in this section provide an overview of the leniency program used by the EC.

4.1. Cartels

In their work to catch existing cartels and to deter new ones from forming, the EC implemented a leniency policy in 1996 as an effort to weaken cartel cooperation. After the implementation of this policy the EC found that a majority of the detected cartels were self-reporting and therefore caught and stopped due to the leniency policy (European Commission, 2013).

4.2. Leniency program

The EC reasoned that the implementation of the 1996 leniency program would benefit the members of the EU because stopping the societal losses incurred by cartel behavior is more important than the ethical question of fining every wrongdoer (European Commission, 1996). The leniency policy consists of a set of conditions that explains what is demanded of a company that would like to apply for leniency and reduce their fines.

4.3. Conditions for leniency

To receive a very substantial reduction of over 75% of the amount of the fine, or even a total exemption from it, there are five main conditions from the EC that need to be met (European Commission, 1996). The first is that the company has to inform the EC about the cartel agreement and who the members are before the EC has started an investigation against any of the involved companies. Secondly they have to provide substantial evidence that there is in fact a cartel and in which way it operates. Thirdly they have to have stopped their own involvement in the cartel on the same day that they report its existence to the EC at the latest. The fourth condition is that during the course of the investigation the company has to keep providing any documents and evidence that they might possess concerning the cartel activities and cooperate to a full extent with the EC. The fifth and final condition is that the company has never recruited or persuaded any new members to join. If a firm fulfills some of these conditions but not all of them, they can still receive a reduction in fines in various degrees depending on their level of cooperation (European Commission, 1996).

4.3. Basic fine 1996

Two years after the implementation of the leniency policy in 1996, the EC decided to release the basic guidelines for how the fines they impose on anti-competitive activities are set. This was done as an effort to be more transparent and open (European Commission, 1998). First they set a basic fine on an infringement based on the gravity and duration of the violation. Although the companies that are involved in a case have been part of the same cartel, it is possible for them to have acted differently and during different periods of time. It is therefore possible for different firms to get different basic fines in the end. The fines imposed are also supposed to reflect a company's turnover during the period of the infringement and should reflect a company's relative size and market power as well as the economic ramifications during the affected period. Although as a basic rule, the fine may never exceed 10% of a company's annual profit no matter the circumstances (European Commission, 1998). Because there is a limitation period of five years on anti-competitive infringements, firms that have ended their participation in a cartel cannot be subjected to any fines after this period of time (European Commission, 2011).

The basic fines are later multiplied by either increasing or decreasing factors if there are any aggravating or mitigating circumstances (European Commission, 1998). One of the three main aggravating circumstances is if the company is a repeat offender, which will increase the fine to some extent per previous infringement. Another aggravating circumstance is if companies refuse to cooperate with the EC. This could even be to the extent that the companies try to hinder the EC's investigations by hiding or destroying evidence, or not letting the investigating authority enter their premises. The third main aggravating circumstance is if a company has started or acted as a leader of a cartel. The main mitigating circumstances that could decrease a company's fines is if they held a passive role in the cartel, if they never actually implemented the illegally agreed upon practices, if there is reasonable doubt as to whether the company understood that they were committing a violation or if the violation was committed due to ignorance or negligence (European Commission, 1998).

To resolve the gravity of an infringement the EC divides them into three different categories; minor, serious, and very serious infringements. A minor infringement is usually fined between 1000 euro and 1 million euro, a serious infringement between 1 and 20 million euro, and a very serious infringement is normally fined over 20 million euro (European Commission, 1998).

The duration of the infringements is also divided into three categories; short, medium and long duration. An infringement that lasts for less than a year is considered short and does not result in an increase of the basic fine. If the infringement has been going on for between one and five years it is considered to be of medium duration and usually increases the basic fine by up to 50%. The long duration infringements last over five years and typically increase the basic fine by up to 10% per year (European Commission, 1998).

The firms usually have about a week to pay their fines and after they are collected from the parties involved, the money goes into the EU's communal budget. These fines therefore help fund the EU's activities and can lessen the tax load on people from all of the member states (European Commission, 2006a) which would result in an increase of social welfare. The convicted cartel cases therefore help raise the social welfare in two different ways, since they are also stopping the anti-competitive actions and therefore making the markets more effective.

4.4. Updates of the leniency guidelines

In 2002, the EC decided to update their guidelines on the level of fines imposed on illegal anti-competitive activities. Although this update did not bring about any major changes to the procedure of setting fines, it did provide some clarifications to what was actually demanded by the EC for firms to receive lenient treatment. After evaluating their work on cartel combating and what effect it had had, in 2006 the EC once again updated their guidelines. This time the guidelines were mainly updated so that the EC would be able to impose larger fines on long lasting cartels acting on larger scale markets (European Commission, 2006a). The EC felt that the implemented policy from 1996 had not been catching big enough actors and therefore decided to up the ante on the fines imposed on big cases so that they could be appropriately punished. Larger potential fines should decrease the expected payoff for an illegal cartel and should therefore both work as deterrence and as an incentive to report on your illegal activities and apply for the leniency notice.

After updating their guidelines in 2006 the EC issued a press release where they pointed out the main differences in the new guidelines (European Commission, 2006a). The gravity of an infringement incorporated in the basic amount of the fine now relates to a percentage of up to 30% of the firm's value of sales during the last full business year of their participation in the cartel. This amount is then multiplied by the number of years the infringement lasted (European Commission, 2006b) So instead of starting with a lump sum and then adding 10%

for each year the of the infringement, they now multiply by the number of years which means, for example, that cartels that lasts for two years instead of one, now receives an increase in fines by 100% instead of a mere 10%.

They also introduced an entry fee, meaning that as soon as a firm joins a cartel, they risk a fine of 15 to 25% of their yearly sales in the appropriate time period even if they were only part of the cartel for one day (European Commission, 2006b). This entry fee is meant to deter firms from joining cartels since the fine is quite substantial even for very short infringements.

Lastly the EC made the fines for repeat offenders stricter and significantly larger than before. The EC now increases the fine for repeat offenders with up to 100% per previous conviction. This does no longer only take into account earlier convictions by the EC itself, but also include decisions from national competition authorities (European Commission, 2006b). This inclusion results in a larger number of companies risking an increase in fines due to being repeat offenders. This increases the incentives for these companies to expose their cartels and apply for leniency, since the expected payoff of staying in the cartel decreases.

4.5. Settlement

The latest thing that has happened with the EC's efforts with upholding the anti-competitive laws is the introduction of a settlements procedure possibility in 2008 which was inspired by the Department of Justice. In a press release the Competition Commissioner of the EC, Neelie Kroes commented "This new settlements procedure will reinforce deterrence by helping the Commission deal more quickly with cartel cases, freeing up resources to open new investigations" (European Commission, 2008). Basically, the EC offers a 10% reduction of fines to any company being charged in a cartel case as long as they do not dispute the allegations. If the company is already eligible for a fine reduction under the leniency notice, the 10% from the settlement procedure will be added cumulatively to the previous reduction. The EC does not believe that the settlement option affects the incentives to use the leniency program, but that it instead works as a complement to it by offering further incentives to cooperate with the authorities (European Commission, 2008).

5. Hypotheses and Variables

In this following section we provide a discussion relating to our two main questions, namely what factors may cause a firm to self-report its cartel to the EC and what factors influence cartel stability in the EU. We provide a number of hypotheses regarding the factors we

believe have an effect on these two questions and the variables we use to measure these effects.

5.1. Snitches

In this subsection we discuss our hypotheses related to what factors may cause a firm to report a cartel to the European Commission. What we try to do is to map out how the snitching firms differ from the other firms in the cartel, which we later test in a probit model.

Due to the limitations of our data we chose to limit our empirical analysis to five testable hypotheses that relates to (1) fines before reduction, (2) relative length of cartel participation, (3) repeat offender, (4) country quota, and (5) uncertainty avoidance.

5.1.1. Fines before reduction

The EC provides the interested reader with information about how they calculate the fines they impose on exposed cartel members, and the firms themselves are therefore able to approximate the size of the fine they might face if they are discovered. As leniency programs aim to change the cost-benefit analysis of cartel firms, we can argue that if the fines firms face increase, *ceteris paribus*, the expected cost of participating in a cartel increases, and therefore the incentives to self-report should increase. This logic is rather straightforward and can also be found in Hoang et al. (2014).

We argue however that it is not just the actual size of the fine that is of importance, but how the size of the fine relates to the other cartel members' fines. We have therefore calculated the total fine the cartels faced, if detected, and thereafter use this to see how big of a share of the total fine each firm expects to pay. Following the same logic as above, we argue that the larger the share of the fine firms will have to pay, the more likely they are to report the cartel.

Hoang et al. (2014) also hypothesize that market share should relate positively to the probability of becoming a snitch, as firms in a dominant position would want to maintain this position and that a high fine therefore may “jeopardize their own performance while strengthening the performance of the competitor who eventually receives immunity from fines” (p 19).

The fines cartel firms face are partially based on their sales during the infringement period (European Commission, 2006b). If a firm faces a higher fine than another firm this can, *ceteris paribus*, be explained by the fact that it had higher sales. Using share of total fine

instead of the actual fine, we argue, also captures the differences in the cartel firms' market shares. As both market share and fine should increase the probability to snitch we formulate the following hypothesis:

***Hypothesis 1.1:** "The probability of becoming a snitch increases with a firm's share of the expected total fine"*

We have calculated this variable by dividing the individual fine before reduction with the cartel's total fine before reduction and then multiplied with 100. This variable can therefore only display a value between 0-100, where a higher value means that the firm expected to pay a larger share of the total fine. We use fine before reduction as this gives us a measure of what was at stake for the different firms before they were reported and detected. We expect this variable to show a positive sign.

5.1.2. Relative length of cartel participation

As discussed earlier, we know that the expected fine increases the longer a firm is part of a cartel. As this is the case, the expected cost of colluding will increase over time. If we, as Hoang et al. (2014), assume that the expected gains from colluding remain the same, snitching may become more attractive the longer a firm is part of a cartel. Hoang et al. also notice that the *Race to the Courthouse Effect* (as discussed by Harrington, 2008) may be prevalent since all firms face higher fines over time. A firm that has been part of a cartel from the beginning should therefore have larger incentives to get to the authorities' door first compared to a firm that joins a cartel at a later stage.

***Hypothesis 1.2:** "The probability of becoming a snitch increases with the length of a cartel member's individual participation in a cartel"*

To be able to compare cartels of different length, we need to look at the relative lengths of the firms' individual participation. We calculated this by dividing the cartel members' individual length of participation with the total duration of the cartel. Its value therefore varies in the interval of 0 to 1, where 1 means that the firm was part of the cartel from its beginning to its end. Following hypothesis 1.2 we expect this variable to show a positive sign.

5.1.3. Repeat offender

As the fines for repeat offenders are higher than for non-repeat offenders, we expect that firms that have been found guilty of previous cartel participation should have larger incentives to

report. Repeat offenders should also be more informed about how the leniency program works, the process, and the consequences of being found guilty (Hoang et al. 2014). Therefore, these firms are able to make a more calculated choice as to whether to report the cartel or not. Some of these firms may have been found guilty before due to another firm self-reporting, which is something they most likely would like to avoid happening again, which would increase their incentives to self-report.

***Hypothesis 1.3:** “The probability of becoming a snitch increases if a firm is a repeat offender”*

This variable is a dummy variable which take on the value 1 if the firm is a repeat offender and 0 if it is not. Consistent with hypothesis 1.3 we expect the sign of this variable to be positive in our model.

5.1.4. Country quota

Drawing some inspiration from Brenner (2011) and Bertrand and Lumineau (2016), we assume that firms are less likely to snitch if they come from a country that is relatively well represented in a cartel. We assume this because these firms are more likely to have been interacting with each other in settings outside the cartel and in their respective domestic markets, previous to the cartel being established. They are also more likely to interact with each other in the future and maintaining good relationships should therefore be important.

We therefore suggest that there should be a higher degree of trust and willingness to cooperate between firms from the same country, and the willingness to report your countrymen should therefore be lower.

***Hypothesis 1.4:** “The probability of becoming a snitch decreases the more represented a firm’s country of origin is in the cartel”*

To be able to test this hypothesis we created quotas for the firms, which were calculated as $\frac{\text{\# of firms from country } i}{\text{total \# of firms in the cartel}}$. For example a cartel may contain 5 firms where 4 firms are from one country and 1 firm is from another. In this example we get the quotas 0.8 and 0.2 which we assign to the corresponding firms in the cartel. Consistent with hypothesis 1.4 we expect this variable to have a negative sign.

5.1.5. Uncertainty avoidance

Brenner (2011) argues that firms from countries who score high on uncertainty avoidance should be more prone to cooperate with the antitrust authorities. Leniency programs destabilize cartels and create a more uncertain environment for cartel members. Firms know that the other firms may choose to report the cartel in order to avoid fines. Firms from high uncertainty avoidance countries could therefore become more intrigued by the idea of snitching themselves as they then know what the outcome will be and are more in control of the situation.

The probability of a game being played another round is negatively related to the probability of detection. This probability can be viewed differently by different individual firms depending on their risk preferences. For example, a 20% risk of being detected can seem like a lot for a more risk adverse firm, compared to a firm with higher risk preferences. This means that more risk adverse firms are less certain of the future outcome of continuing to collude. Assuming that these firms also originate from countries that score high on the uncertainty avoidance index, this means that they might have lower thresholds for when the risk of detection becomes too large for them to want to stay in the cartel and should therefore be more inclined to deviate from the agreement.

Leaving firms may choose to only deviate, or to both deviate *and* report the cartel to the authorities. If a firm deviates but does not report, any of the other members of the cartel have up to five years to report the cartel and receive immunity from fines before the case is nullified. That means that for five years after leaving the cartel, the firm would be uncertain as to whether another firm would report the cartel to the authorities or not. To not have to risk this uncertain future, a firm with a high score on uncertainty avoidance that wants to leave a cartel should therefore, reasonably, choose to both deviate and report. Following the reasoning above we therefore formulate the following hypothesis:

Hypothesis 1.5: “*The probability of becoming a snitch increases the more a firm wants to avoid uncertain situations*”

To test this we use the variable *Uncertainty avoidance* indexed by Hofstede. This is measured on a scale from 0-100 in which a high score represent a culture which seeks to avoid uncertainty to a high extent. We looked at which country each firm is from and thereafter

assigned that firm the value that corresponds to that country. We expect the sign of this variable to be positive.

5.2. Duration

In this section we analyze which factors we believe might affect the stability of cartel agreements. We look at group specific variables for each of the cartels that we have found, to try and see how they affect the duration of the cartel.

We form hypotheses about six different factors that we believe affect the total duration of a cartel agreement. These six factors are (1) number of firms, (2) multinationalism, (3) the presence of a repeat offender in the cartel, (4) under which version of the EC's leniency program the cartel was sentenced, (5) the heterogeneity of uncertainty avoidance amongst the cartel members, and (6) the differences in size of the companies involved in the cartel.

5.2.1. Number of firms

As discussed previously, the number of firms affects cartel stability in a number of ways. It makes it more difficult for the cartel to coordinate their actions, it lowers the individual firms' profits and it makes the cartel more difficult to sustain as it puts more constraints on the probability-adjusted discount factor (see Pepall, Richards and Norman, 2014; Levenstein and Suslow, 2006; Shapiro, 1989). These three effects point in the same direction and lead us to formulate the following hypothesis:

***Hypothesis 2.1:** Cartel duration should be negatively related to the number of member firms"*

The variable we use to test this hypothesis is the total number of firms that have been part of the cartel at some point during its lifespan. According to the hypothesis, this variable should have a negative sign in our regression model.

5.2.2. Multinationalism

For companies to be able to coordinate their actions and agree on the best course to be taken, theory tells us that firms from the same country, sharing the same culture and values, find it easier to reach satisfactory agreements (see Levenstein and Suslow, 2011; Van Driel, 2000). Therefore, having members from many different countries in a cartel should make it less stable.

Hypothesis 2.2: “Cartel duration should be negatively related to the number of different nationalities amongst the cartel members”

We chose not to use the number of nationalities in the cartel as a variable to measure this effect, since it was strongly correlated with the number of firms in the cartel with a correlation of 0,675 (see Appendix A). Because of this, we decided to calculate a Herfindahl–Hirschman Index (HHI) on the nationalities of the firms in a cartel. This index is usually used to measure the market concentration by analyzing the market shares of firms. Instead of market shares we used quotas for the countries, which were calculated as $\frac{\# \text{ of firms from country } i}{\text{total \# of firms in the cartel}}$. Then we summed the squares of those quotas to receive our Herfindahl-Hirschman Index for each cartel. A score of 1 on this index means that all of the firms involved in the cartel originated from the same country, and a score close to 0 therefore characterizes a cartel with many different nationalities. This measure of multinationalism should therefore have a positive sign when testing cartel duration.

5.2.3. Repeat offender

Exogenous factors like the actions of anti-competitive authorities can affect a cartel’s stability by changing the individual firms’ cost-benefit analyses. A larger potential fine for repeat offenders may cause these firms to expose the cartel. This because they do not want to risk the high fine which would have been imposed on them if they had been detected, thus shortening the duration of their cartel.

Since the information about previous cartel cases and offenders is available to the public, one can assume that the other cartel members know if one of the firms in the cartel is a repeat offender. They therefore know that this firm has more to lose if the cartel is detected and might therefore be more likely to report the cartel to the authorities or break the agreement by deviating. If a firm suspects that another firm in the cartel might be inclined to apply for leniency, the incentives to make a preemptive strike should increase. This might result in them reporting the cartel to the authorities themselves, before the repeat offender firm has a chance. The presence of a repeat offender in a cartel might therefore strengthen the *Race to the Courthouse Effect* since the cartel members might not know if they can trust each other which should shorten the duration of the cartel.

Hypothesis 2.3: “Cartel duration should be negatively related to the presence of a repeat offender amongst the cartel members”

We created a dummy variable for whether one of the member firms in a cartel had been previously sentenced for participating in a different cartel or not. Relating to our hypothesis, this dummy variable should have a negative sign in our regression model.

5.2.4. Leniency program of 2006

The 2006 revised version of the EC's leniency program meant harsher punishments for more long-lived cartels. The new way of calculating the fines were an effort to shake the foundations of even the most long-lived and stable of cartels (European Commission, 2006a). According to Zhou (2013), this means that we might expect an increase in average duration right after the new stricter regulations were taken into practice, but that overall length of cartels should decrease after the implementation. This because new stricter rules for setting fines would in the beginning of their implementation give incentives for firms currently operating in long-lived cartels to report their activities to the authorities to avoid the hefty fines that could be imposed on them otherwise. But in the long run, the effects of this policy change should be to shorten the duration of cartels in general, since the risks of maintaining a cartel agreement for a longer period of time has increased considerably.

***Hypothesis 2.4a:** “Cartel duration should be negatively related to the enactment of the 2006 leniency notice”*

This is measured with a dummy variable. If a cartel was sentenced under the 2006 notice it receives a value of 1, and a value of 0 if it was under previous notices. We expect this variable to have a negative sign in our regression model.

We also want to test an interactive term of the repeat offender variable and the 2006 leniency program. This term tries to specifically capture the effect of the substantial increase in fines for repeat offenders the new guidelines from 2006 imposed, and perhaps be a bit clearer to interpret than the other two variables measured individually.

***Hypothesis 2.4b:** “Cartel duration should be negatively related to the presence of a repeat offender amongst the members of cartels that are sentenced under the 2006 leniency notice”*

This effect is also measured with a dummy variable. Here a cartel receives a score of 1 if it was sentenced under the 2006 leniency notice *and* if one of the members had been previously

involved in a convicted cartel. A cartel that do not meet both of these requirements receives a score of 0. We expect this variable to have a negative sign in our regression analysis.

5.2.5. Uncertainty avoidance

As we mentioned before, a factor that can affect the duration of a cartel is the homogeneity of the member firms. Besides just looking at how diverse the composition of the cartel is regarding nationalities, we also want to locate differences in attitudes regarding the avoidance of uncertainty between the different participant firms. The more heterogeneous the firms in a cartel are regarding their willingness to avoid uncertainties, the less stable should their cartel be, and the shorter one might expect it to last (Bertrand and Lumineau, 2016).

With large differences in how comfortable different companies are in taking risks or precautionary measures, the cartel agreement should likely be less satisfactory for the parties involved which should make the cartel less stable and the length of it shorter. Not only would differences regarding uncertainty avoidance make it more difficult to form a cartel in the first place, but once established there would also be a higher risk of a company defecting from the strategy or even reporting the cartel's activities to the authorities, since there would be an absence of trust and commitment between the involved firms (Bertrand and Lumineau, 2016). For example, a high scoring firm might believe that a low scoring firm is not taking enough precautionary measures to avoid detection and therefore decides to snitch on the cartel to reduce their fine before the cartel is discovered by the authorities. Knowing that the high scoring firms might reason in this way, it is then possible that a low scoring firm's incentives to apply for leniency first increases, causing a downwards spiral of trust, and resulting in a *Race to the Courthouse Effect*.

Hypothesis 2.5: “*Cartel duration should be negatively related to the heterogeneity of the level of uncertainty avoidance between the member firms*”

As we are interested in disparity of how different firms within the cartel feel about avoiding uncertainty, we calculated the standard deviation of the member firms' different scores. This variable should have a negative sign when testing for the duration of a cartel.

5.2.6. Size differences among cartel members

Classic economic theory states that homogeneity in regards to cost structures, market shares, and sizes should facilitate collusion (Pepall, Richards and Norman, 2014). This because homogenous firms should find it easier to reach agreements that facilitates their wants and

needs. Profits are also more easily divided between firms if everyone gets an equal share. As we mentioned earlier, Bertrand and Lumineau (2016) argue that a durable cartel requires leadership, so there might be a struggle for power and control of the cartel if all firms are of similar size, which would weaken the cartel's stability. Furthermore, a long lasting, stable cartel must be able to adjust to fluctuations in the economic climate. Eswaran (1997) therefore argues for the need of a more efficient firm that can cover the losses of the other members of the cartel. These theories point in two different directions and it is difficult for us to determine which effect is more influential, therefore we formulate two different hypotheses regarding this issue:

Hypothesis 2.6a: “Cartel duration should be negatively related to the difference in size between cartel members”

Hypothesis 2.6b: Cartel duration should be positively related to the difference in size between cartel members”

Without any data on the firms' market shares we cannot fully check for how differences in firm sizes affect the duration of a cartel. Since the fine is related to the sales of the firms, we use the expected fine as a proxy for firm size. But since the expected fine also reflects the length of the firm's participation, we first needed to divide the firms' expected fines with their individual length of participation, in order to not make the variable endogenous.

To capture the differences in sizes amongst cartel members, we calculated a Herfindahl-Hirschman Index using each firm's share of their respective cartel's total expected fine. To better account for the equality of the distribution of fines, we normalized the index so that large cartels would not have an unproportioned effect on our results. The formula for the normalized HHI is as follows:

$$HHI^N = \frac{(HHI - 1/N)}{(1 - 1/N)} \quad (12)$$

This index gives a score of zero if all firms in the cartel are of the same size and a score approaching 1 the larger the difference in sizes between the firms are. This variable should therefore have a negative sign if our hypothesis 2.6a is correct and a positive sign if our hypothesis 2.6b is correct.

6. Data and Descriptive statistics

In this section we describe how we collected our data, what some of its limitations are, and how this might affect our results. We also provide some relevant descriptive statistics to give the reader an overview of our data.

6.1. Data gathering process

To our knowledge, no dataset on cartels detected by the EC is available, so therefore we collected all our data manually by going through press releases, official case summaries and publicly available case documents posted on the EC's website. On their website, the EC have listed these documents on a case basis and made them publically available from the year 2001 and onwards. Some information regarding earlier cases might be found as well, but these documents are poorly organized and do not contain all the information that we needed for our analysis. Because of this, and due to time constraints and the scope of this paper, we decided that the data from 2001 and onwards was sufficient for our analysis. Data regarding uncertainty avoidance has been collected from the Hofstede Center, which is a center that has been endorsed by Dr. Geert Hofstede to conduct research and education in such areas as organizational behavior and culture. Our full dataset consists of information about 123 cartels and over 600 cartel members that were detected by the EC between the years 2001 and 2016.

6.2. Processing errors

Because all data was collected by us manually, we are aware that we ran the risk of making processing errors, meaning that it is possible that we entered some values incorrectly, which would influence our results. We tried to account for these possible errors by routinely checking outlying values and comparing the values we entered into our dataset with the original documents.

6.3. Data limitations

Any empirical study that deals with illegal activities will encounter some problems with the collection of data. Illegal activities are secretive in their nature and parties involved in such activities will therefore try to hide their actions. Cartel agreements is normally classified as white collar crimes, which means that they are committed by people not generally thought of as criminals. Since these illegal actions are undertaken by people representing companies that want to look innocent in the eyes of the public, one can imagine that the secrecy aspect of these collaborations are of utmost importance. In the data we managed to collect, we can see

that there have been cartel collaborations of different sizes, in all kinds of different markets, of different magnitudes and with a variety of mixtures of nationalities. Because of these reasons, we suspect that there might be a large number of unrecorded cases that have not been detected.

Since we only have data on detected cartels our data is therefore probably subjected to what is known as sample selection bias. This means that the cartels we have analyzed are not a representative sample of the true population of cartels. Other studies on cartels face the same problem (see for example Marvão, 2016; Hoang et al., 2014; Brenner, 2011), but since the only data that is available is on detected cartels, we must base our analysis on this.

Unfortunately there is no way around this problem and it is important that we keep this in mind later on when we analyze our results.

6.4. Descriptive statistics

Table 1 gives an overview of the variables used to analyze the probability of a firm to self-report. We exclude data on firms that were part of cartels that were detected by the EC's regular investigations, as we are interested in investigating what separates the self-reporting firm from the other firms of the cartel. There are some differences between the groups that are worth noticing. We see that the averages for the variables relative duration, share of fine before reduction and repeat offender are larger for snitches than for the other cartel members, which is in line with our hypotheses. The differences regarding country quota and uncertainty avoidance are however not in line with what we hypothesized.

Table 1
Descriptive statistics
Firm Level

Variable	Snitches			Other cartel members			Total				
	N	Mean	Sd	N	Mean	Sd	N	Mean	Sd	Min	Max
Individual Duration (Months)	67	84,045	76,646	328	81,378	64,132	395	81,830	66,442	3	419
Relative Duration	67	0,909	0,219	328	0,806	0,276	395	0,823	0,270	0,038	1
Fine before reduction (Million Euro)	67	92,438	129,784	328	59,060	97,494	395	64,722	104,248	0,001	690
Share of fine before reduction (%)	67	27,316	20,414	328	13,906	15,185	395	16,181	16,928	0,0003	81,569
Repeat Offender	67	0,388	0,491	328	0,223	0,417	395	0,251	0,434	0	1
Country quota	67	0,320	0,255	328	0,312	0,206	395	0,314	0,214	0,056	1
Uncertainty Avoidance	67	59,149	18,186	328	67,978	19,744	395	66,480	19,747	8	100

Table 2 provides some descriptive statistics over our key variables used in our regression on cartel duration. Data was available on over 120 detected cartels but unfortunately data on all variables was not always available. Therefore we had to limit our analysis to 102 cartels, 64 of which were detected due to self-reporting firms, and 38 were detected by the EC's regular investigations.

Table 2
Descriptive statistics
Cartel Level

Variable	Self-Report			Others			Total				
	N	Mean	Sd	N	Mean	Sd	N	Mean	Sd	Min	Max
<i>Duration (Months)</i>	64	97,906	81,608	38	76,105	67,725	102	89,784	77,115	2	419
<i>Number of firms</i>	64	6,297	3,987	38	4,395	2,284	102	5,588	3,561	2	18
<i>Number of nationalities</i>	64	4,125	2,157	38	2,447	1,179	102	3,5	2,018	1	13
<i>HHI of nationalities</i>	64	0,378	0,221	38	0,571	0,293	102	0,450	0,266	0,082	1
<i>Repeat offender (Dummy)</i>	64	0,578	0,498	38	0,579	0,500	102	0,578	0,496	0	1
<i>Sd Uncert. Avoidance</i>	64	15,596	7,407	38	12,696	10,381	102	14,516	8,700	0	33,941
<i>LP 2006 (Dummy)</i>	64	0,578	0,498	38	0,211	0,413	102	0,441	0,499	0	1
<i>Normalized HHI of fines</i>	64	0,142	0,132	38	0,159	0,136	102	0,148	0,133	0	0,640
<i>Repeat/2006 (Dummy)</i>	64	0,3125	0,46718	38	0,079	0,273	102	0,225	0,420	0	1

7. Econometric models

In this section we discuss the two different models we use to test our hypotheses. We chose to use a binary choice model for our analysis of the self-reporting firms and a multiple regression model to test our hypotheses relating to duration.

7.1. Probability model

In this section we explain the model we use to estimate how our variables affect the probability of becoming a snitch. As our dependent variable (Snitch) is a binary variable, meaning that it only can take on the value of 1 or 0, we use a binary choice model. The snitch variable measures whether the firm was a snitch or not, taking on the value 1 if the firm did snitch, and 0 if not. To ensure that the probability of becoming a snitch lies in the interval between 0 and 1 we use the probit model as opposed to a simple linear probability model. The probit model also has the advantage of not assuming that the marginal effects are constant. Since it is usually more realistic to assume that the marginal effects are declining when X_i is increasing, this model should be a better fit than a simple linear probability model.

The probit model assumes that the probability p_i of an event occurring is determined by the function $F(Z)$:

$$p_i = F(Z_i)$$

where $F(Z)$ is the cumulative standardized normal distribution (Dougherty, 2011, p 365-366).

As our dependent variable can only take on the value of 1 or 0, the probability of a firm becoming a snitch is thus specified by the following function:

$$p_i = p(\text{Snitch} = 1) = F(Z_i)$$

Where Z_i is a linear function that we estimate using the following expression:

$$Z_i = \alpha + \beta_1 \text{Share_of_exp_fine}_i + \beta_2 \text{Rel_Dur}_i + \beta_3 \text{Repeat_offender}_i \\ + \beta_4 \text{Country_quota}_i + \beta_5 \text{Uncert_Avoid}_i + \varepsilon_i$$

When using the probit model it is important to know that the estimates for the coefficients are not the same as the marginal effects. What the coefficients can tell us is what sign the marginal effect will have. To calculate the marginal effect we take the derivate of our probability function with respect to our explanatory variable X_i which will result in the following expression.

$$\frac{\delta p}{\delta X_i} = \frac{dp}{dZ} \frac{\delta Z}{\delta X_i} = f(Z)\beta_i$$

Since $F(Z)$ is the cumulative standardized normal distribution, its derivate $f(Z)$ is the standardized normal distribution (Dougherty, 2011, p 365-366):

$$f(Z) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}Z^2}$$

The marginal effect is thus calculated by multiplying the estimated coefficient, β_i , with the expression above.

7.2. Stability model

To be able to measure which effects have an impact on the duration of cartels, we use a multiple regression analysis. This method lets us see to what extent different variables affect our dependent variable, total cartel duration, by estimating regressive coefficients for each explanatory variable. These coefficients then tell us the marginal effect on cartel duration when increasing the explanatory variable by one unit. With our chosen variables, our regression is estimated with the following equation:

$$\text{Duration}_i = \alpha_i + \beta_1 \text{No_of_Firms}_i + \beta_2 \text{HHI_Nationalities}_i + \beta_3 \text{Repeat_Offender_Dummy}_i \\ + \beta_4 \text{Sd_of_Uncert_Avoidance}_i + \beta_5 \text{LP2006_Dummy}_i \\ + \beta_6 \text{Normalized_HHI_Fines}_i + \beta_7 \text{Repeat_Offender_in_2006}_i + \varepsilon_i$$

More specifically we use an ordinary least squares (OLS) method to obtain the best linear unbiased estimates (BLUE) according to the Gauss-Markov theorem. For an estimation to be BLUE they need to have the smallest variance (best), represent a linear relation between the variables, while also being unbiased (Dougherty, 2011). For the Gauss-Markov theorem to hold, there are certain assumptions about the model specification and the error terms that need to be met. These are as follows; that the model is linear in the parameters, that the explaining

variable is not constant, that the expected value of the error term is equal to zero, that the error terms are homoscedastic, that the error terms are not autocorrelated and that the error term comes from a normal distribution. The avid reader can learn more about these assumptions in Dougherty (2011).

7.3. Econometric issues

In this section we discuss different issues that might arise when conducting econometric analyses and how these might affect our results.

7.3.1. Heteroscedasticity

When running a multiple regression we face the risk of encountering heteroscedasticity in our error terms. This means that the variance of the error terms is not constant (Dougherty, 2011). When heteroscedasticity is prevalent, the OLS estimators lose their reliability and effectiveness, and are therefore no longer BLUE. It also causes the standard errors of the variables to be incorrect, which leads to both the t-tests and F-tests on the regression running the risk of being invalid. Because of this, the analysis of the independent variables' effect on the dependent variable will be inconclusive (Dougherty, 2011).

To see if our OLS regression shows any signs of heteroscedasticity we first conducted a visual analysis of the residuals in a scatter plot diagram. Since we were not able to determine any particular trends or patterns we were pleased and moved on to a statistical test. We performed a White-test on the different regressions, which reaffirmed our conclusion from the visual analysis and therefore we cannot reject the null hypothesis of homoscedasticity in the model. Based on these two results we assume that our model is not subjected to heteroscedasticity. Both scatter plots and the results of the White-test can be found in Appendix A. We also include histograms over the distribution of the error terms which seem to come from a normal distribution and they have a mean value of approximately zero, which the Gauss-Markov theorem requires.

Since the model we use in our analysis of snitches is a probit-model, meaning that it is non-linear, we cannot use the White-test to see if this regression shows any signs of heteroscedasticity. Instead we followed the instructions in the E-views User Guide (E-views, 2014) which describes an artificial regression method developed by Davidson and MacKinnon in which you test the null hypothesis of homoscedasticity. This test showed a p-

value of 0,95 which means that we cannot reject the null hypothesis of homoscedasticity. Therefore, we assume that our model did not show any signs of heteroscedasticity.

7.3.2. Multicollinearity

If two or more of the explaining variables in a multiple regression show some sort of linear relationship, the model is said to be suffering from multicollinearity. This leads to an increase in the variance of the variables and therefore weakens the explanatory abilities of the model. If this effect is sufficiently large, it might cause problems with the estimation of the coefficients and the estimates would then become unreliable (Dougherty, 2011). To try to detect any multicollinearity in our model, we first checked for any strong correlations between our variables, using a correlation matrix. It is however important to remember that when the model has more than two explaining variables, as is the case in our regression, it might not be enough to simply check for correlation in pairwise observations (Dougherty, 2011). So to further our analysis we also conducted a test on the Variance Inflation Factors (VIF) of the model. This test checks if there are any linear relationships between the explaining variables by running a regression on each of the variables separately, with the remaining variables as explaining variables. If this regression has a large coefficient of explanation, there might be multicollinearity in the model. The VIF value is then determined as $\frac{1}{(1-R_i^2)}$ and a rule of thumb is that it should be below the value of 10 if there is no prevalence of multicollinearity in the model (Baum, 2006). Fortunately, none of our variables have high VIF values and therefore they show no indication of being linearly related to each other. The correlation matrix and the results of the VIF tests can be found in Appendix A.

As there are no VIF tests available for the probit model, we settled for checking for signs of multicollinearity by using a correlation matrix, which can be found in Appendix A. The highest correlation between two variables is 0,36 which implies that our model does not show any signs of multicollinearity.

8. Results

8.1. Snitches

Table 3 below displays the average marginal effects with the p-values in the parentheses from our probit model. As the marginal effects in the probit model are not constant but functions of the value of Z_i , which is dependent on the value of our independent variables X_i , the marginal effects shown in the table below have been calculated by using the averages of our independent variables. This means that the marginal effects displayed are valid for the average firm in our sample, which is why they are specified in the table as Average Marginal Effects. We choose to display the average marginal effects as opposed to the estimated coefficients, as there is no clear way to interpret the regular coefficients. The interested reader can find a table displaying the coefficients in Appendix A. Our main results are presented in regression (5).

Table 3

Dependent Variable: Snitch (1/0)

Method: Binary Probit

Average Marginal Effects

Variable	(1)	(2)	(3)	(4)	(5)
<i>C</i>	-0,496*** (0,000)	-0,634*** (0,000)	-0,673*** (0,000)	-0,641*** (0,000)	-0,400*** (0,008)
<i>Share of exp. fine</i>	0,0081*** (0,000)	0,0081*** (0,000)	0,0078*** (0,000)	0,0081*** (0,000)	0,0078*** (0,000)
<i>Relative duration</i>		0,138 (0,293)	0,141 (0,300)	0,167 (0,221)	0,201 (0,165)
<i>Repeat offender</i>			0,108 (0,103)	0,095 (0,152)	0,097 (0,160)
<i>Country quota</i>				-0,162 (0,271)	-0,113 (0,460)
<i>Uncertainty Avoidance</i>					-0,005*** (0,006)
McFadden R-sq	0,077	0,090	0,097	0,100	0,122
N	407	395	395	395	395

Significance Level

* $p < 0,10$

** $p < 0,05$

*** $p < 0,01$

As we can see, the McFadden R-squared shows a value of 0,122 which represents the goodness of fit of our model. Although it is not equivalent to the R-squared found in an OLS

model, the value still indicates that the model explains 12,2 % of the variance in our dependent variable.

8.1.1. Share of expected fine

In hypothesis 1.1 we state that the probability of becoming a snitch should become larger when a firm's share of the expected total fine increases. As our results show, this seems to be the case as the variable *Share of exp. fine* both shows the hypothesized positive sign and is highly significant. On average, an increase in share of expected fine with 1 percentage point increases the probability of becoming a snitch with 0,78 percent. This result is also consistent with the descriptive statistics shown in table 1, where we can see that snitches, on average, expected to pay a larger share of the fine.

8.1.2. Relative duration

This variable, in line with our hypothesis, shows the expected positive sign. However, the variable is not significant which means that a firm's relative duration in a cartel does not seem to have an effect on the probability to snitch on the cartel.

8.1.3. Repeat offender

In hypothesis 1.3, we hypothesize that being a repeat offender should increase the probability of becoming a snitch. The regression cannot confirm this as the variable is insignificant, which indicates that repeat offenders are not more prone to snitch than first time offenders. We do however note that the variable shows the expected positive sign.

8.1.4. Country quota

In hypothesis 1.4 we argue that this variable should show a negative sign, which we also see in the regression results. The variable is however insignificant and it is therefore not possible for us to say whether this has any effect on the probability to self-report.

8.1.5. Uncertainty avoidance

Uncertainty Avoidance shows, contrary to our hypothesis, a negative sign and is statistically significant. This indicates that the more you want to avoid uncertain or ambiguous situations, the lower is the probability that you will become a snitch.

8.2. Duration

In the table below we see the results from our linear regressions of the duration of cartels. In the table we present the variables' coefficients, with their respective p-values in parentheses. We also see the R-squared value, which is the coefficient of determination of the regression. We run two regressions, (1) and (3), on the total 102 cartels in our sample as well as two on just the 64 self-reporting cartels, (2) and (4).

Table 4
Dependent variable: Duration
Method: Multiple Regression

Variable	(1) Total	(2) Self-report	(3) Total	(4) Self-report
<i>C</i>	106,706** (0,016)	149,016** (0,011)	67,087 (37,951)	101,344 (0,110)
<i>No. of firms</i>	5,512** (0,014)	4,417 (0,107)	6,568*** (0,003)	5,242* (0,057)
<i>HHI Nationalities</i>	-54,609 (0,207)	-82,236 (0,193)	-44,274 (0,293)	-59,814 (0,345)
<i>Repeat offender dummy</i>	-13,205 (0,406)	-10,969 (0,589)	28,756 (0,194)	32,565 (0,3219)
<i>Sd. of Uncert. Avoidance</i>	-0,544 (0,657)	-1,871 (0,245)	-0,853 (0,474)	-1,769 (0,265)
<i>LP2006 dummy</i>	-32,085** (0,041)	-54,142*** (0,006)	18,261 (0,452)	-12,117 (0,700)
<i>Normalized HHI fines</i>	43,965 (0,447)	133,686* (0,092)	81,490 (0,160)	160,022** (0,046)
<i>Repeat offender in 2006</i>			-81,943*** (0,009)	-66,473* (0,098)
R-sq	0,148	0,283	0,208	0,317
Adjusted R-sq	0,094	0,207	0,149	0,232
N	102	64	102	64

Significance Level

* $p < 0,10$

** $p < 0,05$

*** $p < 0,01$

When we ran the regressions on the 38 cartels in our sample that were detected due to the EC's regular investigations, they had a negative adjusted R-squared value and none of the variables were significant. This then tells us that the theories on cartel stability that we investigate and test do not seem to be applicable to these cases. This is not particularly surprising since the 38 cartels that were caught by the EC's investigations were not necessarily unstable, but might rather have been unfortunate to have been detected. The R-

squared values in Table 4 also indicate that our model is a better fit for only testing the duration of cartels that are detected due to a self-reporting firm.

8.2.1. Number of firms

In our hypothesis 2.1 we argue that a larger number of cartel members should have a negative impact on the stability of a cartel and therefore shorten its duration. Our results, however, indicate the opposite, with significant positive coefficients in all our regressions except (2), which had a p-value of just above 0,10. This means that, the more firms there are in a cartel, the longer it should survive.

8.2.2. Herfindahl–Hirschman Index on nationalities

In the case of the number of nationalities in a cartel, the results differ from our hypothesis as well. Theories state that cartels consisting of member firms from many different countries should be less stable (Levenstein and Suslow, 2011; and Van Driel, 2000) and therefore last a shorter period of time, but our regression results tell another tale. The negative coefficient on the Herfindahl-Hirschman Index on nationalities tell us that the more concentrated a cartel's composition is, in terms of nationalities, the shorter amount of time should it survive. However, since the coefficient is not significant, we cannot with certainty say that this is in fact the case.

8.2.3. Repeat offender

As expected, the dummy variable measuring if one of the members of the cartel had ever been part of another cartel before shows a negative sign in regression (1) and (2). It was however not significant.

In regression (3) and (4), in which the interactive variable is included, *Repeat offender dummy* changes sign but is still not significant. In this regression it measures what effect the presence of a repeat offender had before the implementation of the revised 2006 leniency notice, that is when *LP2006 dummy* = 0.

8.2.4. Leniency program of 2006

In regression (1) and (2) the coefficient on our dummy variable on which version of the leniency program a cartel had been sentenced under, also shows a negative sign as we hypothesized. Since we assign the value of 1 for the new and stricter leniency notice of 2006 and the value 0 for the earlier versions, our results indicate that cartels became shorter after

the implementation of the 2006 notice. The coefficient is highly significant as well, which strengthens this result.

After adding the interactive variable, the interpretation of this coefficient changes as well. In regressions (3) and (4) it measures what effect the 2006 leniency program had on cartels when *Repeat offender dummy* = 0. In these two regressions the variable is insignificant.

8.2.5. Repeat offender after 2006 leniency notice

The interactive term we use in regressions (3) and (4) had a significant negative effect on the duration of cartels. This means that cartels with at least one repeat offender became significantly shorter after the implementation of the 2006 leniency program.

8.2.6. Standard deviation of uncertainty avoidance index

As we reason in hypothesis 2.5, our variable on discrepancies in firms' opinions on uncertainty avoidance shows a negative sign. This variable is however not significant and we can therefore not draw any real conclusions from this result.

8.2.7. Normalized Herfindahl–Hirschman Index on fines imposed

This variable has a positive effect on the duration of cartels, however it is only significant in the regressions on the self-reporting cartels. This means that the more heterogeneously the fines of the firms are distributed, the longer we expect the duration of the cartel to be. Our results then point in favor of the research conducted by Bertrand and Lumineau (2016) and Eswaran (1997) who states that a cartel existing of firms of different sizes should be more stable. This then suggests that our hypothesis 2.6b is correct and that hypothesis 2.6a is wrong.

9. Discussion of key results

The following subsections provides a discussion and an analysis regarding the results from our regressions presented in section 8.

9.1 Snitches

Looking at our probit-model, the results tell us that there seems to be some factors that make firms more likely to contact the EC and expose their respective cartels.

Firstly it seems as though these firms generally face higher fines than their cartel partners and therefore have more to lose by getting caught. This means that the stakes are higher for these firms, which would mean that they have larger incentives to snitch on the cartel agreements and report the cartel. The *Race to the Courthouse Effect* hopes to destabilize cartels by turning the cartel situation into a situation closer to the Prisoners Dilemma (Harrington, 2008), meaning that when the stakes are high, the importance of getting to the authorities' door first is larger. This effect might therefore explain why the share of expected fine has a positive effect on the probability to self-report. Since the expected fines are partially related to firm size we might be inclined to interpret this as that larger firms are more likely to self-report than smaller firms. However what we must note is that it is the relative sizes of the cartel firms that are of importance. Just because a firm is large does not mean that it will become a snitch. What we may cautiously say, is that in cartels that are made up of firms of different sizes, it is more likely that a relatively large firm will report the cartel to the EC than a relatively small firm. This analysis would be improved if we had more extensive data on firm sizes, such as actual market shares or sales figures. Hoang et al. (2014) were able to include data on market shares for some firms in their sample and were able to show that market share has a positive impact on the probability of becoming a snitch.

Secondly, uncertainty avoidance has a significant negative result in our regression. Looking at our descriptive statistics, we see that the snitching firms have a lower score on average on uncertainty avoidance than those who did not snitch, which would explain this result. To try to explain why we find that the snitches score lower on uncertainty avoidance than other firms, we try to implement some of the reasoning from our discussion on the stability of cartels. There we argue that the disparity in views on uncertainty avoidance should create a downwards spiral of trust where firms try to get to the authorities' door first, basically believing that it is better to snitch before getting snitched on. Our result can therefore indicate that high scoring firms' are regarded as less trustworthy, as low scoring firms suspect that they might have larger incentives to deviate and then report the cartel. This could therefore prompt the lower scoring firms to snitch first.

Although not significant, the variable regarding relative duration shows the hypothesized positive sign. This might indicate that the length of the individual duration does play a part in determining which firm is more likely to self-report, although we cannot say this with statistical certainty. The insignificant result may however be a consequence of our assumption that the gains from colluding do not change over time. If the gains are expected to increase it

would mean that, even though the expected cost of colluding increases over time, the expected pay-offs for the firms might not change. A firm may therefore decide to stay in the cartel for a longer period and thus not snitch on the agreement. If we would have had data on the individual cartel profits over time it could have helped this analysis, but since we do not, we can only speculate as to why we got this result.

Since repeat offenders might be regarded as less trustworthy due to the larger incentives they have to snitch, it is possible that this causes first time offenders to reveal the cartel. This could help explain why this variable is insignificant.

Looking at our sample and the descriptive statistics we see that most cartels are composed of firms from multiple countries and it is rare that firms from one country are in a clear majority. This might then be the reason as to why we cannot see any significant results when looking at the country quota variable.

9.2 Stability

In our results we find that some factors have a significant effect on the duration, and therefore the stability, of cartels, while some do not.

We find that the number of firms in a cartel is significantly positively related to the duration of it. As Brock and Scheinkman (1985) points out, an increasing number of firms can have a positive effect on the duration and stability of cartels, if we assume capacity constraints at the firm level and a small number of firms in the market. It is difficult to determine if this is the case for the markets in which the cartels in our sample operated, and we are therefore uncertain that this is the reason behind our result. Another reason for the result we got in our regression might be attributed to the sample selection bias that we believe is prevalent in our dataset. Since the cartels that have been found by the EC are most likely not representative of the true population of cartels, the analysis of the duration of cartels in general falls a bit short. We suspect that cartels consisting of a large number of firms might have collapsed on their own due to reasons discussed previously, before they were detected by the EC. This could then mean that the pattern of large, long-lived cartels that we have in our dataset is actually an exception from the behavior of cartels in general.

Secondly, since we use the firms' expected fines as a proxy for their relative size, our results indicate that a cartel consisting of different sized firms should be expected to last a longer period of time. This result is however only significant in our regression on the self-reporting

cartels and not when including cartels that were detected in other ways. For the 38 cartels that were detected by the EC's regular operations, and not due to the leniency program, this coefficient is negative which would favor our hypothesis 2.6a. This result is however not significant so we cannot draw any real conclusions from this, but it can help explain why the variable is insignificant when we run the regression on the total number of cartels. Since there are diverging theories as to whether cartels are more favored by homogeneity or heterogeneity in firm sizes, it is not unreasonable that the test is affected by them both and therefore does not show any viable results. What our results do indicate, is that the duration of self-reporting cartels is positively related to the heterogeneity in firm sizes.

The third effect of significance on the duration of cartels is related to the presence of a repeat offender in the cartel and the introduction of the updated leniency notice in 2006. We chose to implement an interactive variable to see if the implementation of the 2006 notice causes cartels to be less stable due to the higher fines it imposes on repeat offenders. It was also added because what the *LP2006 dummy*, used in regressions (1) and (2), essentially does is to simply split our data into two parts; cartels that were sentenced before and after the implementation of the 2006 notice. This could mean that the significant negative effect of the variable might be attributed to other, time-dependent factors and not specifically related to the implementation of the notice itself. In regressions (1) and (2), *Repeat Offender* is not significant while *LP2006* has a significant negative effect. After including the interactive variable in regressions (3) and (4), neither of these two variables show significant results while the interactive term has a significant negative effect. This could indicate that the reason behind the negative significant effect of *LP2006* in regressions (1) and (2) is due to the higher fines this notice imposes on repeat offenders. In hypothesis 2.4a we argue that since the fines for longer lasting cartels increased after the 2006 leniency notice, cartels should, on average, become shorter after its implementation. The insignificance of *LP2006* after adding the interactive term indicates that the 2006 notice only has an effect on the duration of cartels that contains at least one repeat offender. These results indicate that if all the cartel members are affected in the same way by a policy change, it does not appear to have an effect on cartel stability. It is instead when one firm is affected more than the others that could be a problem for a cartel, since it changes the group dynamics and the trust among the cartel members.

Our multinationalism variable shows a negative sign, unlike we hypothesize, but it does not have a significant effect. In our dataset we see that most of the cartels are in fact rather multinational and often consists of firms originating from several different countries. This

could then result in many of the cartels receiving similar scores in our Herfindahl-Hirschman Index so that no clear pattern can be observed. Another way of testing this specific factor can be to compare cartels where all firms originated from the same country with multinational cartels. But this is not possible for us, since there are too few observations of single-nationality cartels in our data set.

Unlike Bertrand and Lumineau (2016), we cannot find any indication that disparity in firm's views on uncertainty avoidance has a significant effect on the duration of cartels. Like we mentioned before, most of the cartels in our sample are multinational which means that they all had differences in uncertainty avoidance, regardless of their duration, which could explain our insignificant result. Another suspected reason for the insignificant result is that our method assumes that the management of the firms is from the same country as the firm. This is not necessarily the case and even if it was, it is not certain that the management's individual preferences regarding uncertainty avoidance reflect those of the country they come from. If we had been able to measure these individual preferences, we might be able to see more distinct differences in the disparity of uncertainty avoidance in cartels of different length, which could improve our analysis.

10. Summary and Concluding remarks

This paper set out to investigate what factors affect the probability of self-reporting among members of cartels detected by the EC, as well as how these factors affect cartel stability. This is done by running two regressive models, one binary probit model and one OLS multiple regression model, using data on detected cartels gathered from the EC's website.

Our results show that the individual members' expected shares of the cartel fine, if detected, has a significant positive effect on the probability of self-reporting, while the extent to which firms want to avoid uncertain situations has a significant negative effect. This suggests that the snitching firms face higher fines, and comes from countries that have a higher tolerance for uncertainty, than the other cartel members. On a cartel level we find that both the number of firms in a cartel, and differences in size among cartel members, have significant positive effects on cartel duration, whereas the presence of a repeat offender among the cartel members has a significant negative effect on cartel duration, if the cartel is sentenced under the revised 2006 leniency program. These results therefore indicate that these variables have an effect on cartel stability. We also find that several of our variables do not have a significant effect on neither the probability to self-report nor cartel stability.

Our results and discussions suggest that cartel stability and the probability to self-report are related to each other. If the members of a cartel believe that another member seems to be more likely to report the cartel, it will naturally affect the behavior of those other firms and influence their willingness to be the first one to report. This change in dynamics between the cartel members could bring forth a reduction in trust, which could have an impact on the stability of the cartel. If a cartel becomes more unstable, the possibility of it ending should therefore be larger than before. Under a leniency program, a cartel can either simply fall apart, be detected by the authorities, or it can cease to exist due to a self-reporting firm. If a firm self-reports, it naturally affects the actual duration of the cartel, since cartel activities usually cease when the cartel is discovered.

This relationship indicates that, in reality, it might not always be the most theoretically probable firm that actually snitches. This might help to explain why several of our variables we use in our probability model are insignificant. Our model is not able to capture to which extent the internal dynamics and interactions between the cartel members affect firms' choices to report the cartel or not.

Furthermore, because our sample only consists of detected cartels, we need to note that it excludes cartels that have not been detected, such as stable cartels and cartels that have collapsed on their own. We should therefore be careful with the conclusions we draw regarding the general population of cartels. This might also help to explain why we in some cases do not get results that are consistent with previous theories and our hypotheses. If we could account for the problems associated with our sample, it is possible that our analysis would be improved and that our results could be applied to cartels in general.

11. Future research

Our paper looks at what factors determine the probability to self-report and cartel stability using cartel data from the EC, therefore, our results are more applicable to cartels that operate in the EU area. To further deepen the analysis and to be able to draw more general conclusions, a possible area for future research would be to do a cross-country study using data from other Antitrust Authorities that use other types of leniency programs. The Department of Justice in the USA, for example, only offers lenient treatment to the first firm to report. The results from such a study might be able to provide interesting results on how the designs of different leniency programs affect the probability to self-report and cartel stability.

Furthermore, as our result regarding the effect of the number of firms contradicted most theory on the subject of stability, future research could maybe try to expand on this result by using a model that specifically examines how the number of firms affects cartels and thereby provide a clearer answer to as to why we got the results that we did.

We also acknowledge that our model omitted variables that might, or might not, affect the probability to self-report and cartel stability. Adding firm specific variables such as profits, turnover and market shares, as well as macroeconomic variables that can capture the effects of economic cycles, could provide interesting results and is a possible way of expanding our paper.

Lastly, our paper and many other papers that use data on detected cartels face the problem that the sample might not be representative of the true population of cartels. If future research could find ways on how to deal with this problem, it would be extremely helpful for future papers that are interested in investigating cartels and cartel behavior.

12. References

Baum, C.F. (2006) *An Introduction to Moderns Econometrics Using Stata*, Collage Station, TX: Stata Press

Bertrand, O. and Lumineau, F. (2016). [Forthcoming]. Partners in Crime: The effects of diversity on the longevity of cartels, *Academy of Management Journal*. [Online]. Accessed 2016-05-18. Available at: <https://sites.google.com/site/fabricelumineau/research>

Brenner, S. (2009). An empirical study of the European corporate leniency program, *International Journal of Industrial Organization*, vol. 27, no.6, pp. 639-645.

Brenner, S. (2011) Self-disclosure at international cartels, *Journal of International Business Studies*. vol. 42, no. 2, pp. 221-234.

Brock, W.A. and Scheinkman, J.A. (1985). Price setting supergames with capacity constraints, *The Review of Economic Studies*, vol. 52 no. 3, pp. 371-382.

De, O. (2010). Analysis of Cartel Duration: Evidence from EC Prosecuted Cartels, *International Journal Of The Economics Of Business*, vol. 17, no. 1, pp. 33-65.

Dougherty, C. (2011). *Introduction to Econometrics*, 4th edn, Oxford: Oxford University Press

Eswaran, M. (1997). Cartel unity over the business cycle, *Canadian Journal of Economics*, vol. 30, no. 3, pp. 644-672

European Commission (1996). Commission notice on the non-imposition or reduction of fines in cartel cases, Official Journal C 207, 1996-07-18, pp. 4-6

European Commission (1998). Information from the Commission - Guidelines on the method of setting fines imposed pursuant to Article 15 (2) of Regulation No 17 and Article 65 (5) of the ECSC Treaty, Official Journal C 9, 1998-01-14, pp. 3-5

European Commission (2006a). Press Release, Competition: revised Commission Guidelines for setting fines in antitrust cases – frequently asked questions, 2006-06-28 [Online] Available at: [http://europa.eu/rapid/press-release MEMO-06-256_en.htm?locale=en](http://europa.eu/rapid/press-release_MEMO-06-256_en.htm?locale=en) Accessed: 2016-05-18

European Commission (2006b). Guidelines on the method of setting fines imposed pursuant to Article 23(2)(a) of Regulation No 1/2003, Official Journal C 210, 2006-09-01, pp. 2-5

European Commission, (2008). Press Release, Antitrust: Commission introduces settlement procedure for cartels, 2008-06-30 [Online] Available at: http://europa.eu/rapid/press-release_IP-08-1056_en.htm?locale=en Accessed: 2016-05-18

European Commission (2011). Fact sheet, Fines for breaking EU Competition Law, [Online] Available at: http://ec.europa.eu/competition/cartels/overview/factsheet_fines_en.pdf Accessed: 2016-05-18

European Commission (2013). Competition – Cartels – Overview [Online] Available at: http://ec.europa.eu/competition/cartels/overview/index_en.html Accessed: 2016-05-18

European Commission (2016). Cartel Statistics, as of 2016-04-06 [Online] Available at: <http://ec.europa.eu/competition/cartels/statistics/statistics.pdf> Accessed: 2016-05-16

E-views (2014). E-views 8.1 Users Guide II, IHS Global Inc., Irvine: C.A [Online] Available at: <http://www.eviews.com/EViews8/EViews8/EViews%208%20Users%20Guide%20II.pdf> Accessed: 2016-05-06

Harrington, J.E. (2008). Optimal Corporate Leniency Programs, *The Journal of Industrial Economics*, vol. 56, no.2, pp. 215-246.

Hoang, C.T., Hüschelrath, K., Laitenberger, U., and Smuda, F. (2014). Determinants of self-reporting under the European corporate leniency program, *International Review of Law and Economics*, vol. 40, pp.15-23.

Klein, G.J. (2010). Cartel destabilization and leniency programs: Empirical evidence, discussion paper, no. 10-107, Centre for European Economic Research

- Levenstein, M.C. and Suslow, V.Y. (2006). What determines cartel success?, *Journal of Economic Literature*, vol. 44, no. 1, pp. 43-95.
- Levenstein, M.C. and Suslow, V.Y. (2011) Breaking Up Is Hard to Do: Determinants of Cartel Duration, *The Journal of Law & Economics*, vol. 54, no. 2, pp. 455-492
- Marvão, C. (2016). The EU Leniency Programme and Recidivism, *Review of Industrial Organization*, vol. 48, no. 1, pp. 1-27.
- Miller, N.H. (2009). Strategic leniency and cartel enforcement, *The American Economic Review*, vol. 99, no. 3, pp. 750-768.
- Motta, M. and Polo, M. (2003). Leniency programs and cartel prosecution, *International Journal of Industrial Organization*, vol. 21, no. 3, pp. 347-379.
- Pepall, L., Richards, D.J., and Norman, G. (2014), *Industrial Organization: Contemporary Theory and Empirical Applications*, 5th edn, Hoboken, N.J: Wiley.
- Shapiro, C. (1989) Theories of Oligopoly Behavior, in R. Schmalensee and R. Willig (eds), *Handbook of Industrial Organization volume 1*, Amsterdam: North-Holland, pp. 329-414
- Spagnolo, G. (2005). Divide et Impera: Optimal Leniency Programs, discussion paper, no. 4840 Centre for Economic Policy Research
- Stigler, G.J. (1964). A theory of oligopoly. *The Journal of Political Economy*, vol. 72, no. 1, pp. 44-61.
- Van Driel, H. (200) Collusion in Transport: Group Effects in a Historical Perspective, *Journal of Economic Behavior and Organization*, vol.41, no. 4, pp. 385-404
- Zhou, J. (2013). Evaluating Leniency with Missing Information on Undetected Cartels: Exploring Time-Varying Policy Impacts on Cartel Duration, discussion paper, no. 2011-042 Tilburg Law and Economics Center

13. Appendix A

Table 5

Heteroskedasticity Test: White

Included observations: 102

F-statistic	1,289	Prob. F(29,72)	0,192
Obs*R-squared	34,861	Prob. Chi-Square(29)	0,209
Scaled explained SS	68,519	Prob. Chi-Square(29)	0,000

Table 6

Heteroskedasticity Test: White

Included observations: 64

F-statistic	1,409	Prob. F(29,34)	0,168
Obs*R-squared	34,936	Prob. Chi-Square(29)	0,207
Scaled explained SS	65,476	Prob. Chi-Square(29)	0,0001

Table 7

Correlation Matrix (Stability variables)

Included observations: 102

Variable	No. of firms	No. of nationalities	Repeat offender dummy	HHI of Nationalities	Sd Uncert. Avoidance	LP 2006 dummy	Norm. HHI of fines	Repeat/2006 dummy
No. of firms	1							
No. of nationalities	0,675	1						
Repeat offender dummy	0,002	0,193	1					
HHI of Nationalities	-0,308	-0,762	-0,251	1				
Sd. Uncert. Avoidance	0,130	0,478	0,137	-0,708	1			
LP 2006 dummy	0,031	0,182	-0,121	-0,213	0,185	1		
Norm. HHI of fines	0,030	-0,098	-0,176	0,090	0,047	-0,147	1	
Repeat/2006 dummy	0,102	0,239	0,461	-0,192	0,104	0,607	-0,062	1

Table 8

Variance Inflation Factors

Included Observations: 102

Variable	Coefficient		
	Variance	Uncentered VIF	Centered VIF
C	1999,508	40,287	NA
No_of_firms	4,665	4,115	1,180
HHI_Nationalities	1752,619	9,613	2,470
Repeat_Offender_Dummy	483,845	5,639	2,377
Sd_of_Uncert_Avoidance	1,411	8,121	2,131
LP2006_Dummy	584,189	5,193	2,902
Normalized_HHI_Fines	3310,588	2,632	1,166
Repeat_Offender_in_2006	949,547	4,314	3,341

Table 9

Variance Inflation Factors

Included Observations: 64

Variable	Coefficient		
	Variance	Uncentered VIF	Centered VIF
C	3895,864	48,749	NA
No_of_firms	7,284	5,040	1,426
HHI_Nationalities	3949,790	9,415	2,371
Repeat_Offender_Dummy	1061,759	7,681	3,240
Sd_of_Uncert_Avoidance	2,464	9,163	1,665
LP2006_Dummy	976,036	7,061	2,979
Normalized_HHI_Fines	6151,468	2,860	1,314
Repeat_Offender_in_2006	1555,960	6,084	4,183

Table 10

Correlation Matrix (Probability variables)

Included observations: 395

Variable	Share of expected fine	Relative Duration	Repeat offender	Country quota	Uncertainty Avoidance
Share of expected fine	1				
Relative Duration	0,362	1			
Repeat offender	0,238	0,093	1		
Country quota	0,180	0,299	-0,071	1	
Uncertainty Avoidance	-0,118	-0,005	-0,085	0,111	1

Table 11*Dependent Variable: Snitch (1/0)**Method: Binary Probit**Coefficient Estimates*

Variable	(1)	(2)	(3)	(4)	(5)
<i>C</i>	-1,359*** (0,000)	-1,683*** (0,000)	-1,738*** (0,000)	-1,682*** (0,000)	-1,016*** (0,008)
<i>Share of exp. fine</i>	0,022*** (0,000)	0,022*** (0,000)	0,020*** (0,000)	0,021*** (0,000)	0,020*** (0,000)
<i>Relative duration</i>		0,367 (0,293)	0,364 (0,300)	0,439 (0,221)	0,512 (0,165)
<i>Repeat offender</i>			0,280 (0,103)	0,250 (0,152)	0,247 (0,160)
<i>Country quota</i>				-0,425 (0,271)	-0,288 (0,460)
<i>Uncertainty Avoidance</i>					-0,011*** (0,006)
McFadden R-sq	0,077	0,090	0,097	0,100	0,122
N	407	395	395	395	395

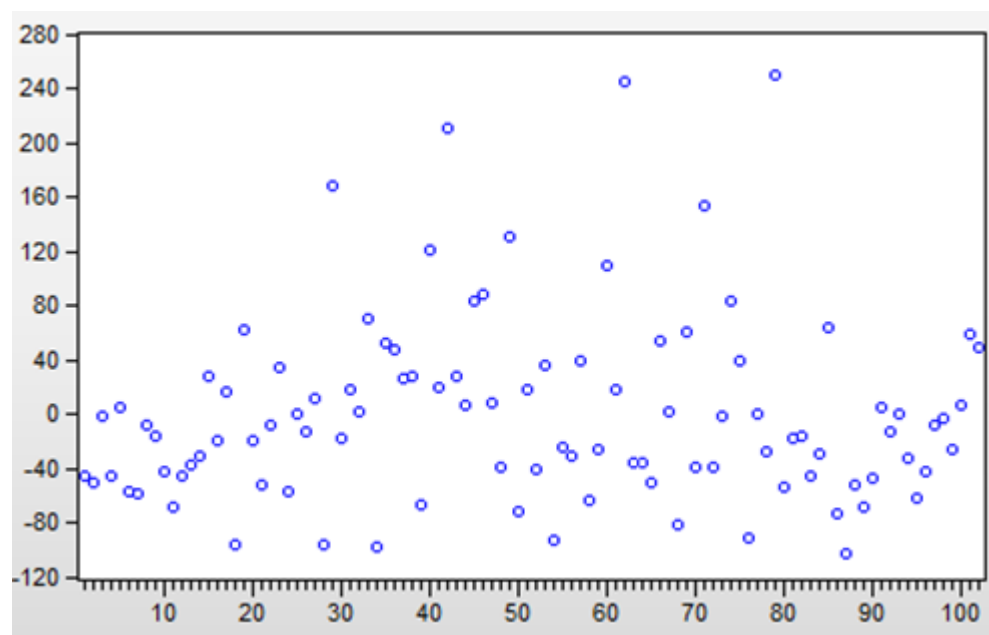
*Significance Level** $p < 0,10$ ** $p < 0,05$ *** $p < 0,01$ **Figure 1***Scatter Plot of Residuals (Stability Model)**Included observations: 102*

Figure 2

Scatter Plot of residuals (Stability Model)

Included observations: 64

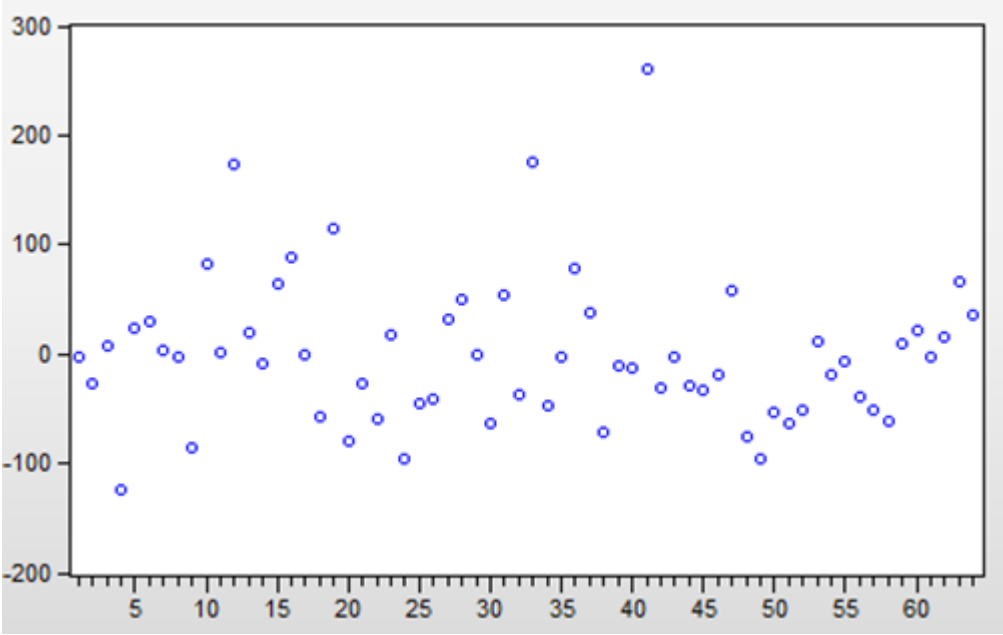


Figure 3

Histogram of residuals (Stability Model)

Included observations: 102

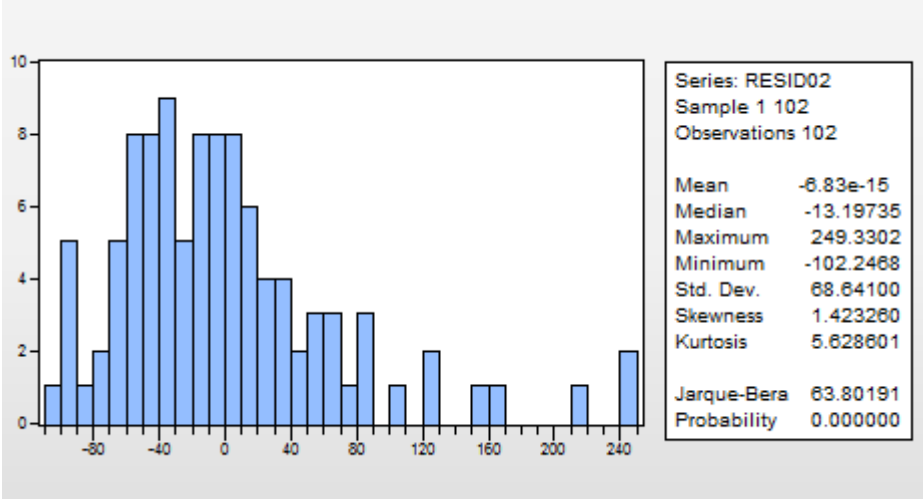


Figure 4
Histogram of residuals (Stability Model)
Included observations: 64

