ERASMUS UNIVERSITY ROTTERDAM

MASTER'S THESIS POLICY ECONOMICS

The Effectiveness of the Dutch Leniency Program

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December 14, 2016

Abstract

Competition authorities around the world have implanted leniency programs with the aim to detect and destabilise existing cartels and deter the formation of new ones. However, the effects of leniency programs, as predicted by the theoretical literature, are ambiguous. Therefore, scholars have developed theoretical models of cartel behaviour that provide empirical predictions on the effectiveness of such programs. Empirical studies so far mainly focused on the European leniency program and its US counterpart. This study evaluates the Dutch leniency program by applying the theoretical models of Miller (2009) and Harrington Jr. and Chang (2009) to a set of cartels, investigated and convicted by the NMa/ACM between 1998 and 2015. The statistical tests are in accordance with the view that leniency improves cartel detection and helps destabilising cartels. They also provide partial evidence of enhanced cartel deterrence. Results may therefore help to justify the implementation of the Dutch leniency program. Whilst this study is the first one on a national European leniency program, the aim is to offer incentives to further research other leniency programs, implanted by individual European member states. The cross-sectional variation provided by the leniency introduction at individual European member states is important to better infer the causal effect of leniency and the different factors influencing its effectiveness.

JEL Classification: L1, L2, L4, L5

Keywords: leniency, competition, antitrust, collusion

Contents

List of Figures

List of Tables

1 Introduction

Antitrust policy aims to "increase the economic efficiency of markets by preventing firms from unfairly limiting competition" (Council on Foreign Relations, 2014). Firms typically restrict competition through collusive/cartel agreements. In a cartel otherwise independent firms act as if they were a single producer and typically agree on prices or share markets. Such agreements are illegal in the Netherlands since 1998 [1].

Imperfect competition due to existing cartels imposes an important cost to society. The incentive of firms to innovate are reduced and overcharges imposed by cartel members increase the dead weight loss and reduce consumer surplus. Therefore, destabilising cartels and deterring anti-competitive market behaviour is important to increase competition again and move towards an efficient and socially optimal market.

However, cartels are hard to identify by only observing market movements, since high price levels and constant market shares are not enough to proof the existence of collusive agreements. Therefore, competition authorities often rely on information on cartels, received through complaints by rivals or customers. Another tool that may help the authorities to “fight” cartels are leniency programs. Under a leniency program, firms may receive a fine reduction if they report their cartel to the authorities. The aim of the program is to incentivise firms to stop colluding and report their cartel.

On July 1st, 2002, the Netherlands Competition Authority (NMa) introduced its leniency program, with the intent to detect existing cartels and deter the formation of new ones. Leniency programs may help to "fight" cartels, as will be discussed in more details throughout the literature review. They may benefit society as a whole because the resources used to investigate cartels may be saved if cartel offenders provide evidence of the cartels themselves (Motta & Polo, 2003). Competition authorities have a limited budget that they may spend on the "fight" against cartels. It is indeed very costly to assess the market and look for price movements that could indicate the existence of cartels. If instead, firms report their cartel themselves competi-

[1] Collusion is illegal in the Netherlands as of 1st January 1998, the date the Dutch Competition Act (DCA) came into force. The cartel prohibition is laid down in article 6 of the DCA. The DCA replaced the former Economic Competition Act, "which used an abuse-based system that allowed collusive agreements to exist, in principle, unless there were grounds to prohibit all or any part of such agreements in the public interest" (Social and Economic Council, 2013).

tion authorities may save a lot of time and money. This time could then be used to investigate and convict additional cartels. This would ultimately benefit society as more cartels can be stopped and a more competitive market equilibrium with lower prices and more choice for the consumer can be attained.

Furthermore, an investigation by the authority does not guarantee that all cartel activities will be documented. Therefore, self-reporting may be important for the successful prosecution of cartels. It can provide additional evidence on which a conviction and the total fine can be based on (Motta & Polo, 2003).

However, recently, there has been increasing criticism from experts in the field arguing that competition authorities nowadays rely too much on such leniency programs. Competition authorities use too little pro-active detection tools, such as random audits and market assessments followed by on-site firm visits (Newman, 2016; Kovacic 2016; OECD, 2013). Experts argue that leniency cannot be effective without a strong and pro-active competition authority behind the program. The effectiveness of leniency programs and the extent to which competition authorities can rely on them is a topic that is highly debated amongst scholars (See also Section 2 of this paper: Literature Review and Contribution). This also provides the motivation behind my thesis, which has the aim to evaluate the effectiveness of the Dutch leniency program.

This paper evaluates the leniency program of the Netherlands by looking at how the number of discovered cartels and their respective duration changes after the leniency introduction. By applying different theoretical models, changes in these variables allow us to conclude on the cartel detection and deterrence capabilities of the leniency program. The paper ultimately tries to answer the question, whether leniency in the Netherlands is effective in the fight against cartels.

The paper proceeds as follows. Section 2 evaluates the theoretical and empirical evidence on the effectiveness of leniency programs. It also describes what can be found in the literature about different factors influencing the effectiveness of leniency programs. Section 3 describes the history of the Dutch leniency program and its subsequent revisions. In Section 4 the hypotheses are developed. The data set is described in Section 5. Thereafter, the empirical framework is described. Results are discussed in Section 7 and 8. The last section concludes.

2 Literature Review and Contribution

This section evaluates what theory tells us about the effectiveness of leniency programs. It will be concluded that the effects of leniency programs, as predicted by theory, operate in opposite directions. The contradicting theoretical findings mean that it remains an empirical question whether leniency is effective. After commenting on the different factors influencing the effectiveness of leniency, this section therefore compares different empirical studies evaluating some of the leniency programs that are currently in place.

2.1 What Theory Predicts - Opposing Views

Leniency programs seek to ex-ante deter cartel formation and ex-post detect, destabilise and desist (i.e. break up) cartels. However, theory predicts that leniency might increase or decrease cartel stability.

A number of theoretical studies show that leniency programs can be effective in destabilising cartels. Harrington Jr. (2008) explains how leniency lowers the expected penalty for a leniency applicant and therefore increases the incentive to break up and report a cartel. A prisoners' dilemma situation is created among cartel members that drives them to confess in equilibrium in order to be the first one to profit from a fine reduction. This destabilising effect of leniency is called "run to the court effect". Under a leniency program, the first leniency applicant is generally awarded a fine reduction up to a 100%, while later applicants can only be granted partial immunity. Such a fining scheme creates an incentive for the cartel members to be the first to report the cartel. Depending on the magnitude of the fine reduction awarded to each subsequent leniency applicant, the "run to the court effect" can be stronger.

Spagnolo (2004) investigates, in a repeated game, how leniency might increase the short-term deviation profits, which further destabilises existing cartels. To be precise, he assumes that deviating from and reporting the cartel results in a lower expected fine than if one only deviates. In the former case, the firm would be assured immunity, or at least a significant fine reduction, by reporting the cartel to the authorities. However, in the latter case, the firm still faces the risk to be fined for participating in the cartel even after it deviated. Whilst the benefit of deviating remains the same, the potential cost is lower if one can also simultaneously report the cartel.

This increases the incentive to deviate once a leniency program is in place.

Ellis and Wilson (2003) provide further evidence on how leniency may decrease cartel stability. They show that the reporting firm may gain a competitive advantage, which increases its incentive to deviate and report the cartel. The idea is that once the cartel has been reported, the fines and compliance cost of cartel members increase. The compliance cost in this case mainly represents the cost incurred from introducing internal mechanisms that ensure future compliance with the competition law. This results in higher (marginal) cost for the firms. However, the reporting firm will receive a lower fine or even benefit from immunity. Therefore, the reporting firm will profit from a relative strengthening of its (marginal) cost as compared to those of its cartel partners, who do not benefit from leniency. This increases the incentive to report the cartel in order to gain a relative cost advantage (i.e. in form of a lower fine and/or lower compliance costs) over the other cartel members, who become direct competitors again once the cartel has been reported and stopped.

In contrast to the above findings, Harrington Jr. and Chen (2007) show that leniency might increase cartel stability. Using a model that allows for endogenously changing detection probabilities, they show that leniency programs may increase cartel stability if they do not limit fine reductions to the first applicant. This is due to the fact that leniency lowers the expected fine and therefore the future expected penalty from colluding. Thereby, it increases the expected profit of continuing a cartel, leading to more stable cartels (see also Motchenkova, 2004 and Harrington Jr., 2008).

These ambiguous effects are also underlined by Motta and Polo (2003). The authors show that leniency may increase the formation rate of cartels. They explain that, with the option of applying for leniency, the future expected fine of participating in a cartel is reduced. The cartel member now has the option to cooperate with the authorities and receive a fine reduction if the risk of getting detected becomes too high (i.e. due to an exogenous increase in the probability of detection), or even if the cartel investigation by the authorities already started. Being aware of this option, the firm will incorporate this when deciding whether to form a cartel or not. With the leniency option, the expected fine is lower and the expected net benefits of forming a cartel are higher as compared to the situation in which no leniency program exists. Consequently, leniency might increase the cartel stability and formation rate.

A last explanation on how leniency might increase cartel stability is provided by Gray, Nguyen and Wait (2013) and Spagnolo (2004). In their theoretical model, they show that a leniency policy can be used to punish a deviator that did not report the cartel. To be precise, they show that the cartel ruler might "run to the court" to report the cartel once a member deviates. The initial deviator might then still be punished by the competition authorities for participating in the former cartel. Such a threat by the cartel ruler is credible because he can typically profit from fine immunity by being the first to report the cartel. Additionally, he could provide information to the authorities that is especially harmful to the initial deviator. This threat makes deviation costlier and relaxes the condition for cartel stability. Ellis and Wilson (2003) further support this view by introducing a theoretical model in which "squealing" (deviating and reporting simultaneously) is used by the remaining cartel members as a punishment for the deviating firm.
Overall, the effects operate in the opposite directions. It is not clear from the theoretical literature which of the effects dominate. Hence, the theory does not provide a definite answer on the effectiveness of leniency. It is thus of major importance to further research the effects of leniency programs and it is an empirical question if leniency effectively reduces cartel stability and formation.

2.2 Factors Influencing the Effectiveness of Leniency Programs

Before connecting the theoretical and the empirical findings, it is important to look at the different factors that may influence the effectiveness of leniency programs.
As already mentioned, different fine reduction schemes may affect the impact of a leniency program. Theory predicts that if the potential reduction of fines for the second and subsequent applicants become more restricted, the leniency program may be more effective in destabilising cartels. This is due to the increase in the “run to the courthouse effect”. Cartel members face a prisoner dilemma in which they have an incentive to run to the court and report their cartel in order to avoid a higher penalty. With a "steeper" fining scheme, each subsequent leniency applicant faces a smaller fine reduction and consequently a higher penalty (see also Harrington & Chang, 2009). This increases the incentive to "run to the courthouse" before others do.
On the other hand, referring back to Ellis and Wilson (2003), leniency for the second reporter only dilutes the market advantage enjoyed by the first one. To be precise, the competitive cost

advantage (i.e. the relative lower fine received through leniency) gained over the second applicant is reduced. Thereby, it makes initial reporting less attractive. This further speaks for a "steep" fining scheme, which might even fully restrict any fine reduction for subsequent reporters. However, the authors add that It might be worth decreasing the initial incentive to report if, in return, the probability of a successful prosecution sufficiently increases with the additional information provided by subsequent applicants.

There are also numerous other factors that influence the effectiveness of a leniency program. For example, the way a competition authority works and fines in absence of such a program. Hence, whether the competition authority gives severe fines and if it is active in doing random audits and market assessments followed by on-site firm visits. This can strongly impact the effectiveness of a leniency program. The absence of such pro-active behaviour by the competition authority may even cause the leniency program to increase, rather than decrease, cartel stability. An important contribution on this topic is provided by Aubert et al. (2006). Aubert et al. (2006), show that leniency does not influence the profitability of collusion, but only affects its sustainability. This works by giving deviating firms the possibility to avoid fines from competition authorities. Consequently, leniency programs can only be effective when the expected fine the firm may avoid through leniency is significantly high. When the expected fine would be low anyways, the firm would have no significant incentive to avoid it. The expected fine for a cartel member increases both with the fine amount and the detection probability. A strict and active competition authority (i.e. one that regularly performs random audits) behind the leniency program is thus key for the program's effectiveness.

Further contribution on how competition authorities should fine is offered by Bruneckiene et al. (2015). In their book, the authors critically reflect on the economic efficiency of cartel fines imposed by competition authorities. They reviewed the literature on the theoretical concept of optimal fines, and come to a consensus that fines imposed by competition authorities are possibly too low. They argue that there is a mismatch between the concept of optimal fines and the fine calculation methods used by competition enforcers (see also Bolotova and Connor, 2008). According to the authors, fines should be determined by including the 3 different roles of fines. Fines should be set according to their compensating and deterrence capability. Hence, an optimal fine should not only compensate the overcharged consumer, but it should also be

set high enough to effectively eliminate the incentive of firms to form a cartel in the future. Lastly, fines should also be set in order for the cartel members to have an incentive to self-report (and provide information) to the competition authorities (OECD, 2002). The consensus of the book is that this last role is often not included in the fine calculation of competition authorities. However, an optimal sanction should include this last component and the fine should be set according to the "carrot and stick" approach (see also Abreu, 1988). The idea is that the stick, representing the total possible sanction (i.e. fine) should be sufficiently high to give a significant effect to the possibility of avoiding that fine (i.e. through leniency = effect to the carrot). Hence, the general consensus supports the idea that fines by the competition authorities should be high in order to incentivise colluding firms to apply for leniency.

Allain et al. (2015) also add that the determination of the optimal deterrence fine level, hence the fine level that effectively eliminates cartel formation, should always be done in perspective of the best combination of policy instruments. Leniency programs are likely to affect the optimal deterrence fine level because leniency affects cartel stability and formation. On the other hand, the deterrence fine also affects the effectiveness of the leniency program by altering the expected fine for colluding. Hence, one should always find the best combination of the two interdependent instruments.

Overall, the lesson learned from these last five paragraphs is that a leniency program should not be used as a "compensating instrument" for the lack of effective enforcement of authorities, but it should be used to complement and further strengthen an established competition enforcer. A leniency program can only work if firms sufficiently fear the competition authorities (i.e. through a high expected fine). It was established that severe fines, random audits and market assessments followed by on-site firm visits all help to increase the expected fine for colluding [2]. Only with such pro-active behaviour by the competition authorities, the expected fines for colluding firms are high enough to give those firms an incentive to apply for leniency. On the other hand, we saw that if the expected fine for colluding is very low, firms lack the incentive to apply for leniency. This is because there is no significant effect to the possibility of avoiding

[2] One should notice the importance of actively assessing complaints of rivals and consumers/customers. The exchange between the competition authorities and the public plays an important role in the fight against cartels. It is important that complaints are taking into consideration and followed by extensive market assessments and on-site firm visits. This will help to increase the expected fines for colluding firms.

that fine. Hence, a leniency program can be very efficient with a strong pro-active competition enforcer. In this case, the leniency program can be an important instrument and may help to further strengthen the competition enforcers. However, once a competition authority relies too much on leniency and reduces its pro-active behaviour, leniency will become ineffective. Leniency cannot compensate for the lack of pro-active enforcement of the competition law. One should thus always make sure that leniency is accompanied by a pro-active detection strategy (including market assessments followed by on-site firm visits) of the competition authority. This also explains the emergence of recent critics, arguing that competition authorities nowadays rely too much on leniency programs and should increase pro-active detection (Newman, 2016; see also introduction).

The paper by Aubert et al. (2006) also explains an additional way how the impact of a leniency program can be improved. Namely, by extending leniency to individuals if collusion is a criminal offence for which these individuals can be convicted.

Aubert et al. (2006) show that a whistleblowing program that offers positive rewards (bounties) to employees reporting incriminating evidence can be more effective than a full corporate leniency program [3]. The idea is that if there exists a whistleblowing program that offers positive rewards, firms may have to bribe their employees, such that these do not disclose information to the competition authorities. Such bribing is costly and makes collusion less sustainable. In their model, the authors show that having to bear the cost of such bribing destabilises cartels even more than a full corporate leniency program. However, the main conclusion of their paper is that combining corporate leniency with an individual reward system is more effective than each program alone. More generally, this also holds true when corporate leniency is combined with a program that "only" shields employees from individual sanctions (i.e jail) instead of giving them positive rewards in form of bounties. Hence, in a situation in which corporate leniency is combined with leniency for individuals.

The mechanism works as follows. If collusion is a criminal offence for which individuals can be convicted, the firm has to compensate (similar to a bribe) employees for the juridical risk to which they are exposed. If leniency is then extended to individuals, the deviating profits

[3] Note that in contrast to most other studies, including my study on the Dutch leniency program, the authors here formally distinguish between firm and individual leniency. Corporate leniency refers only to leniency for firms. A full corporate leniency program is one that grants up to full fine immunity for firms, but no positive rewards.

are higher as compared to the situation in which leniency only exists for firms. It was already established how leniency may increase the deviation profits by reducing the expected fine for a firm. Deviating profits for the firm increase even further with the option to simultaneously apply for individual leniency. By applying simultaneously for individual leniency, the firm can reduce employee compensation because employees are now also shielded from the juridical risk. A firm when deviating therefore gains more when it can apply for firm and individual leniency together. The firm now not only avoids the probability of getting fined (in the future) but can also reduce employee compensation (no need to bribe anymore). The latter effect adds to the former, further increasing deviating profits and thereby also the incentive of cartel members to deviate and report the cartel. Leniency programs are therefore most effective if they are extended to individuals.

According to Bruneckiere and Pekarskiene (2015), the ideal sanction system should include both monetary and non-monetary sanctions (i.e. jail) and be focused on both corporations and individuals. In such a sanction scheme, in which also individuals can be convicted, the leniency program should be extended to individuals. Firms would otherwise be reluctant to apply for leniency because employees/managers would not be shielded against possible sanctions, such as prison sentences, which might cause the firms to lose some of their key employees.

The last important factor that influences the effectiveness of a leniency program is how ringleaders are treated with respect to leniency. According to the European Commission, a ringleader can either represent the instigator of the cartel or the leader who proactively leads and enlarges the cartel (European Commission, 2006). Some leniency systems are more favourable than others towards fine reductions for ringleaders. For example, the European Leniency Program[4] offers fine reductions and even full immunity to ringleaders, whilst this is not possible under the US leniency program[5]. Theoretical literature is not quite clear on whether the inclusion of ringleaders in leniency increases or decreases the effectiveness of the program.

Leslie (2006) clearly argues in favour of including leniency for ringleaders. According to the au-

[4]In the revised European leniency notice of 2002, fine immunity for ringleaders was introduced. The European Commission became more favourable towards ringleaders, who can even apply for fine immunity provided that: "the undertaking did not take steps to coerce other undertakings to participate in the infringement" (European Commission, 2002)

[5]Under the US leniency program, fine reduction is only granted to a ringleader if there is more than one ringleader and the first leniency applicant is one of these ringleaders. Single ringleaders are not being granted amnesty.

thor, including everyone in leniency maximizes distrust among all cartel members. Knowing that each member, including the ringleader, can report and profit from a fine reduction intensifies the prisoner dilemma situation. Additionally, excluding the ringleader from leniency, ultimately makes the ringleader a more credible partner because he has no reason to report the cartel.

Bos and Wanschneider (2011) also predict that ringleader's exclusion from leniency can have adverse effects. It leads to an increase in cartel prices if the following conditions are met. Firstly, the joint profit maximum cannot be sustained under a non-discriminatory leniency program. Secondly, cartel fines depend on individual collusive profits in a nonlinear way, and lastly, cartel members have to be heterogeneous in size.

To be precise, the authors show how ringleaders' exclusion from leniency tightens the incentive-compatibility-constraint (ICC) of ringleaders[6] whilst it loosens the ICC of the other members[7]. The authors establish in their model that the largest firm has the tightest ICC when the fining scheme is convex to the firm size, the smallest firm has the tightest ICC when the fining scheme is concave to the firm size and when the fining scheme is linear all firms have the same ICC. Consequently, If the fining scheme is convex, excluding the ringleader from leniency loosens the tightest ICC when the ringleader is not the largest firm. Reversely, if the fining scheme is concave, excluding the ringleader from leniency loosens the tightest ICC when the ringleader is not the smallest firm. A cartel that could not be sustained under the non-discriminatory leniency program could then be sustained under the discriminatory program. This is because the tightest ICC, the one that has to be satisfied to sustain collusion off all members, is loosened. The transition to a discriminatory leniency program could then help to sustain collusion and high prices. Only if the fining scheme is linear (or all firms are sufficiently homogeneous in size) the ringleader's exclusion will lead with certainty to a tightening of the tightest ICC (all firms face the same ICC).

Lastly, Herre et al. (2012) find ambiguous results of excluding ringleaders from leniency. Their theoretical model explores the deterrent effect of ringleader's exclusion from the leniency pro-

[6]The ringleader cannot run to the court to apply for leniency, while the other members have this option. This makes collusion for the (from leniency excluded) ringleader less attractive/sustainable. Hence, it tightens his ICC

[7]Regular cartel members are more likely to win the "race to the courthouse" because they don't have to compete against the ringleader. This is an additional benefit which makes collusion more attractive. Hence, it loosens the ICC of regular cartel members.

gram by allowing the probability of conviction to vary exogenously. In their model, they show that if there is a relatively small probability of conviction, a non-discriminatory leniency program is preferred. The extra evidence that may be provided by the ringleader can be crucial for a successful cartel conviction.

On the other hand, if the ex-ante probability of conviction is relatively high the authors conclude that it is optimal to exclude ringleaders from leniency. The additional information that could be provided by the ringleader cannot considerably increase the conviction rate anymore. Excluding the ringleader from leniency then only has the effect to increase the asymmetry among firms. Such increased "asymmetry" among cartels members increases the chances that some profit a lot from the cartel while others only profit marginally. However, in order to sustain collusion everyone should have the incentive to collude, also those profiting the least. If increased "asymmetry" between firm leads to lower collusive gains for those profiting the least, the cartel becomes more difficult to sustain. Hence, when excluding ringleaders from leniency does not lead to a significant loss in the conviction rate, it may be worthwhile to exclude ringleaders.

According to Herre et al. (2012), it thus depends on the ex-ante probability of conviction, hence the effectiveness of the competition authority, whether one should exclude ringleaders from leniency or not. If the competition authority is likely to detect and convict cartels without the help of additional information from ringleaders, it may be worthwhile to exclude them. However, if the ex-ante probability of conviction is low, the additional information from ringleaders might be essential for a successful conviction.

2.3 Empirical Evidence

Keeping in mind what the theoretical literature taught us about leniency, it becomes interesting to compare the empirical findings on the effectiveness of different leniency programs.

Empirical studies on collusion face the common difficulty that all active cartels are never observed in the data. Consequently, it is difficult to evaluate the effectiveness of leniency programs and one has to draw conclusions from a limited sample of cartels. Empirical research on leniency deals with that problem by setting up theoretical models which allow to draw conclusions on the program's effectiveness by observing only discovered cartels. The findings thus rely on the credibility of the assumptions behind the theoretical models.

The empirical evidence on the effectiveness of leniency has been growing but there remain further areas to research, especially on the effectiveness of leniency programs introduced at individual European member states. So far, the main empirical studies on leniency focus on the European Leniency Program and its US counterpart.

The first study on the European Leniency Program, adopted in 1996, was conducted by Brenner (2009). The author uses a sample of 61 cartels, investigated and convicted by the European Commission between 1990 and 2003. The study focuses on two different effects of the leniency program.

In the first part of his study, Brenner evaluates if the introduction of the leniency program resulted in more information on cartels being revealed. Additionally, he analysis whether the introduction of leniency lead to a decrease of the investigation and prosecution cost. The collected data indeed confirms that more information is revealed and that investigation cost, measured by the duration of the cartel investigation, decreases after the leniency introduction. To be precise Brenner finds that, after the implementation of leniency, the average cartel investigation duration decreases by roughly one and a halve years. In the second part of his study, the author focuses on the effect of the leniency program on formation and stability of cartels. By observing the time pattern of discovered cartels he cannot conclude that the leniency program deterred collusion (by applying the theoretical approach of Miller, 2009). Additionally, using a hazard/-duration model (see also footnote 10), he finds no evidence that the probability of stopping collusion changes after adopting the leniency program (by applying the theoretical approach of Harrington Jr. & Chang, 2009). Overall, his empirical results suggest that the initial European leniency notice was not effective enough to deter collusion and destabilise cartels. Brenner argues that the increase in cartel discoveries, observed after the adoption of the leniency program, could be due to an exogenous change in the economic environment and is not necessarily related to the introduction of the leniency program.

The finding that the European leniency program was ineffective is also supported by De (2010). Using a sample of cartels convicted by the European Commission during the years 1990 until 2008, De finds no evidence that the introduction of the program increased cartel duration of discovered cartels in the short run. He concludes that the observed pattern of cartel duration of discovered cartels is not in line with the one of an effective leniency program, based the theo-

retical model of Harrington Jr. and Chang (2009).

According to Harrington Jr. and Chang (2009), an effective leniency program should lead to an increase in cartel duration of discovered cartels in the short run (after the leniency introduction). In the long run, cartel duration might go up or down. The intuition is that once leniency is introduced all marginal, short-lived cartels will directly break-off. Marginal cartels are short-lived cartels that are only marginally stable and on the verge of breaking up. These will immediately dissolute if an effective leniency program (i.e. one that helps destabilising and detecting cartels) is introduced. Hence, only the more stable (longer-lived) cartels will remain and the average duration of discovered cartels will mainly come from these more stable cartels. This increases the average duration of discovered cartels in the short run after the leniency introduction. In the long run, there are 2 opposing effects. On the one hand, the marginal cartels that collapsed due to the enhanced detection will not form in the first place. This increases average cartel duration of discovered cartels. On the other hand, the destabilising effect of the leniency program decreases the average duration of the longer-lived cartels, which per se decreases the average duration of discovered cartels. Average cartel duration of discovered cartels can thus go up or down in the long run. The intuition and underlying assumptions behind the theoretical model of Harrington Jr. and Chang (2009) are discussed in more detail in section 4.

The study by Zhou (2013), in contrast to the ones by Brenner (2009) and De (2010), finds evidence that the European leniency program was effective in deterring and destabilising cartels. However, it is important to notice that Zhou mainly focuses on the revised European leniency program of 2002, whilst De and Brenner focus on the initial European leniency program, introduced in 1996. Using a hazard model, Zhou finds that once the revised leniency program is introduced, the average cartel duration of increases in the short run and decreases again in the long run. This time pattern of cartel duration of discovered cartels is in line with an effective leniency program according to the theoretical model of Harrington Jr. and Chang (2009).

The difference results of the studies conducted by Brenner (2009) and De (2010) as compared to the one conducted by Zhou (2013) could be explained by the different assumption behind their models. The study of Zhou differs from the one conducted by De and Brenner in the way they differentiate between the short-run and long-run effects of the leniency program. Brenner for example, endogenously determines the short-run period to be three years. Zhou on the other

hand, formally differentiate the impacts by the starting date of cartels. The short-run impact is evaluated with the use of the data on cartels that formed before, whilst the long-run effect is evaluated with data on cartels that formed after the implementation of the leniency program. However, Zhou also uses a longer and more recent data set (1985-2012). As mentioned above, he mainly evaluates the effectiveness of the revised European leniency program of 2002, whilst the focus of De and Brenner lies on the initial European leniency program of 1996. One of the major changes of the revised leniency program of 2002 was that the European Commission (EC) no longer had the power to alter the size of the fine for the first applicant[8]. Additionally, the maximum percentages of fine reductions granted to subsequent applicants (Second and following ones) under the new leniency guidelines were lower than under the initial ones (European Commission, 2002). By referring back to the discussion of the impact of the fine reduction scheme on the effectiveness of leniency, one can find a possible explanation why the revised leniency program proved to be more effective. The increase in effectiveness of the leniency might be explained by the "steeper" fining scheme, increasing the "run to the court effect". Assuring immunity to the first applicant most likely had the biggest impact.

The results of all three studies are robust when allowing for changes in the model specification. They also control for various factors in their regressions, such as changes in GDP, funds assigned to the competition enforcer and the fine level. However, the studies are mainly time-series studies and therefore very sensitive to the exogenously changing, economic environment. The regressions of Brenner (2009) and De (2010) are basically single time series with exogenous policy changes (i.e. the EC's 1996 leniency introduction). Zhou (2013), in contrast, uses both the EC and the US Department of Justice (DOJ) data for which similar leniency programs are in place. The analysis using the DOJ data finds that the US leniency program, which is comparable to the revised European leniency program of 2002, also increased cartel duration of discovered cartels. This underlines his finding that the effect on cartel duration is caused by leniency rather than by exogenous events. Such cross-sectional robustness checks increase the reliability of his estimates. This speaks for the validity of the results of the study conducted by Zhou.

However, also Zhou mentions that in the future, additional cross-sectional variation provided

[8] Immunity is granted to the first applicant under the condition that he provides sufficient additional information and "did not take any steps to coerce other undertakings to join the cartel or to remain in it" (European Commission, 2002).

by the recent introduction of national European leniency programs may help to better infer the causal effect of leniency. By looking whether similar leniency programs at the national level have the same effect on cartel duration as the European leniency program, the validity of the results can be improved. Additionally, the cross-sectional variation might help to deal with common exogenous events affecting cartel discoveries. By comparing cartel discoveries of European national competition authorities and of the EC over time, one can correct for common trends and outside events which mutually affect cartel discoveries across Europe. This can help to find the real causal effect of leniency on cartel duration. Nevertheless, it should be mentioned that all three studies already partly correct for exogenous changes throughout time by adding the earlier mentioned controls in their regressions.

Lastly, one should notice that all three studies rely on the validity of their identification strategy when inferring information from observed cartels to all active ones (also unobserved ones). For correct inference discovered cartels have to be characteristically representative of all cartels. Zhou (2013) assumes that all cartels are detected with an equal probability. Hence, on average discovered cartels will be representative of all cartels.

Before proceeding with this paper, it is important to further address the concerns as to what extent information on discovered cartels can be representative of all existing ones. The empirical studies covered so far use theoretical models which enable the authors to assess the effectiveness of leniency programs solely by observing discovered cartels. Scholars have been questioning to what extent information retrieved from discovered cartels can be used to gain knowledge about all existing cartels, including those who are not observed.

Recent work by Harrington Jr. and Wei (2015) provides evidence on the potential bias of using information on cartel duration from discovered cartels, as an approximation for all cartels. The authors first use a theoretical model in which all cartels are subject to the same death and discovery process. The average duration of discovered cartels is then equal to the average duration of all cartels and the bias is non-existent. Under the assumption of Zhou (2013), that all cartels are detected with an equal probability, resulting estimates will also be unbiased. However, if we relax the assumptions and allow the collapse and discovery probability to vary across cartels, then a bias may exist. According to the model of Harrington Jr. and Wei (2015), the bias remains small ranging from 10% to 15% difference in cartel duration. This bias can be over- or underesti-

mated depending on whether the variation of collapse or discovery probabilities is dominating. The authors conclude that, if we allow for realistic variation of discovery and death probabilities across cartels (i.e. due to differences in the number of firms participating in a cartel), a bias may exist. However, this bias is small and estimates of the cartel duration from discovered cartels still offer a good approximation of the duration of all existing cartels. The validity of the estimates using cartel duration from discovered cartels, as a proxy for all cartels, could nevertheless be further improved by creating models that endogenise discovery and collapse probabilities.

Turing to the evidence on the effectiveness of the US leniency program, the main contribution comes from Miller (2009). In his paper, Miller constructs a theoretical model of cartel behaviour that deals with the issue, prevailing in all empirical studies on collusion, that all active cartels cannot be observed. The model describes how changes in the cartel formation and discovery rate influence the time series of cartel discoveries. The effectiveness of a leniency program can then be estimated by only looking at the number of discovered cartels. An immediate increase in cartel discoveries following a leniency innovation, i.e. a revision of the leniency guidelines, is consistent with an increased detection rate, and a successive readjustment below pre-innovation values is consistent with increased cartel deterrence. The idea behind the model is that the number of expected cartel discoveries increases immediately after the innovation (i.e. the introduction of a leniency program or a revision of the leniency guidelines) because of the rise in the detection rate. However, in the long term, the enhanced detection and decreased cartel formation rate reduces the number of active cartels. Consequently, cartel discoveries fall again. Cartel discoveries fall under the initial pre-innovation values because the decrease in the cartel formation rate is sufficiently strong. The intuition and assumptions of the theoretical model of Miller (2009) are discussed in more detail in section 4.

Miller (2009) uses a sample of 342 cartels filed by the DOJ between 1985 to 2005. With the help of the data on discovered cartels, he concludes on the effectiveness of the "new" US leniency program, introduced in 1993. Using time-series data, he provides empirical evidence on the effectiveness of the leniency program. To be precise, the author shows that cartel discoveries rise significantly immediately after the introduction of the leniency innovation. In the long run then cartel discoveries fall below pre-innovation values. According to his theoretical model, this pattern of cartel discoveries is consistent with improved cartel detection and deterrence. The latter

dominating the former in the long run, leading to a significant decrease in cartel discoveries below initial pre-leniency levels.

The study by Miller uses quite a substantial data-set and runs several robustness checks on various changes in the model specification, and additionally checks for anticipation effects of cartels. Nevertheless, results should be interpreted carefully. One of the reasons is the lack of cross-sectional variation in the data. Indeed, some small endogeneity bias could remain. There could be exogenously determined events, outside the model, that affect the time series data of discovered cartels. The author partly controls for such outside events by controlling for changes in GDP, funds assigned to the enforcement authorities and by looking whether alternative break-points better fit the data. The inclusion of controls and the various robustness checks speak for the internal validity of the study. Nevertheless, there remains some possible room for improvement by providing additional cross-sectional variation to further increase the reliability of the results of this study.

However, the big question remains why the "new" US leniency program seems to perform so much better than the in 1996 introduced European counterpart, evaluated by Brenner (2009) and De (2010). An explanation can be found by having a closer look at the two leniency programs. The main differences between the initial European leniency program and its US counterpart from 1993 are the following. The modified US leniency program already offered full immunity if a firm "reported an antitrust violation before an investigation began or before the government had sufficient evidence to prosecute a case" (Irvine, 2003). This was not the case for the initial European leniency program, which did not assure complete amnesty for the first applicant. Moreover, the European leniency program was less restrictive to later applicants. Hence, referring back to theory, the US fine reduction scheme being "steeper" has the effect of increasing the "run to the court effect". Here again, the difference in the effectiveness of the two programs could be explained by the different fine reduction schemes.

An additional difference between the US and the "initial" European leniency program is that collusion in the U.S. is a criminal offence for which also individuals can be convicted, and leniency is extended to include individual sanctions. In Europe however, individuals did not face this risk, and there existed no leniency for individuals [9]. As already mentioned, theory predicts

[9] Notice that some member states of the European Union introduced criminal cartel offence for individuals.

that extending leniency to individuals increases the program's effectiveness (see Aubert, 2006). This is thus also in line with the finding that the US leniency program is more effective than its European counterpart, introduced in 1996. Overall, the empirical finding that the US leniency program is more effective than the "initial" European leniency program, can be explained by the differences in the specifications of these programs. One should notice that the revised European leniency guidelines of 2002 adapted to the US leniency program with respect to the fine reduction scheme. Zhou (2013) is the first study that provides evidence of the efficacy of the European leniency revision.

Another contribution on the effectiveness of the Korean leniency program is provided by Choi et al. (2014). In their paper, the authors apply a semi-parametric hazard model [10]to a sample of 619 cartels, investigated and convicted from September 1981 to July 2012 by the Korea Fair Trade Commission (KFTC). The study evaluates how leniency influences the discovered cartel's characteristics. Estimation results show that the cartel hazard rate decreases and hence the average cartel duration increases shortly after the leniency introduction. In the long run, the hazard rate increases and therefore the duration of discovered cartels decreases again. This pattern is again in line with the theoretical prediction of an effective leniency program according to Harrington Jr. and Chang (2009). The study by Choi et al. (2014) is one of the first studies on leniency programs of eastern countries. Studies until then were mainly based on western leniency programs. This study made it possible to compare western leniency programs to those in the eastern countries in terms of effectiveness and differences in the fine reduction scheme.

The study includes control variables, such as the GDP growth, the interest rate, the fine level and also controls for industry-fixed effects. Additionally, the findings are robust to changes in the model specification. These include changes in the short and long-term duration, changes in the logarithm specification of variables and also whether estimation results are based on either total fines by the KFTC or the cartel specific fines. However, the time-series data remains, although only limited, subject to uncontrolled outside events which could influence the average duration of cartels over time. Some cross-sectional variation is advisable as there always remain factors

These also include the Netherlands, which ,shortly after making collusion a criminal offence, extended leniency to individuals (see section 3 for more details).

[10]In statistics, hazard models are a class of survival models. They account for the time that passes by before a specific event (i.e. cartel collapse) occurs. An increase in the hazard rate decreases the time before the event occurs.

outside the model that were not corrected for. Overall, the results of this study are still very credible and provide us with further evidence of the effectiveness of leniency programs.

One last contribution comes from Gray, Nguyen and Wait (2013). In their paper, the authors evaluate the impact of the Australian 'Leniency Policy for Cartel Conduct'. The program was introduced in June 2003 by the Australian Competition and Consumer Commission (ACCC). This leniency program is only limited to the first applicant and offers immunity, provided that the authority has not commenced the prosecution. Later applicants, however, may still apply for fine reductions under the cooperation policy. The author conducts a research on a purely theoretical basis. Their theoretical model on cartel behaviour provides further insight which factors of the Australian leniency program effectively tightens the condition required to sustain a cartel. The authors find that the introduction of the leniency program can act to deter collusion. They also find that, compared to the leniency program alone, the use of both the leniency and cooperation policy is less effective [11]. Adding the cooperation policy, in which the ACCC also reduces fines to subsequent applicants, weakens the constraint that has to be satisfied in order for a cartel to be stable. Thereby, it reduces the effectiveness of the leniency program. This finding supports earlier findings that a "steep" leniency scheme, with more restrictive (or even without) fine reductions for later applicants, is preferred. Overall, the authors conclude that the Australian leniency program can deter collusion. However, it would be more effective in absence of the cooperation policy.

3 History of the Dutch Leniency Program

Turning to leniency in the Netherlands, this section summarises the history of the Dutch leniency program introduced by the NMa on July 1st, 2002. This also includes the subsequent leniency revisions of 2007 and 2014.

Cartels have only been illegal in the Netherlands since the introduction of the Competition Act in 1997 (see footnote 1 for more details). The initial leniency program was introduced 4 years later. Under the initial guidelines of 2002, the program already complete immunity to the first leniency applicant, under the condition that the NMa had not yet commenced an investigation

[11] The adverse effects of adding the cooperation policy to the leniency program should not be confused with earlier findings that leniency is more effective, if it is extended to individuals.

into the cartel in question (see "Category A" Table 2). Even after the NMa had commenced an investigation, an undertaking, which was the first to provide information on a cartel, may have been eligible for immunity. However, such an applicant fell under "Category B" and his fine may have been reduced by 50% up to a maximum of 100% (see Table 2). Additional condition for such fine reductions were that the undertaking provided the NMa with sufficient information to enable a conviction and prove an infringement of the Competition Act. Additionally, in order to fall under "Category B" the applicant was not allowed to have practiced any coercion towards other members of the cartel. Coercion means to actively threaten or compel any other firm to be part of the cartel. Any subsequent leniency applicant, or if the applicant was first but had practiced coercion, was "only" qualified for a fine reduction ranging from 10% up to 50% ("Category C"). The condition to obtain such a fine reduction was relatively simple. The applicant had to provide information which could be used as evidence by the competition enforcer to prove the existence of the cartel. The level of the fine then varied "according to the stage of investigation at the time of application and the quality of the additional information provided" (NMa, 2002).

The aforementioned guidelines were re-evaluated and the revised guidelines were introduced on October 1st, 2007. These guidelines came as a respond to the in September 2006 introduced European Competition Network (ECN) Model Leniency Program. The Model Leniency Program (MLP) was introduced by the European Commission, with the intention to harmonise the different national European leniency programs. The idea of the program "is to harmonise those rules and procedures that could deter applicants from reporting cartels". The program introduced "a uniform summary application filing system that facilitates the task of applicants and authorities in those cases where the co-existence of different programmes still led to inefficiencies" (Gauer & Jaspers, 2007). On the basis of the agreement between the competition authorities being part of the ECN, the national competition authorities try to align their leniency rules as much as possible with the MLP. However, they are not legally obliged to fully adapt their national leniency program to the Model Program. "They are free, on the basis of the agreement, to deviate" from the aforementioned model "in their national leniency rules to the advantage of leniency applicants" (The Minister of Economic Affairs, 2014). The harmonisation envisaged by the MLP of 2006 was realised in the Dutch revised leniency guidelines of October 2007.

The "basic system" of the revised Dutch leniency program of 2007 is summarised in table 1. When comparing the revised guidelines with the old ones, the "basic fine reduction system" did not change substantially. The only difference is that under the revised guidelines applicants that fall under category B are granted fine reductions ranging from 60% to 100%. Under the initial leniency guidelines of 2002 such applicants received fine reductions ranging from 50% to 100%. Moreover, the range of the fine reduction for any applicant other than the first one ("Category C") was reduced from 10% to 50% under the old guidelines, to only 10% to 40% under the revised ones. Overall, the fine-reduction system did become slightly "steeper" with respect to subsequent applicants. Other than this, the "basic system" did not differ from the old one.

Table 1: Basic system of the revised 2007 leniency guidelines

Category	Rank	Coercion towards other undertakings in the cartel	NMa has started investigation	Reduction
A	1st	No	No	100 %
B	1st	No	Yes	60-100 %
C	2nd and following or 1st and coercion	Possibly	Possibly	10-40 %

Source: NMa (2007)

However, there were other major changes in the revised guidelines of 2007. The first important change was that leniency under the revised guidelines has been expanded to individuals. Under the revised Leniency Guidelines, individuals as well as firms may apply for leniency. This differs from the old system, in which only firms could apply for leniency. This change in the leniency guidelines followed an amendment to the Competition Act, that as of October 1st, 2007, allowed the NMa to levy fines also on individuals who initiated or lead a cartel. Other changes included the introduction of a marker system. Generally, it may take a lot of time to gather all the evidence a leniency applicant would want to bring forward to the authorities. "By means of a marker an applicant's position in the queue relative to other possible applicants is established and secured for a limited period of time" (NMa, 2007). Setting a marker thus enables applicants to secure their position in the leniency queue, even if they did not gather all relevant evidence yet. This

incentivises firms to report the cartel to the authorities earlier and intensifies the "run to the court race".

Additionally, as compared to the initial guidelines, the scope of the revised leniency guidelines has been specified and limited to hard core infringements. Lastly, a minor change under the revised guidelines extended the full duty of co-operation to the second and subsequent applicants. The initial guidelines only attached this duty to the first applicant.

The leniency guidelines were updated one more time on August 1st 2014, partly in response to the revision of the MLP in 2012. Major changes, as compared to the guidelines of 2007, include those made with respect to the "basic fining system". The evolution of the fining system under the initial leniency program and both revisions is summarised in Table 2. The most recent 2014 leniency guidelines ensure fine immunity to the first applicant, even if the Authority for Consumers and Markets (ACM)[12] has already launched an investigation, under the condition that the ACM has not yet sent a statement of objections. In the 2007 leniency guidelines, such situations "only" warranted a reduction of the fine between 60% up to 100% (see "Category B" in table 2). The fact that the first one to apply will not receive a fine, regardless of whether the ACM already started an investigation or not, might create some adverse incentive to report a cartel later (see conclusion for more details).

Table 2: Evolution of the "basic fining scheme"

2002					2007 revision	2014 revision	
Category	Rank	Coercion	Investigation has already started	Reduction	Reduction	Rank	Reduction
A	1st	No	No	100%	100%		100%
B	1st	No	Yes	50-100%	60-100%		100%
C	2nd and following or 1st and coercion	Possibly	Possibly	10-50%	10-40%	2nd	30-50%
						3rd	20-30%
						Subsequent	Max. 20%

Additionally, the percentage bandwidths for the fine reductions of subsequent applicants have been expanded. The second one to come forward may now receive a reduction between 30% up

[12] The Netherlands Consumer Authority, the Netherlands Competition Authority (NMa) and the Netherlands Independent Post and Telecommunications Authority (OPTA) joined forces on April 1st, 2013. This merger created a new regulator: The Netherlands Authority for Consumers and Markets. Cases prosecuted after April 1st, 2013 therefore fall under the Authority of the ACM.

to 50%, the third one between 20% up to 30%, while subsequent parties may receive a reduction of up to 20%. These percentages replace the previous bandwidth of 10% to 40% ("Category C" table 2) for all but the first applicant of leniency. Thereby, the second applicant can now obtain a higher fine reduction than before: 50% instead of a maximum of 40%. However, the fine reduction scheme became more restricted for the third and subsequent applicants.

4 Hypotheses

This section is devoted to the construction of the hypotheses used to evaluate the effectiveness of the Dutch leniency program. Three different hypotheses are developed. Two are based on the theoretical model of Miller (2009), whilst the other one is based on the theoretical model of Harrington Jr. and Chang (2009).

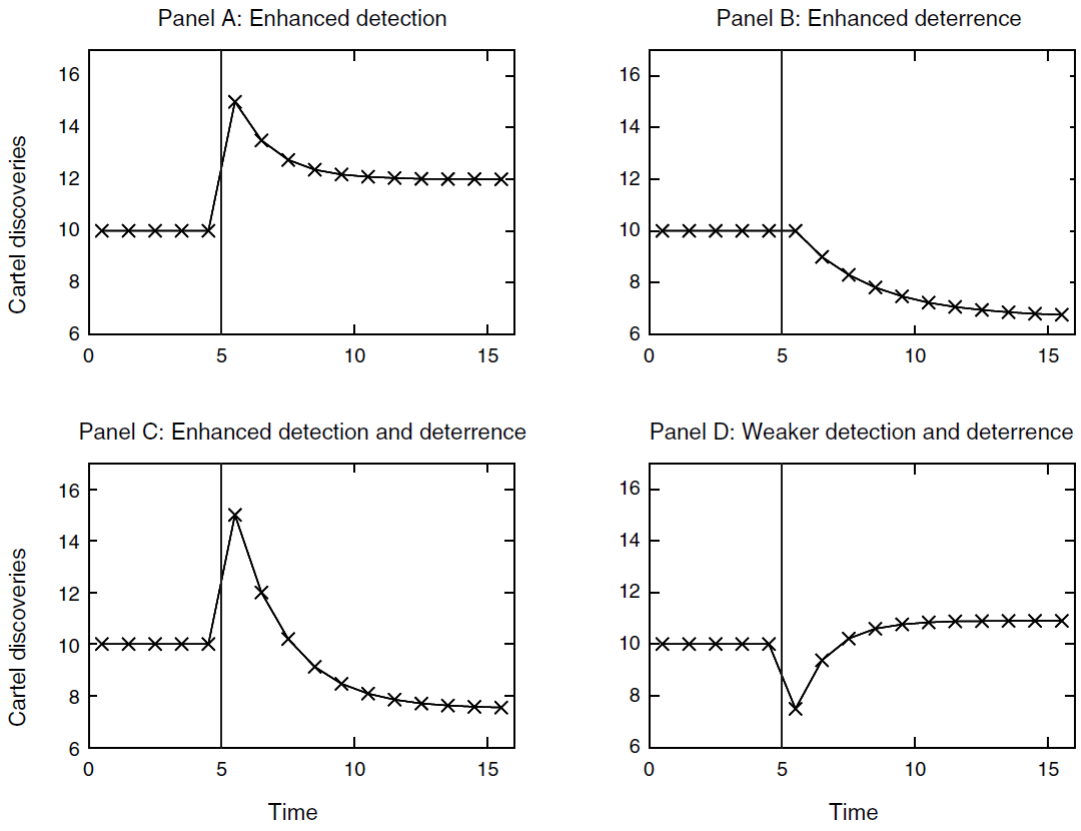
According to the theoretical model of moment condition of Miller (2009), the effectiveness of a leniency program can be evaluated by looking at the time series of cartel discoveries.

Figure 1 illustrates how the changes in detection probability and deterrence affect cartel discoveries over time. The vertical line always corresponds to the introduction of the leniency program, hence the innovation. Panels A and B respectively isolate changes in the detection and formation rates of cartels. Panel A simulates a rise in the detection rate keeping all else constant. The amount of expected cartel discoveries increases directly after the leniency introduction because the competition authority discovers a larger share of active cartels. However, this effect weakens because the improved cartel detection reduces the amount of active cartels over time. On the other hand, panel B describes what happens if a leniency program decreases formation of cartels without affecting the probability that a cartel is detected. One can observe that cartel discoveries do not change directly after the innovation. However, as time passes by, the decreased formation rate reduces the amount of active cartels. Given a constant detection probability, the number of discovered cartels decreases over time because fewer and fewer active cartels exist.

Panels C and D stimulate simultaneous changes in the detection and formation rates. Panel C describes the changes consistent with an effective innovation. One for which detection and deterrence increases. Panel D describes the opposite. An ineffective leniency innovation for

which detection and deterrence decreases. In Panel C the number of expected cartel discoveries increases directly after the innovation. This is because increased cartel detection rate. However, in the long term, the higher detection and lower formation rate reduces the amount of active cartels. Therefore the number of cartel discoveries fall again. Cartel discoveries fall under the initial values because the decrease of the cartel formation rate is sufficiently strong. Panel D describes the convergence path of cartel discoveries if the innovation decreases detection and deterrence of cartels. Immediately after the innovation cartel discoveries decrease due to the lower detection rate. However, after the initial drop, cartel discoveries will rise again. Cartel discoveries rise above initial levels because the lower detection and deterrence increases the pool of active cartels. The decrease in cartel discoveries due to the lower detection probability will be offset by the fact that a lot more active cartels exist.

Figure 1: How changes in detection and deterrence affect cartel discoveries



Source: Miller (2009)

Optimally, a leniency program should increase detection and deterrence of cartels. In order to

provide evidence of the effectiveness of the leniency introduction in the Netherlands the observed convergence path should therefore be the one described in Panel C. This expected convergence path provides the intuition that underlines the following two hypotheses.

Hypothesis 1.1: If a leniency program increases the detection rate, then the number of cartel discoveries will increase directly following the introduction of the leniency program.

Hypothesis 1.1 describes the short-term effect of an effective leniency program. In order for the program to be effective in the long run, the second hypothesis has to be validated.

Hypothesis 1.2: If a leniency program decreases the formation rate of active cartels, then the number of cartel discoveries should readjust below initial pre-leniency levels.

If *hypothesis 1.1* and *hypothesis 1.2* can be jointly validated, then we can conclude that the leniency program helped to detect cartels and also deterred cartel formation. This depends on whether the data supports the time pattern of cartel discoveries as described in the hypotheses. However, according to Harrington Jr. and Chang (2009), there can be cases in which the inference of a policy change on the number of discovered cartels is not very informative about the change in the number of existing cartels. This applies to policies that are designed to affect the discovery and conviction probability in a specific way. An effective enforcement strategy may then effectively reduce the cartel formation rate but the effect on discovered cartels is ambiguous[13]. Depending on whether the effect of an increased discovery rate or a decreased formation rate dominates, there can be fewer or more discovered cartels after an effective leniency innovation. To be precise, the authors find that if the initial detection probability is sufficiently low, a limited amount of cartels are discovered. A leniency innovation which increases the detection probability then leads to more discovered cartels. The reason is that the increase in discovery rate affects a large pool of active cartels and dominates the decrease in the cartel formation rate. This leads to more cartels being discovered. However, if the initial detection probability

[13]This is described in theorem 6 of Harrington Jr. & Chang, 2009: "The rate of cartel formation, 1 - $\beta(0)$, is decreasing in σ but the effect of σ on the rate of discovered cartels, σ [1 - $^{-}\beta(0)$], is ambiguous (that is, its sign depends on the parameter value)".

is high enough (close to 1), the reduced cartel formation rate dominates the higher detection probability (only affecting a small initial pool of active cartels). This means that fewer cartels are discovered after the leniency introduction[14]. Hence, even if the cartel formation rate is decreased, the authors argue that there may be more or fewer cartel discoveries after the leniency introduction, depending on how high the initial pre-leniency detection probability was.

Consequently, Harrington Jr. and Chang argue that the time pattern of the number of discovered cartels does not always provide us with a definite answer on whether leniency is effective. Harrington Jr. and Chang therefore retrieve additional information by modelling the birth and death process of discovered cartels.

In their paper, Harrington Jr. and Chang (2009) describe a dynamic model, in which a firm only joins a cartel in a given period if the participation constraint is binding and the net benefits from colluding are higher than those from the competitive outcome. Absent the leniency program, there exists a "marginal" industry where firms are indifferent between competing and forming a cartel because the long-run profits from colluding are equal to the short-run profits of deviating from the cartel. Cartels which are just worthwhile to undertake, so called "marginal" cartels, are just on the verge between collusion and competition. These are weak cartels and by virtue will only survive a short, limited amount of time.

Theory predicts that once the leniency program is implemented, it becomes more profitable to deviate. This is because when the firm deviates, it will also directly report the cartel and thereby avoid any future fine risk and profit from immunity. Before the leniency introduction the firm could not apply for leniency. Hence, when deviating from the cartel the firm still faced the risk that it may sometime in the future be fined for having participated in a cartel. With the option to apply for leniency, it can now eliminate this risk by deviating and simultaneously reporting the cartel. The firm can then expect a high fine reduction or even immunity from the fine. As already mentioned, this increases the incentive to deviate once a firm can simultaneously apply for leniency.

Additionally, increased detection probability due to the leniency program reduces the long-run net benefits from colluding. The risk of being caught and convicted is higher each period. Hence, the expected fine is also higher each period and the profits from colluding are reduced.

[14] The authors provide a proof of their theorem 6 (See Harrington Jr. & Chang (2009), p.1413-1414).

The profits from colluding include the risk of being fined by subtracting the expected fine of colluding[15] from the benefits of colluding.
Overall, if the leniency program is effective, its introduction will lead to fewer profits from colluding and higher benefits from deviating. Consequently, some cartels that were sustainable before the leniency introduction now become unsustainable. Those cartels that were only marginally stable will be the first ones to fall into a stage of outcomes that are unsustainable and dissolute once the leniency program is introduced. These marginal cartels, by cause of being marginally stable, are relatively short-lived. The remaining active cartels are then mainly stable, longer-lived cartels. Ensuing cartel detections will therefore come from these longer-lived cartels. Hence, if a leniency program effectively destabilises cartels, the following hypothesis has to be validated.

Hypothesis 2: In the short term after the introduction of the leniency program, the average duration of detected cartels will increase.

In the long run, there will be two ways in which cartel duration of detected cartels will be affected. Firstly, marginal cartels that collapsed due to enhanced detection will not form in the first place. This means that detection more dominantly comes from longer-lived cartels, which increases the average duration of discovered cartels. However, the second effect is that due to the higher detection and deterrence the formerly stable, long-lived cartels break up earlier. Overall, these effects oppose each other and the average cartel duration of discovered cartels can increase or decrease in the long term. Hence, the analysis on cartel duration focuses on assessing the short-term effect of leniency on cartel duration.

5 Data

For this study an extensive data set was created covering all cartel cases prosecuted by the NMa, and later by the ACM, over the years 1998 to 2015. Only publicly available information was used to create this data set. In total, the data set covers 77 prosecuted cartels, which were active in

[15] expected fine = Total fine amount × probability of being caught

the Netherlands. Most cases cover horizontal agreements on prices and quantities. These cases fall under article 6, first paragraph of the Dutch competition act and Article 101 of the Treaty on the Functioning of the European Union (ex Article 81, first paragraph, of the Treaty establishing a Constitution for Europe (TCE)).

The cases are analysed on the firm level. Information from around 1300 decision reports was retrieved. The data set indicates the initial fine and ,if applicable, the changed fine (i.e. due to the final ruling of the College van Beroep voor het bedrijfsleven (CBb)[16]) of all firms which participated in the cartels. For the analysis, the final, most recent fine decision is used. Additionally, information on investigation duration, cartel duration, the percentage of leniency granted (if applicable) and other particularities of the procedures was retrieved. Particularities in the procedure include fine discounts due to the relative size of the colluding firm (based on the turnover of the firm), the willingness of the firm to cooperate to accelerate the prosecution ("settlement procedure") and lastly the potential fine reduction or elimination due to the potential risk of bankruptcy of the firm.

Many cartels result in numerous different documents. Additionally, the documents often list numerous firms and/or individuals that took part in the same cartel. Therefore, the different violating firms are grouped into cartels, making later analyses on the broader cartel level easier. Table 3 provides summary statistics of the data.

One should notice that the data set originally contained 85 cartel decision. However, 8 cases have not been confirmed as cartels and were therefore not included as cartel discoveries in the data set. These cases represented mainly those in which the council/CBb had the final ruling and decided that there was not enough evidence for a conviction.

Moreover, I have to bring to the reader's attention that one of the cases was excluded as a cartel discovery from the current data set because it is still ongoing. The case represents a price and market fixing agreement in the market of collection of maritime waste in Rotterdam, first prosecuted in 2011. For this case, the initial decision was cancelled by the court because the court came to the conclusion that some of the information was not retrieved in a correct manner. This included information that the ACM retrieved via wiretaps provided by the Ministry of Public Af-

[16]The CBb is the Supreme Administrative Court for the socio-economic administrative law in the Netherlands. It is the highest instance in decisions regarding among others competition policy and agricultural subsidies.

fairs of the Netherlands. However, the CBb ruled that this information was retrieved correctly, which means that the case is currently reviewed once more by the court. As no final decision has yet been made, this case could not be included as a cartel discovery.

Table 3: Summary statistics

Cartel discoveries:		**Leniency:**	(exclusive construction cartels)	**Others:**	
Total number of cartel discoveries	**77**	Number of leniency applicants	**41**	Average investigation time (in days)	**824**
Number of cartel discoveries from July 2007 onwards	**38**	Cartels with at least one leniency applicant	**19**	Average cartel duration (in days)	**1247**
Number of cartel discoveries before July 2007	**39**	% of total cartels	**27,94%**		
		"Category A" applicants	**7**		
		% of total applicants	**17,07%**		
		Cartels with at least one "Category A" leniency applicant	**7**		
		% of total cartels	**10,29%**		
		Categories:			
		"Category B" applicants (>=50% but <100%)	**18**		
		"Category C" applicants (<50%)	**16**		

Lastly, it is important to notice that Table 3 provides summary statistics of the number of leniency applicants, excluding those which applied for fine reductions in the big construction cartels prosecuted around 2005. The NMa started investigating in the construction sector in 2001 after receiving numerous complaints by customers and competitors. The extent of the infringement was huge and included cartels in the whole of Netherlands in many different construction sectors such as the installation, the civil and road construction, the land road and water construction and the cable and pipe work sector. Due to the immense scale of these cartels, the competition authority set up a special fine reduction procedure. A deadline was set for all the involved companies to cooperate with the authorities and apply for fine reductions. All participating firms could then receive fine reductions based on the level of cooperation and evidence they presented. The goal was to, once and for all, wipe out all construction cartels.

This was done without limiting the number of firms that could apply for a fine reduction. After having evaluated these huge cartels, I came to the conclusion that these should be analysed separately. The numerous applicants of fine reductions should not simply be added to the leniency applicants of the other cartels prosecuted between 1999 and 2015 in the Netherlands. The civil and road construction cartel alone had up to 550 participating firms, from which approximately 250 applied for fine reductions. Similar numbers are found for the land roads and water construction cartel, which counted approximately 320 participants, from which 38% applied for this special procedure, receiving a maximum of 50% fine reduction. Including the applicants of these huge construction cartels as leniency applicants would create huge outliers. The overall sample, excluding the big construction cartels, only counts 41 separate leniency applicants. Due to the special procedure of these big construction cartels, which resulted in a huge number of applicants, these applicants are not included as leniency candidates.

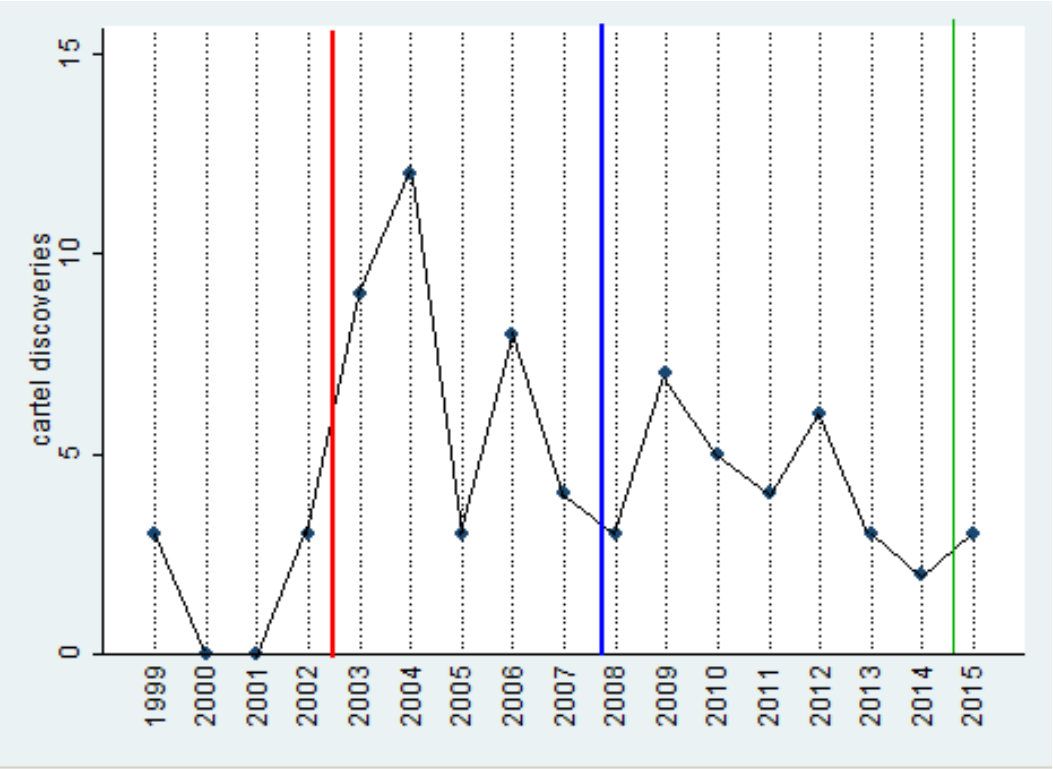
A first glance at the data seems to reveal some interesting properties. I created a series of one-year periods to track discoveries. Figure 2 plots the total number of cartel discoveries per year[17]. The year of discovery is set in correspondence to the publication date of the final decision report. Alternatively, one could have used the date at which the cartel investigation started. However, sometimes the NMa/ACM concludes in the final decision report that the initial concerns do not represent an infringement of the competition act. Starting an investigation is thus not equivalent to identifying a cartel. It is thus more intuitive to use the date of the publication of the final decision report because this marks the date at which the case was truly identified as a cartel. The vertical bars in figure 2 mark respectively the implementation of the leniency program (red), the introduction of the first revised leniency guidelines (blue) and the implantation of the second revised leniency guidelines (green). The observed pattern of cartel discoveries over time gives us a first idea whether the leniency program is effective.

The pattern in cartel discoveries over the years 1999 to 2015 seems to correspond to the desired pattern as shown in Panel C in figure 1. To be precise, after the introduction of the leniency program in July 2002 an immediate increase in the number of cartel discoveries can be observed.

[17] Note that the figures 2 and 3 plot the total number of cartel discoveries/average cartel duration per 12-month period. This is done for illustrative purposes. In the later analysis, I use the average number of cartel discoveries per 6-month period and the average cartel duration per case. This is done in order to better distinguish between those cartels discovered before the leniency introduction on July, 1st 2002 and the ones discovered later that year (after the leniency introduction).

Thereafter, cartel discoveries seem to decrease again, which could be due to the increased deterrence. Cartel discoveries then slightly recover after the implementation of the revised leniency guidelines in October 2007. However, a clear second spike or a revision in the downward trend cannot be observed. In the long term, discoveries fall further, reaching values close to those in the pre-leniency period.

Figure 2: Cartel discoveries over the years 1999 to 2015

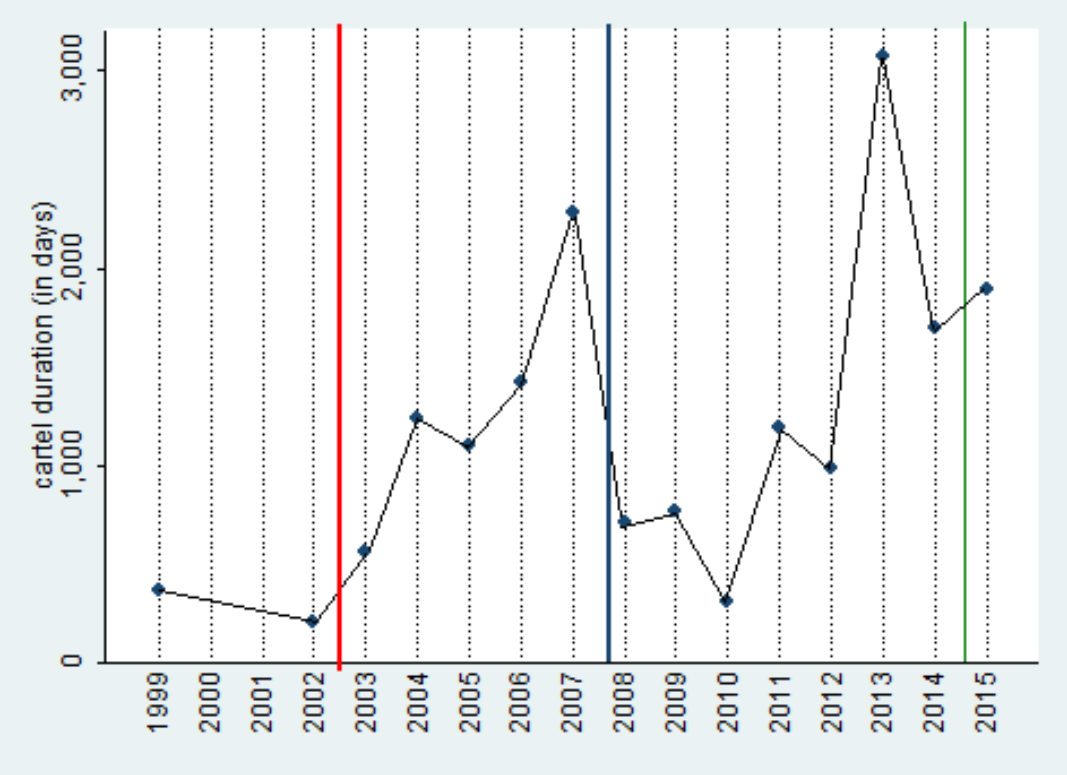


Note: The vertical bars mark respectively the introduction of the leniency program (red), the introduction of the first revised leniency guidelines (blue) and the implantation of the second revised leniency guidelines (green).

Figure 3 gives a first insight into the evolution of cartel duration of discovered cartels over the years 1999 to 2015. The graph displays the median cartel duration of all cartels discovered throughout the year specified on the horizontal axis. The desired pattern of cartel duration, corresponding to an effective Leniency program according to Harrington Jr. and Chang, 2009, can partly be observed. Cartel duration of detected cartels immediately after the leniency introduction, represented by the red, vertical line, increases. Most of the discovered cartels now seem to be longer-lived, stable cartels. However, Cartel duration falls directly after the introduction of the first revised leniency guidelines. This is not in line with an effective leniency innovation. In

the long run, cartel duration increases further and does not readjust below the short-run level. It is important to notice that these first insights do not yet provide the needed evidence to conclude on the effectiveness of the leniency program and its subsequent revision of 2007 (and 2014). Both graphs do not control for factors such as the number of participants in the cartel, the annual GDP, the annual budget of the competition authority or other industry specific factors. It could well be that the differences in the number of cartels/average cartel duration over the years come from differences in the above-mentioned factors that have yet to be controlled for. Figures 2 and 3 therefore only provide limited insights and should be interpreted very carefully. Regression, with needed controls, are assessed in section 7.

Figure 3: Cartel duration over the years 1999 to 2015



Note: The vertical bars mark respectively the introduction of the leniency program (red), the introduction of the first revised leniency guidelines (blue) and the implantation of the second revised leniency guidelines (green).

6 Empirical Framework

In the first part of my analysis, I use ordinary least squares (OLS) regressions in order to test whether the data is consistent with the desired cartel discoveries pattern of an effective leniency program (see figure 1, panel C). I perform three statistical tests, corresponding to the short-term detection and the long-term deterrence effect of the leniency program.

For the short-term effect, I evaluate whether the number of cartel discoveries rises directly following the implementation of the leniency program. This corresponds to testing *hypothesis 1.1*. The OLS regression looks as follows:

$$Number_{(cartels)} = \theta + \alpha \times LENIENCY + \beta \times X + \varepsilon, \tag{1}$$

The dependent variable, $Number_{(cartels)}$, denotes the number of discovered cartels per 6-month period (unit of observation). The independent variable, $LENIENCY$, is a dummy variable which equals one if the period postdates the introduction of the leniency and zero otherwise. In the regression X represent a set of controls, which include the Dutch semi-annual GDP and the semi-annual budget of the competition authority of the Netherlands[18]. The regression also includes a constant θ. Lastly, ε is the normally distributed error term of the regression.

I then test:

$$H_0 : \alpha_{(LENIENCY)} \leqslant 0 \; versus \; H_a : \alpha_{(LENIENCY)} > 0,$$

The full sample includes cartels discovered between 1998 until the end of 2015. However, as the short-term effect is considered, I run this specific regression only over the period 1998 until the end of 2004[19]. By running the regression over the period up to the 31st of December 2004, only cartels discovered before the end of the short-term leniency period, here defined as the 18 months following the leniency introduction in July 2002[20], are considered. This also includes

[18] For robustness the regression is also tested with an additional control for the total number of firms in the Netherlands (see also footnote 28).

[19] By the use of a time dummy I limit my sample to the specified time period.

[20] Note that for robustness checks additional tests for different durations of the short-term leniency period are conducted. The time period over which the regression runs is changed correspondingly. For example, if the short-term leniency period is reduced to the 12 months following the leniency introduction, the regression will run from 1998 until the 1st of July 2003. Hence, the regression will only include those cartels discovered in the pre-leniency

those cartels discovered in the pre-leniency period. The $LENIENCY$ coefficient then compares the values in the pre-leniency period to those in the short-term period after the leniency introduction (short-term leniency period). Only if the $LENIENCY$ coefficient turns out to be positive, the regression model generates an increase in cartel discoveries in the short term after the leniency introduction. Meaning that, the average number of cartel discoveries is higher as compared to the pre-leniency levels. This corresponds to an immediate increase in cartel discoveries once leniency is introduced.

I then test whether, after the initial spike in the short term (if observed), cartel discoveries start falling again. For this I run the following regression:

$$Number_{(cartels)} = \theta + \rho \times CHANGE + \beta \times X + \varepsilon, \tag{2}$$

$CHANGE$ is a dummy which equals 1 if the period postdates July 1, 2004 and 0 otherwise. Just like in regression 1, X represent a set of controls, which include the Dutch semi-annual GDP and the semi-annual budget of the competition authority of the Netherlands. The regression also includes a constant θ and an error term ε.

I then test:

$$H_0 : \rho_{(CHANGE)} \geqslant 0 \; versus \; H_a : \rho_{(CHANGE)} < 0,$$

I run the regression over the limited time period from the 1st of July 2002 until the 1st of July 2005. The Change dummy thus compares the average number of cartel discoveries in the first 2 years after the leniency introduction to those in the 3rd year after the leniency introduction[21]. Only if the $CHANGE$ coefficient is negative, the average number of cartel discoveries (per 6-month period) starts falling again after the short-term leniency period[22].

For the long-term deterrence effect, I test whether cartel discoveries fall back to levels below the initial pre-leniency levels. This corresponds to testing *hypothesis 1.2.* Here a regression similar

period and in the "reduced" short-term leniency period.

[21] For robustness cartel discoveries in the first 2 years after the leniency introduction are compared to those in the 3rd and 4th year after the leniency introduction. The regression then runs over the period from the 1st of July 2002 until the 1st of July 2006

[22] Note that I define the 2 years following the leniency introduction as the short-term leniency period for this regression. This is my upper-bound for the short-term leniency period, as will be explained in more details in section 7.

to the first one is tested:

$$Number_{(cartels)} = \theta + \alpha \times LENIENCY + \beta \times X + \varepsilon, \tag{3}$$

However, I run this regression over the two time periods from 1998 until the 1st of July 2002 and from January 2007 until the end of 2015.

I then test:

$$H_0 : \alpha_{(LENIENCY)} \geqslant 0 \; versus \; H_a : \alpha_{(LENIENCY)} < 0,$$

By running the regression over the specified time periods, cartels that are discovered between the 1st of July 2002 and the 1st of January 2007 are excluded. This limits the evaluated sample to cartels discovered in the pre-leniency period and in the long-run period after the leniency introduction[23]. The $LENIENCY$ coefficient thus directly compares the number of cartel discoveries in the pre-leniency period to those in the long-run leniency period. If the $LENIENCY$ coefficient is negative, it means that the average number of cartel discoveries in the long run after the leniency introduction is lower than in the pre-leniency period. Hence, only if the leniency coefficient is negative, the regression model generates a decrease in cartel discoveries in the long run below the initial pre-leniency levels.

If the null hypothesis can be rejected for all three regressions, we can conclude that the Dutch leniency program helped to detect cartels and also deterred the formation of new ones. The data would be consistent with the cartel discoveries pattern of an effective leniency program according to the theoretical model of Miller (2009).

To further investigate the effectiveness of the Dutch leniency program, I evaluate the pattern of cartel duration. This helps to conclude on the efficacy of the leniency program according to the theoretical model of Harrington Jr. and Chang (2009). To test *hypothesis 2* I set up the following regression:

$$Duration_{(cartel)} = \theta + \alpha \times LENIENCY + \beta \times X + \varepsilon, \tag{4}$$

[23] For robustness an additional test is conducted in which I define the long-term leniency period as the year 2009 onwards. The corresponding regression runs over the two time periods from 1998 until the 1st of July 2002 and from the 1st of January 2009 until the end of 2015

Regression 3 looks similar to regression 1. However, the dependent variable is now $Duration_{(cartel)}$ and denotes the cartel duration (in days) per case. Moreover, the number of cartel members is included as an additional control, as will be explained in more details at the end of this section. Just like regression 1, I run this regression over the period 1998 until the end of the short-term leniency period. Thereby, I limit the evaluated sample to cartels discovered in the pre-leniency period and in the short-run period after the leniency introduction.

In order to validate *hypothesis 2*, I test if the null can be rejected in favour of the alternative hypothesis. I thus test:

$$H_0 : \alpha_{(LENIENCY)} \leqslant 0 \; versus \; H_a : \alpha_{(LENIENCY)} > 0,$$

When running the regression over the above specified time period, the dummy $LENIENCY$ in the regression compares the average duration of cartels discovered in the pre-leniency period to those in the short-term period after the leniency introduction. Consequently, only if the leniency coefficient is positive, the regression model generates an increase in the average cartel duration in the short run.

If the null hypothesis can be rejected in favour of the alternative hypothesis, we can conclude that the leniency introduction was effective in destabilising cartels and resulted in the dissolution of the marginal cartels. The program thus helped to reduce the pool of active cartels. In the long term, an effective leniency program may lead to an increase or decrease in cartel duration of detected cartels. The long-term effect is thus ambiguous. As already mentioned, I therefore focus on evaluating the short-term effect of the leniency introduction on cartel duration.

For robustness, all models are estimated controlling for possible confounding variables. The first control is the (semi-) annual GDP. Empirical evidence on the effects, which higher economic activity has on the case load of competition authorities (hence the number of investigated cartels) is ambiguous. Some scholars argue that case load of competition authorities is procyclical (Posner, 1970) whilst other argue the opposite (Ghosal, 2001). To correct for the possibility that higher economic activity over the years may lead to more cartels[24] being formed, I control for the business cycle in my regressions.

Additionally, I control for the annual budget of the NMa/ACM. Generally, the case load a com-

[24] Or fewer according to Ghosal (2001).

petition authority can take up, and thus also the corresponding cartel discoveries, will be higher the more budget is allocated to the competition authority. This means that we have to correct for changes in the allocated budget over the years. I therefore add a control variable, "semi-annual budget", that captures the budget allocated to the competition department of either the NMa or in later years the ACM. The fact that I use only the part devoted to the competition department does not only yield more accurate estimates but also makes the allocated budget between the NMa and ACM more comparable. Both organisations had several different departments, which makes the total budget allocated to the organisations not very informative for our purpose.
Lastly, I control for the number of cartel members in my regression on cartel duration. The number of cartel members influences cartel stability, and therefore the duration of cartels. When the number of participating firms in a cartel increases, monitoring within the cartel becomes more difficult. There is thus a higher risk that some members undercut the cartel price and deviate from the cartel in order to increase their sales. This has adverse effects on stability, and therefore on the duration of cartels (Choi & Hahn, 2014).

6.1 Alternative Models

There exist many alternative models to ordinary least squares (OLS) for analysing count data. Indeed, OLS has been used frequently by researchers and may be desirable to use because of its familiarity. Furthermore, Sturman (1999) provides evidence that OLS does not yield more "false positives" (type 1 errors) than expected. Through a simulation test that counts the number of times that each model incorrectly identifies a statistically significant relationship, he shows that OLS is not overly sensitive to type 1 errors. Therefore, OLS does not incorrectly reject a true null hypothesis more often than other count-data models.
However, OLS is relatively restrictive in its assumptions. On the one hand, my relatively small sample size of cartel discoveries makes the assumption of normality a rather strong assumption. On the other hand, the OLS assumption of homoscedasticity has been taking care off. By using robust standard errors for my OLS regressions, I account for potential heteroscedasticity in the error term. Nevertheless, OLS does not account for the data being truncated at zero, which means that OLS may lead to negative values that are senseless for my count-data outcome variable (i.e. number of cartel discoveries per 6-month period).

Moreover, there has been a lot of discussions and there is a consensus that using multiple methods of analysis helps to cope with the difficulties of research performed with count data (Sturman, 1999; Baba, 1990). For this reason, I quickly introduce two additional count-data models, which are used for robustness checks for my estimates of the short-term effect of the leniency program on the number of cartel discoveries (discrete count).

The Poisson model, which was also used by Miller (2009), is generally both "an easy and accurate way" of modelling count data (Sturman, 1999). The reduced Poisson regression as compared to OLS assumes that the errors follow a Poisson, not normal, distribution. It may be more appropriate to count data because Poisson distributed data is intrinsically integer-valued. Moreover, Poisson-distributed data is always positive and cannot lead to meaningless negative outcomes. Therefore, it makes sense to illustrate the results of the Poisson model to our reader.

The Poisson-regression model expresses the probability that Dt, which is the number of cartel discoveries, has the realization dt as:

$$Pr(D_t = d_t|z_t) = \frac{exp(-\lambda_t)\lambda_t^{d_t}}{d_t^!}, \qquad d_t = 0,1,2,..., \tag{5}$$

where the conditional mean λ_t is:

$$\lambda_t = exp(z_t^{'}\sigma) \tag{6}$$

Here, the vector z_t includes the regressor, and σ is a vector of parameters. The regressor is again the dummy for the leniency introduction. I then, once more, test the earlier mentioned *hypothesis 1.1*. In order to test whether the introduction of the leniency program resulted in a direct increase in the number of cartel discoveries, I test:

$$H_0 : \sigma_{(LENIENCY)} \leqslant 0 \; versus \; H_a : \sigma_{(LENIENCY)} > 0,$$

By running the regression only over the period 1998 until the end of 2004, the $LENIENCY$ coefficient directly compares the average number of cartel discoveries (per 6 months) in the pre-leniency period to those in the short-term leniency period. For robustness, the model is estimated with the same controls included in the OLS regression.

However, using Poisson regressions introduces an additional restriction. Namely, that the mean

equals the variance. This might not be a very realistic assumption for our model. In our sample, cartel discoveries this year might be dependent on cartel discoveries in the past (year). If for example, there have been a lot of cartel discoveries in the past, cartel members fear the competition enforcer and they are more likely to "run to the court", in order to avoid potential future fines. This will then lead to an increase of (self-reported) cartel discoveries this year. Such dependence of cartel discoveries over time can lead to extra variation, referred to as overdispersion[25]. In this case, the variance would be higher than the mean and the true variation would be higher than the one predicted by the model.

The negative binomial model can be used for overdispersed data. It is one of the more general count data models. The Poisson model is a special case of the negative binomial model and it has the same structure. The difference between the two models is that the negative binomial model has an extra parameter η , modelling the overdispersion. The negative binomial model does not only correct for overdispersion but it is also more appropriate when the mean level of the dependent variable is different across intervals. Lastly, it yields fewer false positives than the Poisson regression in the simulation test performed by Sturman (1999). It may therefore be used as a conservative test.

Typically, the negative binomial model is characterized by one of the following specifications of the variance of the dependent variable: $\text{Var(y)} = \text{E(y)} \times (1 + \eta)$ or $\text{Var(y)} = \text{E(y)}^2 \times (1 + \eta)$, where η is positive. The first specification implies a constant ratio between the mean and the variance. The second specification implies a linear relation between the mean and the variance (Cameron & Trivedi, 1986). Clearly, both specifications are less restrictive than the Poisson specification, for which $\text{Var(y)} = \text{E(y)}$ has to hold. There exist even more possibilities. However, this study uses the first model, for which $\text{Var(y)} = \text{E(y)} \times (1 + \eta)$, which is the one available in the software packaged used (Stata).

7 Empirical Results

This section discusses the regression results of the effect of the Dutch leniency program on detection and deterrence capabilities. The first part discusses the regression results according to

[25] The model is tested for overdispersion in section 7.

the theoretical model of Miller (2009). The second part considers the regression results of the effect of the leniency program on cartel duration. The latter corresponds to testing the effectiveness of the leniency program according to the theoretical model of Harrington Jr. and Chang (2009).

7.1 Testing the Effect of the Leniency Program on Cartel Discoveries

I first consider the short-term effect of the leniency program on detection capabilities according to the theoretical model of Miller (2009). Table 4 presents the main OLS regression results of the short-term effect of the leniency program on cartel discoveries. In each regression, the dependent variable is the number of discovered cartels per 6-month period. The short-term leniency period is defined as the 18 months following the leniency introduction. I define the short-term leniency period as 18 months because this allows the competition authorities to process cases of cartels for whom it becomes now worthwhile to self-report. As discussed earlier, the publication date of the final report marks the definite discovery of a cartel. It can thus require some time until reports are published and the effect on cartel discoveries can be observed. Therefore, I choose the short-term period to end just before the end of the year following the leniency introduction. Some might even argue that the average time to investigate the potential new cartel discoveries might be longer than a year[26]. This is why I also provide the regression results for the short-term leniency period defined as the 24 months, hence 2 years, after the leniency introduction. Finally, the results for a short-term leniency period, defined as the 12 months following the leniency introduction, are provided as an additional robustness check.

Column 1 provides the regression results excluding any controls. The estimated *LENIENCY* coefficient is 3.222. The coefficient indicates that there are on average 3.2 more cartels discovered each 6 months in the 18 months following the leniency introduction (short-term leniency period), as compared to in the pre-leniency period. This immediate increase is significant at the 5% level and very close to the 1% significance[27].

Columns 2, 3 and 4 show that the results are robust to the inclusion of the control variables. Columns 2 and 3 respectively include controls for the total semi-annual Dutch GDP and the

[26] The average investigation time for the cartels convicted by the NMa/ACM throughout the years 1998 to 2015 is around 2 years

[27] p-value: 0.015

semi-annual budget allocation devoted to the competition department of the NMa/ACM. Column 4 includes both control variables. For all 3 specifications, the estimated *LENIENCY* coefficient remains positive and statistically significant at the 5% level[28]. The control for the budget allocation has the expected positive sign. A higher budget allocated to the competition department increases the number of cartels discovered by the competition authority.

Moreover, Columns 5 and 6 provide evidence that the results are also robust to changes in the short-term leniency period length. The coefficient for the *LENIENCY* dummy remains positive once the short-term leniency period is reduced to the 12 months following the leniency introduction[29]. Column 5 shows that the *LENIENCY* coefficient is now slightly lower and still significant at the 5% level. Lastly, column 6 shows that even if the short-term leniency period is extended to 2 years, the increase in cartel discoveries remains positive and significant at the 5% level. The coefficient is now even slightly higher and indicates that there are on average 4.5 more cartels discovered each 6 months throughout the 2 years following the leniency introduction, as compared to in the pre-leniency period.

[28] It has also been checked if the regression results for the effects on cartel discoveries are robust to the inclusion of a control for the total number of firms in the Netherlands. The *LENIENCY* coefficient remains significant and has the same sign after including the control for the number of firms.

[29] It has additionally been checked if an increase in cartel discoveries can be observed when limiting the short-term leniency period to the first 6 months following the leniency introduction. Also for this reduced short-term period the *LENIENCY* coefficient remains positive and significant at the 1% level (coefficient: 1.617).

Table 4: OLS regression results: detection capabilities

Variables	*No Control Variables*	*Control Variables*			*12-month Period*	*24-month Period*
	(1)	(2)	(3)	(4)	(5)	(6)
LENIENCY	3.222**	3.208**	3.192**	3.200**	2.099**	4.524**
	(1.104)	(1.193)	(1.190)	(1.271)	(0.616)	(1.871)
Control Variables						
GDP(semi-annual)		0.441		-1.145	-4.394	49.036
		(12.397)		(18.598)	(18.920)	(56.725)
Budget (semi-annual)			0.007	0.014	0.022	-0.264
			(0.083)	(0.120)	(0.117)	(0.363)
R^2	0.644	0.645	0.645	0.645	0.596	0.591
Observations	12	12	12	12	11	13

Note: Table 4 shows the regression results for the short-term effect of the leniency program on cartel discoveries. The dependent variable is the number of cartel discoveries per 6-month period. Columns 1, 2, 3 and 4 use the 18 months following the leniency introduction as the short-term leniency period. Columns 4 and 5 are robustness checks and use respectively the 12 months and 24 months after the leniency introduction as the short-term leniency period. For columns 1, 2, 3 and 4 the regressions run over the time period January 1998 until the end of 2004. For column 5 the regression runs over the time period January 1998 until the 1st of July 2003, whilst for column 6 the time period is extended until the 1st of July 2004 (see empirical framework, regression 1 and footnote 20 for more details). *LENIENCY* is a dummy which equals 1 if the period postdates July 1st, 2002 and 0 otherwise. In the regressions, the *LENIENCY* dummy thus compares the average number of cartel discoveries (per 6 months) in the pre-leniency period, to the one in the short-term leniency period. The variable GDP is the semi-annual Dutch Gross Domestic Product. The variable budget is the budget of the NMa/ACM solely allocated to the competition department. The yearly budget allocation is divided by two in order to get the semi-annual budget allocation. The t-statistics are computed with Newey-West (NW) standard errors, which are shown in parentheses.

*** Significance at the 1 percent level.

** Significance at the 5 percent level.

* Significance at the 10 percent level.

Turning to the effect of the leniency program on deterrence capabilities, Table 5 provides the regression results for the long-term effect of the leniency program on the number of cartel discoveries. Following the theoretical model of Miller (2009), one should observe that after the initial increase in cartel discoveries, an effective leniency program should, through a higher detection and deterrence capability, decrease the pool of active cartels. Consequently, cartel discoveries should fall again. In the long run, cartel discoveries should fall below pre-leniency levels because the decrease in the formation rate is sufficiently strong.

Columns 1 and 2 indicate whether the number of cartel discoveries, after the initial short-term increase, start to fall again. This corresponds to testing regression 2 (see empirical framework). Results in columns 3 to 5 provide an answer to the question, whether the long-term effect on the formation rate is strong enough to decrease the number of discovered cartels below the initial pre-leniency levels. They correspond to testing regression 3. For columns 1 and 2 the variable *CHANGE* is a dummy which equals 1 if the period postdates July 1st, 2004 and 0 otherwise. For the columns 3, 4 and 5 the variable *LENIENCY* is again a dummy variable, which equals 1 if the period postdates July 1st, 2002 and 0 otherwise.

The estimated coefficient for the variable *CHANGE* in the first column is -10.531, indicating that there are on average 10 fewer cartels discovered each 6 months in the 12 months from July 2004 onwards, as compared to in the short-term leniency period[30]. This decrease in cartel discoveries is significant at the 1% level. Column 2 uses the 24 months following the short-term leniency period. In this period as well, cartel discoveries decrease as compared to the short-term leniency period. There are on average 8 fewer cartels discovered each 6 months in the 24 months following the short-term leniency period, as compared to in the short-term leniency period itself. The negative coefficient is only significant at the 10% level.

Now that we observe a reversion in the number of cartel discoveries, it becomes interesting to see whether the fall persists and leads to a decrease in cartel discoveries below the pre-leniency levels in the long run.

Column 3 of Table 5 compares the average number of cartel discoveries (per 6-month period)

[30]Note that I used the 2 years following the leniency introduction as the short-term leniency period for this regression. This is my upper-bound for the short-term leniency period as defined earlier (see table 4 column 6)

in the pre-leniency period to those at least four and a half years after the leniency introduction. This interval should leave enough time for the deterrence effect of the leniency program to shrink the number of active cartels, leading to a reversion in the number of cartel discoveries below the initial pre-leniency levels. However, the coefficient for the *LENIENCY* dummy is 1.429, indicating that the average number of cartel discoveries (per 6 months) at least 4 and a half years after the leniency introduction is still higher than in the pre-leniency period. The coefficient is significant at the 1% level. Even after including controls for GDP and annual budget the coefficient remains positive and significant at the 10% level. A possible reason that the fall in cartel discoveries does not persist is that the leniency innovation of August 1st, 2007 may have increased the detection capabilities once more. The short-term effect of the leniency innovation of 2007, if effective, would be to increase cartel discoveries. This would work against the decrease in cartel discoveries caused by the deterrence effect of the initial leniency program.

For Robustness, I change the long-term period to the years 2010 until 2015 (the end of my sample of discovered cartels). I therefore compare the cartel discoveries in the pre-leniency period to those at least seven and a half years after the leniency introduction. The long-term period now includes only the years after the short-term period (approximately 2 years) of the in August 2007 revised leniency program. This should reduce the "direct" influence of the short-term effect of the leniency revision on cartel discoveries. However, the *LENIENCY* coefficient in column 5 remains positive, indicating that the average number of cartel discoveries does not revert below initial pre-leniency levels. The coefficient becomes insignificant.

Overall, there seems to be evidence of a reversion in the number of cartel discoveries in the periods following the immediate spike in cartel discoveries. However, the deterrence effect is not strong enough to decrease the number of cartel discoveries below the initial pre-leniency levels in the long run. Another reason why cartel discoveries do not revert below the pre-leniency levels could be due to the enhanced detection capabilities of the subsequent leniency revisions, overlapping with the long-term deterrence effect of the initial leniency introduction. If detection capabilities are endogenous in our model and increase over the years, the number of cartel discoveries could stay high even if the pool of active cartels shrinks.

Table 5: OLS regression results: deterrence capabilities

Variables	*12 months*	*24-months*	*2007 onwards*		*2010 onwards*
	(1)	(2)	(3)	(4)	(5)
CHANGE	-10.531 ***	-8.209*			
	(1.047)	(1.193)			
LENIENCY			1.429***	4.323*	5.791
			(0.458)	(2.236)	(3.941)
Control Variables					
GDP(semi-annual)	804.941	251.584		-32.383	46.985
	(180.736)	(115.518)		(22.686)	(38.503)
Budget (semi-annual)	-6,626	0.124		0.070	0.151
	(3.152)	(1.971)		(0.117)	(0.180)
R^2	0.909	0.661	0.198	0.261	0.339
Observations	6	8	25	25	19

Note: Table 5 shows the regression results for the long-term deterrence capabilities of the leniency program. The dependent variable is the number of cartel discoveries per 6-month period. Columns 1 and 2 respectively compare the number of cartel discoveries in the 12 months and 24 months after the short-term leniency period, to the ones in the short-term leniency period. The regressions respectively run over the time periods from the 1st of July 2002 until the 1st of July 2005, and from the 1st of July 2002 until the 1st of July 2006. The variable *CHANGE* is a dummy which equals 1 if the period postdates July 1st, 2004 and 0 otherwise. The *CHANGE* dummy thus compares the values directly after the short-term leniency period, to the ones in the short-term leniency period (see empirical framework, regression 2 for more details). Columns 3, 4 and 5 compare the average number of cartel discoveries in the pre-leniency period to those in the long-term. For columns 3 and 4 the long-term is defined as the years 2007 until 2015. For column 5 the long-term includes the years 2010 until 2015. *LENIENCY* is a dummy which equals 1 if the period postdates July 1st, 2002 and 0 otherwise. The regressions in columns 3, 4 and 5 only run over the pre-leniency period and the long-term leniency period. The *LENIENCY* dummy in columns 3, 4 and 5 thus compares the pre-leniency values to those in the long-term leniency period (see empirical framework, regression 3 for more details). Controls again include the semi-annual Dutch GDP and the semi-annual budget allocated to the competition department of the NMa/ACM. The t-statistics are computed with Newey-West (NW) standard errors, which are shown in parentheses.

*** Significance at the 1 percent level.

** Significance at the 5 percent level.

* Significance at the 10 percent level.

The main result of this section is that whilst evidence for the deterrence effect of the leniency program remains limited, the desired short-term effect of the leniency program on detection capabilities is observed in the data.

In order to further underline the results of the short-term effect of the Dutch leniency program on cartel discoveries, I replicate the regression results of Table 4 using two alternative count models. For robustness, Table 6 provides the most important results of the short-term effect of the leniency program using both the Poisson and the negative binomial regression model.

One should note that both count models are valid for our regressions. As already mentioned, the negative binomial model does not require the mean to be equal to the conditional variance. This inequality is captured by estimating a dispersion parameter η. In contrast to the negative binomial model, this parameter is held constant (= zero) in a Poisson model. If the overdispersion is zero, the more restricted Poisson model can be used without having to rely on the estimates of the negative binomial model.

The Pearson and the Deviance goodness-of-fit test for the Poisson regression are both statistically insignificant. This indicates that the model fits our data reasonably well. This is a first indication that overdispersion might not be an issue after all. Additionally, I calculated the likelihood ratio test that the dispersion parameter $\eta = 0$. This likelihood ratio test, which compares the Poisson model to the negative binomial model, is also insignificant. This means that overdispersion is not an issue and that we could rely on the estimates of the Poisson regression. All test results can be found in the Appendix in Table 8.

Nevertheless, I decide to illustrate the results of both, the Poisson and the negative binomial regression, as robustness checks. The coefficients and corresponding significance are compared in Table 6. As expected, the coefficient estimates of both models are very similar. This is because the underlying assumption of overdispersion is not violated and the inequality between both models, captured by the dispersion parameter, vanishes.

More importantly, Table 6 shows that using the two alternative count models does not change our results of the short-term effect of the leniency introduction. The *LENIENCY* coefficient remains positive and significant, indicating a direct increase in the number of discovered cartels after the leniency introduction in July 2002. Columns 2 and 3 show that the estimates are also robust to changes in the short-term leniency period.

One should notice that the coefficients in Table 6 are in log counts. The reason is that both, the Poisson and the negative binomial regressions, model the log of the expected count (number of cartel discoveries per 6 months) as a function of the independent variables. They use the maximum likelihood estimation method to obtain the coefficient estimates and can thus not be directly compared to the OLS-coefficients of Table 4. The leniency coefficient in the first column suggests that the expected log count of cartels discovered each 6 months throughout the 18 months following the leniency introduction is 2.061 higher than in the pre-leniency period. This corresponds to an immediate 685,4% increase in cartel discoveries. The message that Table 6 should convey to the reader is that all models provide evidence of an immediate spike in cartel discoveries following the leniency introduction. The alternative models therefore confirm that the Dutch leniency program significantly enhanced the detection capabilities of the competition authorities. *Hypothesis 1.1* is thus validated.

Table 6: Robustness check with alternative models

Model	*18 month Period* (1)	*12-month Period* (2)	*24-month period* (3)
Poisson model			
LENIENCY	2.061***	1.821 **	1.836 ***
	(0.794)	(0.819)	(0.674)
Pseudo R^2	0.360	0.226	0.505
Negative binomial model			
LENIENCY	2.062***	1.821**	1.836***
	(0.794)	(0.819)	(0.674)
Pseudo R^2	0.258	0.211	0.275

Note: Table 6 compares the Poisson and the negative binomial regression results for the short-term effect of the leniency program on cartel discoveries. Columns 1, 2 and 3 respectively use the 18, 12 and 24 months following the leniency introduction as the short-term leniency period. For column 1 the regression runs over the time period from January 1st, 1998 until January 1st, 2004. For column 2 the regression runs over the time period January 1st, 1998 until the 1st of July 2003, whilst for column 3 the time period is extended until the 1st of July 2004. *LENIENCY* is a dummy, which equals 1 if the period postdates July 1st, 2002 and 0 otherwise. Both models include controls for the semi-annual Dutch GDP and the semi-annual budget allocated to the competition department of the NMa/ACM. The z-statistics are computed with Newey-West (NW) standard errors, which are shown in parentheses.

*** Significance at the 1 percent level.

** Significance at the 5 percent level.

* Significance at the 10 percent level.

7.2 Testing the Effect of the Leniency Program on Cartel Duration

Turning to the short-term effect of the leniency program on cartel duration, I conduct an analysis according to the theoretical model of Harrington Jr. and Chang (2009). If the leniency program is effective, one should optimally observe a rise in cartel duration of discovered cartels after leniency is implanted. The leniency introduction should lead to the immediate dissolution of the marginal cartels. Resulting cartel detections should thus come from stable, longer-lived cartels.

Table 7 provides the different estimates of the *LENIENCY* coefficient. The dependent variable is the cartel duration per case.

The *LENIENCY* coefficient in column 1 suggests that the average duration of cartels discovered in the short-term leniency period (here defined as the 18 months following the leniency introduction) is 221.727 days higher than for those discovered in the pre-leniency period. However, this immediate increase in cartel duration is not significant.

Columns 2, 3 and 4 respectively include controls for the Dutch GDP, the budget allocation and the number of cartel members (per cartel). The *LENIENCY* coefficient remains positive and becomes significant when including controls for the GDP and the annual budget. However, the *LENIENCY* coefficient stays insignificant when only adding the number of cartel members as control. All controls have the expected negative sign. As already mentioned, a higher number of cartel members is likely to decrease cartel stability because monitoring within the cartel becomes more difficult. The higher budget allocation to the competition authority also decreases cartel stability. This is due to the fact that the competition authority can take up a higher case load when it has a higher budget. Consequently, a cartel is more likely to be discovered and to dissolute earlier. Additionally, a higher budget allocated to the competition authority means that the competition enforcer can also perform more pro-active detection such as random audits. Therefore, the probability of being fined for participating in a cartel increases. Hence, the expected fine from participating in a cartel is higher, which reduces cartel stability and duration. Column 5 shows that once we include all controls in the regression, except the control for GDP, the *LENIENCY* coefficient becomes positive and significant. One should notice that I decided not to include the control for the annual GDP in my regression on cartel duration. This is be-

cause of multicollinearity issues as explained hereunder [31].

Although the *LENIENCY* coefficient has the expected positive sign for all model specifications, the first 4 columns show that the significance of the coefficient is quite sensitive to the model specification. Additionally, the considerably high standard errors of my regressors, once I included all controls (including GDP), raised my concerns that multicollinearity may be an issue in my regression.

I therefore conducted a test on the correlation between the different regressors in the regression including all controls. I found that the *LENIENCY* coefficient was correlated to both the annual GDP and the annual budget [32]. Moreover, the control for the annual GDP and the annual budget were very highly correlated (above 0.95) in the model. Some predictors in my regression were thus (highly) correlated with each other and my regression suffered from multicollinearity.

The issue with multicollinearity is that the regressors can to a certain extend be linearly predicted from each other. However, in the regression the unique effects of each individual predictor are estimated by holding all other predictors constant. Therefore, the regression ignores the variance shared between the different regressors. This effectively reduces the variability of a predictor and decreases its individual influence. Less variability will thus mean that there is also less information to assess the individual effect of each predictor. My model may then still correctly predict how all regressors together predict the outcome variable, but the individual effect (although still unbiased) is estimated less accurately (Verbeek, 2012). This is also reflected in high standard errors, making the *LENIENCY* coefficient insignificant once I include all regressors.

Generally, three remedies exist in case of multicollinearity. One can either drop one of the highly correlated regressors, transform or combine the regressors or do nothing and report the inflated results (Baguely, 2012). The correlation between the GDP and the annual budget was simply too

[31] In previous regressions, the dependent variable was the number of cartel discoveries per 6-month period. In those regressions, the units of observations were half-year periods and the variation in the semi-annual GDP and the semi-annual budget was relatively high across observations. The two regressors did not correlate with each other as highly as in the regressions which have cartel duration per case as the dependent variable. For the latter regressions, the fact that cartels (before leniency) were mainly discovered in the same year reduced the variation in annual GDP and annual budget across the units of observation (per cartel case). The limited variation of both of these regressors resulted in a high correlation between them. Multicollinearity (collinearity) was thus less of an issue in the previous regressions but is an important issue for the regressions on cartel duration.

[32] The correlation of the *LENIENCY* regressor with GDP was approximately 0.85 and was slightly lower with the annual budget.

high to consider the last option and ignore the issue. Additionally, combining the two regressors in a coherent way was not possible. Due to the very strong correlation between the annual budget and the GDP I thus decided to drop one of the variables. After careful consideration, I decided to drop the control for the GDP. I dropped the control for the GDP instead of the one for the annual budget for 3 reasons. The first reason was that the annual GDP correlated more strongly with my dummy *LENIENCY*. In order to reduce the correlation between my remaining regressors the more obvious choice was to drop the control for the GDP. Additionally, the variation in my model for the annual budget was quite strong. To be precise, there was a considerable increase in the annual budget around the year 2000, when the Netherlands Electricity Regulatory Service (DTE) became a department of the NMa. Around the year 2000, the annual budget increased quite strongly, also for the competition department. In the model, this variation is quite important and it should be controlled for. Lastly, it was discussed above that the annual budget is very likely to affect the expected fine of cartel members. This has a significant effect on cartel stability. The explanatory power of the annual budget in my regression is therefore very important and should be controlled for.

Columns 5, 6 and 7 therefore include the controls for the number of cartel members and the annual budget. The columns show that the value of the *LENIENCY* coefficient still varies with changes in the specification of the short-term leniency period. However, overall, the results are robust and the *LENIENCY* coefficient is positive and significant for all specifications of the short-term leniency period. Column 5 suggests that the cartel duration of cartels discovered in the 18 months following the leniency introduction, is on average approximately 600 days higher than for those discovered in the pre-leniency period. When extending the short-term leniency period to the 24 months following the leniency introduction this increase is even stronger.

Overall, there is evidence that the introduction of the leniency program increased the cartel duration of discovered cartels in the short run. The robustness checks, however, showed that the results are sensitive to the inclusion of the different controls. Once we include the controls for the number of cartel members and the annual budget, the increase in cartel duration is significant for all specifications of the short-term leniency period. Once these controls are included in the regression, *Hypothesis 2* is thus validated.

Nevertheless, the standard error of the *LENIENCY* coefficient remains quite high, even after ex-

cluding the annual GDP. One should note that multicollinearity can never be fully eliminated. In this specific model, the annual budget still significantly correlates with the dummy *LENIENCY* and the limited amount of cartel discoveries before the leniency introduction, unfortunately, limits the amount of variation in the model. The individual predictor coefficients have thus to be interpreted with care, even though the *LENIENCY* coefficient proved robust to changes in the short-term leniency period. Overall, the coefficient should be interpreted as evidence for a significant increase in the average cartel duration, rather than as a precise estimate of how large this increase is.

Table 7: OLS regression results: short-term effect on cartel duration

Variables	*No Control Variables*	*Control Variables*				*12-month Period*	*24-month Period*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LENIENCY	221.727	570.722**	555.834***	226.719	638.624***	550.609*	769.121***
	(197.973)	(201.261)	(181.861)	(205.923)	(189.298)	(272.940)	(208.269)
Control Variables							
GDP		-5.007**					
		(2.168)					
Budget			-36.651**		-45.153***	-47.256**	-35.564**
			(13.478)		(13.753)	(14.337)	(14.468)
Number of cartel members				-36.608**	-38.752***	-36.045*	-20.414
				(16.629)	(15.363)	(16.559)	(25.820)
R^2	0.050	0.093	0.092	0.244	0.308	0.555	0.074
Observations	15	15	15	15	15	9	26

Note: Table 7 shows the regression results for the short-term effect of the leniency program on cartel duration. The dependent variable is the cartel duration per case. Columns 1, 2, 3, 4 and 5 use the period up to 18 months after the leniency introduction as the short-term leniency period. Columns 6 and 7 are robustness checks and use respectively the period 12 months and 24 months after the leniency introduction as the short-term leniency period. *LENIENCY* is a dummy which equals 1 if the period postdates July 1st, 2002 and 0 otherwise. The time period over which the regressions run is reduced (as compared to the full sample), such that the evaluated sample only includes cartels discovered before the end of the short-term leniency period. For columns 1, 2, 3, 4 and 5 the regressions run over the time period January 1998 until the end of 2004. For column 6 the regression runs over the time period January 1998 until the 1st of July 2003, whilst for column 7 the time period is extended until the 1st of July 2004 (see empirical framework, regression 4 for more details). Controls include the annual budget, annual GDP and the number of firms per cartel. The t-statistics are computed with Newey-West (NW) standard errors, which are shown in parentheses.

*** Significance at the 1 percent level.

** Significance at the 5 percent level.

* Significance at the 10 percent level.

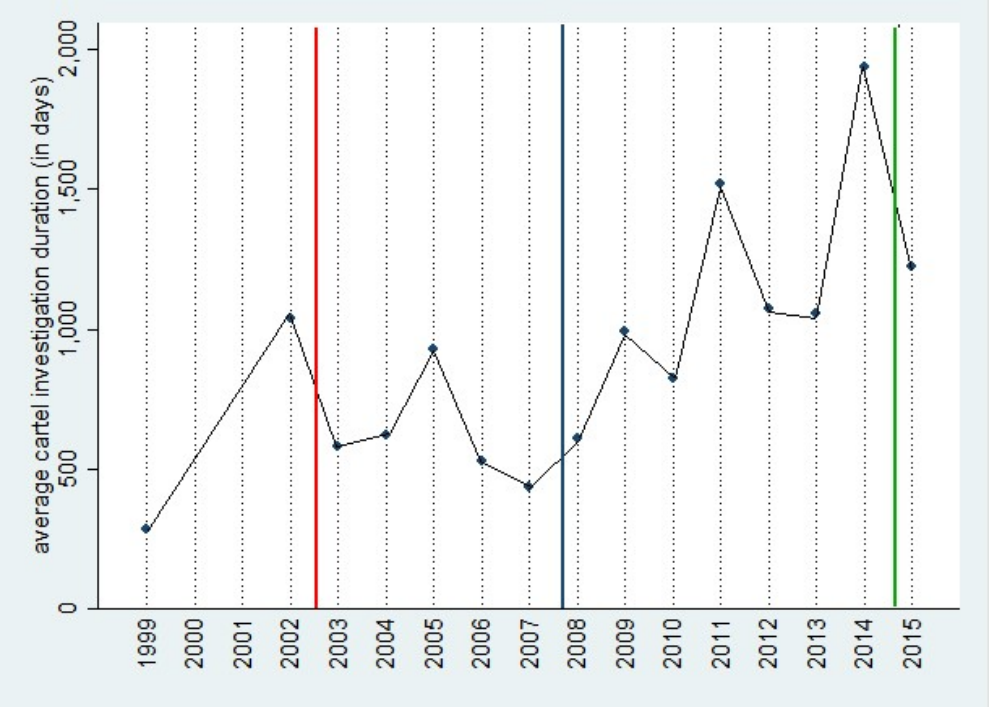
8 Extending the Discussion to Include the Leniency Revision

This section first discusses the effects of the leniency introduction on investigation time. Thereafter, potential effects of the 2007 revision of the Dutch leniency program are addressed.

8.1 What Happened to the Investigation Time after the Introduction of the Leniency Program

For the purpose of completeness, and because of the earlier findings of Brenner (2009), this section comments on what happens to the investigation time after leniency is introduced. Brenner (2009) found that the investigation cost, represented by the average investigation time to prosecute a cartel, decreases considerably after the introduction of the European leniency program. I do not perform a formal test to evaluate in detail how investigation duration changes after the leniency introduction in the Netherlands. This would go beyond the scope of this paper. However, I would like to comment on the trend, which is observable in figure 4.

Figure 4: Cartel investigation duration over the years 1999 to 2015



Note: The vertical bars mark respectively the introduction of the leniency program (red), the introduction of the first revised leniency guidelines (blue) and the implantation of the second revised leniency guidelines (green).

To be precise, average investigation time seems to be increasing over the years 1999 to 2015. After the initial leniency introduction (here again marked by the red, vertical bar; see also figures 2 and 3) investigation time increases rather than decreases. This seems counter-intuitive at first and contradicts earlier findings of Brenner (2009), who found that leniency decreased the investigation time of prosecuted cartels. Several factors could play a role and explain why the investigation duration increases after the leniency introduction in the Netherlands.

First, one should notice that this graph does not correct for any cartel specific characteristics. It could, for example, be that cartels over the years become more complex and have a lot more cartel members. This could considerably increase the average investigation time a competition authority needs to fully prosecute such complex cartels. Moreover, this trend could also more generally reflect the idea that the Dutch competition authority tries to gather more information in order to more precisely base the fines for cartels.

With respect to leniency, it is not always clear that it decreases the investigation time. Brenner (2009) argues that revealed information by leniency applicants will generally make it easier for the competition authority to fully document all cartel activities and to gather the needed evidence for a successful conviction. He thereby distinguishes between information that is easy to collect and information that is hard to collect. Intuitively, if cartel members reveal information that is hard to collect, this will generally decrease investigation costs (and time) of the competition authority by a lot more than if easily obtainable information is revealed.

However, Brenner (2009) also mentions, that the additional information of leniency applicants may increase the time a competition authority needs in order to fully investigate and prosecute a cartel. This is the case if better-documented cases expose additional complex information on the cartel and the relationship between its members. Documenting and investigating all this information may lead to an increase rather than a decrease of the prosecution time. This especially holds true if the competition authority inspects all the additional information carefully in order to make a better and more expansive fine assessment.

The increasing trend in the average cartel investigation time after the leniency introduction is thus not necessarily counter-intuitive. The above-mentioned aspects may all play a role in explaining the increase in the average cartel investigation time. It might be due to the increasing complexity of cartels. However, the higher investigation time might also be the result of the will-

ingness of the competition authority to use all the additionally revealed information to better set cartel fines. The increasing trend in the cartel investigation time might thus reflect a qualitative increase of the fine assessment of the Dutch competition authority, rather than just reflecting a reduction in the efficiency of the prosecution process.

8.2 What Happened after the Revised Leniency Program

Before concluding this paper, this section evaluates the subsequent revision of the Dutch leniency program. To be precise, I test whether there is an increase in cartel discoveries shortly after the introduction of the revised leniency program on October 1st, 2007. I solely focus on the short-term effect because of the limited time span of my sample of discovered cartels.

According to Miller (2009), an effective leniency innovation should lead to an increase in the detection capabilities and increase the cartel discoveries in the short term. Hence, we should observe a second spike in cartel discoveries shortly after the introduction of the revised leniency program. However, in figure 2 we cannot observe a clear reversion of the downward trend in cartel discoveries, which followed the short-term spike in cartel discoveries around the initial leniency introduction. No clear second spike in cartel discoveries can be observed around 2007, the year the leniency guidelines were revised.

Nevertheless, I perform a test in order to further investigate the short-term effect of the revised leniency program on cartel discoveries. To be precise, I construct an OLS regression, in which I compare the cartel discoveries in the 24 months before the leniency revision to those in the 24 months thereafter. In my regression, I control for the semi-annual Dutch GDP and the semi-annual budget of the NMa/ACM. As expected the test reveals that the number of cartel discoveries is not significantly higher in the 2 years following the leniency revision as compared to the 2 years before[33]. The test results can be found in the appendix, table 9. This finding may indicate that the leniency revision was too weak to have an additional impact on cartel discoveries.

When turning to the effect of the leniency revision on cartel duration, figure 3 shows that cartel duration does not increase immediately after the revised leniency guidelines of 2007 (marked by the blue, vertical bar). There is no formal analysis needed to see that cartel duration does not increase significantly. If anything, the graph shows that the average cartel duration falls after

[33] Results also proved robust to the inclusion of the control for the total number of firms in the Netherlands.

the introduction of the leniency revision. Of course, this graph does not yet control for cartel characteristics such as the number of cartel members. Nevertheless, I limit myself to testing the short-term effect of the leniency revision on cartel discoveries. I leave it for future research to fully evaluate the revised and the 2nd revised leniency program, based on an updated sample of cartel discoveries.

9 Conclusion

Leniency programs have become an essential tool for competition authorities to "fight" cartels. However, it is difficult to justify to the public that some firms who participated in a cartel, and by virtue committed a crime, are granted fine immunity and remain unpunished by the competition enforcers. This is why it is important to provide evidence on the efficacy of leniency programs, in order to justify their implementation to the public. Competition authorities around the world, and especially the ACM, have begun to "start measuring the economic and customer benefits from competition law enforcement in specific cases" (European Commission, 2016). There is a trend in providing more and more evidence to the public on the importance of the work of competition authorities. It is important to extend such evidence provision by evaluating the effectiveness of leniency programs.

The impacts of leniency as provided by the theoretical literature are ambiguous. Empirical assessments of leniency programs are therefore particularly important. This paper provides some evidence that the Dutch leniency program is effective in fighting cartels. To be precise, I show that the number of discovered cartels increases significantly after the implementation of the leniency program and then starts falling again. This pattern is consistent with improved cartel detection and also provides partial evidence for enhanced deterrence capabilities according to Miller (2009). The fact that cartel discoveries do not revert below pre-leniency levels does not necessarily reflect limited deterrence capabilities of the leniency program. It may also be due to the short-term effect of the revised leniency programs counteracting the long-term effect of the initial leniency program. If the leniency revisions increase detection capabilities even further, cartel discoveries may remain high. Additionally, I show that cartel duration of discovered cartels increases shortly after the leniency introduction. According to the theoretical model of

Harrington Jr. and Chang (2009), this is in line with an effective leniency program that destabilises cartels and leads to the dissolution of all marginal cartels.

The findings of this paper may help to justify the implementation of leniency in the Netherlands. Results should still be interpreted with care because of the remaining collinearity issues in the regression on cartel duration. Nevertheless, it is the first study on a national European leniency program and confirms earlier findings of Zhou (2013) on the efficacy of the revised European leniency program of 2002. The Dutch leniency program was initially based on the revised European leniency program of 2002. The leniency programs are very similar and the fact that both of the studies found similar effects of leniency on cartel duration confirms the causality and reliability of the estimated effects of leniency.

Moreover, this study offers a remedy to the existing literature on leniency programs. To be precise, this study, which only focuses on cartel discoveries at the Dutch national level, offers the cross-sectional variation needed to address any remaining endogeneity issues in earlier assessments. This especially holds true for the studies on the European leniency program. By comparing how cartel discoveries on the Dutch national and the European level change around, for example, the introduction of the European leniency revision of 2002, one can correct for common trends that affect cartel discoveries in Europe. This will help to better assess the causal effect of the leniency innovation. Future research should exploit such cross-sectional variation. Furthermore, cross-sectional variation should be extended by also evaluating some of the other national European leniency programs. This will make it possible to compare and confirm the estimated effects, and thereby increase the validity of the studies on leniency.

Additionally, different factors that might influence the effectiveness of a leniency program are discussed. This also means that the evidence provided on the efficacy of the Dutch leniency program does not necessarily implicate that leniency is effective in all other countries. This paper especially emphasises on the increasing reliance of competition authorities on leniency and the adverse effects this might have on the effectiveness of such programs. The vast majority of cartel cases at the European Commission are triggered by leniency applications. In 2015 and 2016 all decision adopted by the European Commission on cartel cases were based on immunity applications (Ysewyn & Van Schoorisse, 2016). This raises the question whether competition enforcers nowadays rely too much on such leniency programs.

In the sample of cartels convicted in the Netherlands between 1998 to 2015, approximately 30% of all convicted cartels had at least one leniency applicant and around 10% of cartel convictions were triggered by a type A leniency application. This indicates that the Dutch competition authority (NMa and later the ACM) does not only rely on leniency but also discovers cartels by other means. The ACM conducts market research and also performs on-site firm visits to "fight" cartels. These are often triggered by initial complaints of rivals and customers. Active communication with the public and rigorously assessing complaints (i.e through follow-up market research and on-site firm visits) is important to increase the expected fine for colluding firms. This may account for the finding that the Dutch leniency program, with an established competition enforcer behind it, is effective. It is therefore advisable that the Dutch competition authority, as well as other competition enforcers, remain pro-active in the future and do not simply rely on leniency.

Despite the extensive analysis of the Dutch leniency program, further room for research on this topic exists. Even though this paper already comments on the 1st Dutch leniency revision, a more extensive evaluation of the 1st and 2nd revision would be interesting. This would help to further assess the effectiveness of recent changes in the Dutch leniency guidelines and ultimately also in the ECN Model Leniency guidelines, to which the former adapt. It would be particularly interesting to evaluate the effectiveness of the 2nd revised Dutch leniency guidelines. In fact, these revised guidelines assure that the first one to apply for leniency will not receive a fine, regardless of whether the ACM already started an investigation or not. This could potentially have adverse effects. It may reduce the incentive of cartel members to provide information to the authority if the latter has not yet commenced an investigation. This could considerably reduce the information flow to the authority. It may also further increase the need of costly random audits and data collection by the competition enforcer before he receives direct information of the cartel from leniency applicants. It would thus be interesting to follow and evaluate the future trends with respect to the timing of the first leniency application in the cartel prosecution process.

10 Appendix

Table 8: Test results for the Poisson and negative binomial model fit

Test Results	*Deviance goodness-of-fit* (1)	*Pearson goodness-of-fit* (2)	*Likelihood-ratio test of η=0:* (3)
chi-squared value	11.532	11.925	0
Prob > chi^2	0.173	0.155	0.500
degrees of freedom	8	8	1

Table 9: Short-term effect of the revised leniency program on cartel discoveries

	without controls (1)	*with controls* (2)
REVISION	0.25	2.575
	(1.409)	(1.948)
Control Variables		
GDP		-58.873
		(100.457)
Budget		0.609
		(0.883)
R^2	0.005	0.300
Observations	8	8

Note: Table 9 shows the regression results for the short-term effect of the revised leniency program on cartel discoveries. The dependent variable is the number of cartel discoveries per 6 months. $REVISION$ is a dummy that equals 1 if the period postdates the introduction of the revised leniency program of 2007 and 0 otherwise. The regressions in columns 1 and 2 only run over the limited time period from July 2005 to July 2009. This reduces the evaluated sample to cartels discovered in the two years before and in the two years after the introduction of the revised leniency guidelines. The $REVISION$ dummy therefore compares the average number of cartel discoveries (per 6 months) in the two years following the leniency revision to the one in the two years before. The variable GDP is the annual Dutch GDP. The variable budget is the budget of the NMa/ACM solely allocated to the competition department. The t-statistics are computed with Newey-West (NW) standard errors, which are shown in parentheses.

*** Significance at the 1 percent level.

** Significance at the 5 percent level.

* Significance at the 10 percent level.

References

Abreu, D. (1988). On the theory of infinitely repeated games with discounting. *Econometrica*, *56*(2), 383–96.

ACM (2002, July). *Nma approves leniency guidelines*. Retrieved 24-05-2016, from ttps://www.acm.nl/en/publications/publication/5942/NMa-Approves-Leniency-Guidelines/

ACM (2014). *Report your cartel and escape the fine*. Retrieved 25-05-2016, from https://www.acm.nl/en/publications/publication/13314/Report-your-cartel-and-escape-the-fine/

Allain, M. L., Boyer, M., Kotchoni, R., & Ponssard, J. P. (2015). Are cartel fines optimal? theory and evidence from the european union. *International Review of Law and Economics*, *42*, 38–47.

Aubert, C., Rey, P., & Kovacic, W. E. (2006). The impact of leniency and whistle-blowing on cartels. *International Journal of Industrial Organisation*, *24*(6), 1241–1266.

Baba, V. V. (1990). Methodological issues in modeling absence: A comparison of least squares and tobit analysis. *Journal of Applied Psychology*, *75*, 428-432.

Baguely, T. (2012). *Serious stats: A guide to advanced statistics for the behavioral sciences*. Palgrave Macmillan.

Baguley, T. (2013). *Multicollinearity and collinearity (in multiple regression) - a tutorial*. Retrieved 2016-09-27, from http://psychologicalstatistics.blogspot.nl/2013/11/multicollinearity-and-collinearity-in.html

Bolotova, Y., & Connor, J. M. (2008). Cartel sanctions: An empirical analysi. In (pp. 1–30).

Bos, I., & Wandschneider, F. (2011). Cartel ringleaders and the corporate leniency program. *Centre for Competition Policy working paper 11-13*, *27*(6), 1–21.

Brenner, S. (2009). An empirical study of the european corporate leniency program. *International Journal of Industrial Organization*, *27*(6), 639–645.

Bruneckiene, J., & Pekarskiene, I. (2015). Economic efficiency of fines imposed on cartels. *Inzinerine Ekonomika-Engineering Economics*, *26*(1).

Bruneckiene, J., Pekarskiene, I., Guzavicius, A., Palekiene, O., & oviene, J. (2015). The impact of cartels on national economy and competitiveness: A lithuanian case study. In *The impact of cartels on national economy and competitiveness: A lithuanian case study* (pp. 155–171). Switzerland: Springer International Publishing.

Cameron, A., & Trivedi, P. (1986). Econometric models based on count data: Comparisons and applications of some estimators and tests. *Journal of Applied Econometrics, 1*(1), 29-53. Retrieved from http://EconPapers.repec.org/RePEc:jae:japmet:v:1:y:1986:i:1:p:29-53

Choi, Y. J., & Hahn, K. S. (2014). The impact of the corporate leniency program on cartel stability. *Journal of Competition Law Economics, 10*(4), 883–907.

Council on Foreign Relations (2014). *Cfr backgrounders*. Retrieved 19-09-2016, from http://www.cfr.org/corporate-regulation/us-antitrust-policy/p29984

Davies, S., & De, O. (2013). Ringleaders in larger number asymmetric cartels. *The Economic Journal*.

De, O. (2010). Analysis of cartel duration: Evidence from EC prosecuted cartels. *International Journal of the Economics of Business, 17*(1), 33–65.

Ellis, C. J., & Wilson, W. W. (2013). *Cartels, price-fixing, and corporate leniency policy: What doesn't kill us makes us stronger*.

European Commision (2006). *Case t-15/02 basf ag v commission of the european communitie* (Tech. Rep.).

European Commision (2012). *European competition network refines its model leniency programme* (Tech. Rep.). Brussels.

European Commision (2016, July). commit or not to commit? *Competition policy brief , 14*, 1–4. Retrieved from http://ec.europa.eu/competition/publications/cpb/2014/003_en.pdf

European Commission (2002). Commission notice on immunity from fines and reduction of fines in cartel cases. *Official Journal of the European Union*, 3-5.

European Commission (2016). Eu competition policy in action: Why competition policy is a good value for money. *COMP in Action*, 10–11.

Feinberg, R. M., Kim, H., & Park, M. (2016). *The determinants of cartel duration in korea.* Review of Industrial Organization.

Gauer, C., & Jaspers, M. (2007). *Ecn model leniency programme: a first step towards a harmonised leniency policy in the eu.* Directorate-General for Competition.

Ghosal, V., & Gallo, J. (2001). The cyclical behavior of the department of justice's antitrust enforcement activity. *International Journal of Industrial Organization, 19*(1–2), 27 - 54. Retrieved from http://www.sciencedirect.com/science/article/pii/S0167718799000132 doi: http://dx.doi.org/10.1016/S0167-7187(99)00013-2

Global Competition Review (2010). *Rating enforcement 2010* (Tech. Rep.). London.

Global Competition Review (2011). *Rating enforcement 2011* (Tech. Rep.). London.

Global Competition Review (2012). *Rating enforcement 2012* (Tech. Rep.). London.

Global Competition Review (2013). *Rating enforcement 2013* (Tech. Rep.). London.

Global Competition Review (2014). *Rating enforcement 2014* (Tech. Rep.). London.

Global Competition Review (2015). *Rating enforcement 2015* (Tech. Rep.). London.

Global Competition Review (2016). *Rating enforcement 2016* (Tech. Rep.). London.

Gray, A., Nguyen, B. T., & Wait, A. (2013). The prodigal corporation: an analysis on the effectiveness of the accc's immunity policy for cartel conduct. *Australian Economic Papers, 52*(1).

Harrington Jr., J. E., & Wei, Y. (2015, April). What can the duration of discovered cartels tell us about the duration of all cartels? *PIER Working paper No. 14-042*, 1–35.

Harrington Jr., J. E. (2008). Optimal corporate leniency programs. *Journal of Industrial Economics, 56*(2), 215–246.

Harrington Jr., J. E., & Chang, M. H. (2009, December). Modelling the birth and death of cartels with an application to evaluating competition policy. *Journal of the European Economic Association, 7*(6), 1401-1435.

Harrington Jr., J. E., & Chen, J. (2007). The impact of the corporate leniency program on cartel formation and the cartel price path. *The Political Economy of Antitrust*(282), 59–80.

Herre, J., Mimra, W., & Rasch, A. (2012). *Excluding ringleaders from leniency.* Discussion Paper.

Irvine (2003). *(the european commission's new leniency policy).* Crowell Moring LLP.

Kovacic, W. E. (2013). The value of policy diversification in cartel detection and deterrence. *OECD, DAF COMP*, 1–22.

Leslie, C. R. (2006). *Antitrust amnesty, game theory, and cartel stability*. Journal of Corporation Law(31).

Miller, N. H. (2009). Strategic leniency and cartel enforcement. *The American Economic Review*, *99*(3), 750–768.

Motchenkova, E. (2004). Effects of leniency programs on cartel stability. *CentER Discussion Paper*, *2004-98*, 1-32. Retrieved from `https://pure.uvt.nl/ws/files/629269/98.pdf`

Motta, M. (2004). *Competition policy theory and practice*. Camebridge University Press.

Motta, M., & Polo, M. (2002). Leniency programs and cartel prosecution. *International Journal of Industrial Organization*, *21*(3), 347–379.

Newman, M. (2016). Eu cartel watchdogs rely too much on whistleblowers, judge says. *MLex market insight*, *99*(3), 1–3.

NMa (2007, July). *Draft leniency guidelines*. Nma.

OECD (1999). *The netherlands (1999 - august 2000)* (Tech. Rep.). The Netherlands.

OECD (2002). *Fighting hard core cartels: Harm, effective sanctions and leniency programmes* (Tech. Rep.). Paris.

OECD (2013). Ex officio cartel investigations and the use of screens to detect cartels. *Competition Law Policy OECD*, *99*(3), 1–10.

Posner, R. A. (1970). A statistical study of antitrust enforcement. *The Journal of Law and Economics*, *13*(2), 365-419. Retrieved from `http://dx.doi.org/10.1086/466698` doi: 10.1086/466698

Social and Economic Council (2013). *Review and amendment of the dutch competition act*. Retrieved 4-10-2016, from `https://www.ser.nl/en/~/media/files/internet/talen/engels/2003/2003_06.ashx`

Spagnolo, G. (2004). Divide et impera. optimnal deterrence mechanisms against cartels and organized crime. *Center for Economic Policy Research Discussion Paper 4840*.

Spagnolo, G. (2008). Leniency and whistleblowers in antitrust. In *Handbook of antitrust economics* (pp. 259–304). Cambridge MA, US: MIT Press.

Statistics Netherlands (2016). *Bedrijven; bedrijfsgrootte en rechtsvorm.* Retrieved 24-11-2016, from http://statline.cbs.nl/StatWeb/publication/?VW=T&DM=SLNL&PA=81588NED&LA=NL

Sturman, M. C. (1999) *Multiple approaches to analyzing count data in studies of individual differences: The propensity for type 1 errors, illustrated with the case of absenteeism prediction.* Retrieved 15-08-2016, from http://scholarship.sha.cornell.edu/articles/207

The Netherlands Competition Authority (1998). *Nma annual report 1998* (Tech. Rep.). The Hague.

The Netherlands Competition Authority (1999). *Nma annual report 1999* (Tech. Rep.). The Hague.

The Netherlands Competition Authority (2000). *Nma annual report 2000* (Tech. Rep.). The Hague.

The Netherlands Competition Authority (2001). *Nma annual report 2001* (Tech. Rep.). The Hague.

The Netherlands Competition Authority (2002). *Nma annual report 2002* (Tech. Rep.). The Hague.

The Netherlands Competition Authority (2003). *Nma annual report 1999* (Tech. Rep.). The Hague.

The Netherlands Competition Authority (2004). *Nma annual report 2004* (Tech. Rep.). The Hague.

The Netherlands Competition Authority (2005). *Nma annual report 2005* (Tech. Rep.). The Hague.

The Netherlands Competition Authority (2006). *Nma annual report 2006* (Tech. Rep.). The Hague.

The Netherlands Competition Authority (2007). *Nma annual report 2007* (Tech. Rep.). The Hague.

The Netherlands Competition Authority (2008). *Nma annual report 1999* (Tech. Rep.). The Hague.

The Netherlands Competition Authority (2009). *Nma annual report 1999* (Tech. Rep.). The Hague.

The Netherlands Competition Authority (2010). *Nma annual report 2010* (Tech. Rep.). The Hague.

The Netherlands Competition Authority (2011). *Nma annual report 2011* (Tech. Rep.). The Hague.

The Netherlands Competition Authority (2012). *Nma annual report 2012* (Tech. Rep.). The Hague.

Van Stel, A., & Diephuis, B. (2004). *Research report h200408: Aantallen ondernemers en ondernemingen* (Tech. Rep.). Zoetermeer. Retrieved 25-11-2016, from `http://ondernemerschap.panteia.nl/pdf-ez/h200408.pdf`

Verbeek, M. (2012). *A guide to modern econometrics 4th edition* (4th ed.). John Wiley Sons.

Ysewyn, Y., & Van Schoorisse, M. (2016). *Latest developments in anti-cartel enforcement in the european union (june 2015-june 2016).* Retrieved 5-10-2016, from `https://www.cov.com/-/media/files/corporate/publications/2016/09/latest_developments_in_anti_cartel_enforcement_in_the_european_union.pdf`

Zhou, J. (2013, April). Evaluating leniency with missing information on undetected cartels: Exploring time-varying policy impacts on cartel duration. *TILEC Discussion Paper No. 2011-042*, 1–52.