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Cartels and Leniency: Taking stock of what we learnt

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Cartels and Leniency: Taking stock of what we learnt

(Prepared for the *HANDBOOK OF GAME THEORY AND INDUSTRIAL ORGANIZATION*)

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Abstract

Cartels remain widespread and constitute a major problem for society. Leniency policies reduce or cancel the sanctions for the first firm(s) that self-report being part of a cartel and have become the main enforcement instrument used by competition authorities around the world in their fight against cartels. Such policies have shown to be a powerful tool in inducing firms to self-report or cooperate with a cartel investigation in exchange for a reduction in sanctions. Since they reduce sanctions for successful leniency applicants, these programs may also be abused to generate many successful convictions for the competition authority at the expense of reduced cartel deterrence and social welfare. Hence, it is vital for competition authorities and society to understand how leniency programs affect firms' incentives, in order to optimize their design and administration. A rich theoretical, empirical and experimental economic literature developed in the last two decades to meet the challenge.

In this chapter, we review some of the key studies which have been undertaken to date, with emphasis on more recent contributions and without claiming to be exhaustive (we apologize in advance to the authors of papers we could not discuss), highlighting and comparing the main results, and setting out their limitations. We conclude with a general assessment and an agenda for future research on this topic at the core of competition policy.

I. Introduction

Basic law and economics explains that, as other forms of public law enforcement, anti-cartel enforcement increases social welfare if the social gain from detecting and deterring cartels is larger than the deadweight loss from wasteful administration, prosecution and litigation activities (e.g. Posner 1976, Cooter and Ulen 1988), and from the possible economic distortions directly caused by poorly designed enforcement policies (like fines based on firms' turnover, see Bageri, Katsoulacos and Spagnolo 2013).

Law enforcement agencies, and more specifically competition authorities, have started to publish in their annual reports the number of successful cartel convictions and the amount of fines collected, implicitly proposing them as performance measures. While this increase in transparency is welcomed, it should also be taken with due care, as it may tend to generate a discrepancy between the objectives of law enforcement agencies and those of society. Using the amount of cases, of successful convictions, or of fines collected as a measure of output or performance creates a natural incentive to win many easy cases, possibly abusing leniency policy (and plea bargaining) by being too generous, so as to win more cases more easily. An overly generous leniency policy offering fine reductions to several reporting firms may make a competition authority appear very successful in terms of the number cases won, of firms convicted, or amount of fines collected, while reducing social welfare by decreasing

cartel deterrence (because firms expect a lenient treatment if caught) and increasing the amount of prosecution costs (because there are more prosecuted cartels).[1]
Moreover, when considering firms' incentives to apply for leniency, we are unavoidably drawn into discussing the issue of cartel damages, and more generally of the interaction between private and public law enforcement. The recently approved EU Damages Directive is likely to significantly change the incentives of applying for leniency in Europe, and, potentially, in directions that differ depending on the previously existing national legislation.
For welfare considerations, there may be a need to further increase (e.g. criminal) sanctions and step up proactive cartel detection policies (e.g. incentivizing whistleblowers and screening large databases) not as possible substitutes but as potential complements of less generous leniency policies. This combination of tools may improve efficiency and social welfare by increasing cartel deterrence and reducing the large deadweight loss society currently suffers in terms of private and public litigation costs.

In the past 5 years, 29 international cartels have been discovered in the EU and the US, including the ones of the automotive parts' suppliers which are the largest set of bid rigging schemes ever discovered, suggesting that antitrust enforcement still has limited deterrence effects (of course we are not arguing that full cartel deterrence would be optimal, just that deterrence seems to be limited). There is little evidence on the effects of fines on corporate governance, such as CEO disqualification and clauses in the contracts of CEOs, lower management or others. This is particularly important in the banking sector where financial stability concerns generate a "too-big-to-fine" problem. A recent example is from the EIRD cartel. The CEO of Barclays bank, Bob Diamond, was fired for applying for leniency, while the CEOs of the other banks remained in place (or received large severance packages). This illustrates the large gap between the current climate, where colluding managers are rewarded (revealed preferences argument), and a scenario with optimal enforcement. The fact that there is little evidence of colluding managers being punished and managerial contracts having provisions against collusion, suggests that European Commission (*EC*) fines are too low, given that even in the absence of EC criminal sanctions, they are not harsher than US fines.
It can also be observed that some of these cartels are convicted in an increasing number of jurisdictions in parallel. There are clear signs that the perceived "pros" of leniency are leading the EC to a particularly generous use of the leniency tool, almost as if it was a form of plea bargaining: leniency reductions have been granted to 52% of all EC cartel fines (1998-2014), and this percentage, corresponding to an average of 4 leniency recipients per cartel, is on the rise. Extended leniency seems to be driven by an attempt to solve a problem – too many cartel cases waiting to be prosecuted by competition authorities with a fixed amount of resources – which may be worsened, rather than solved, by overusing leniency to speed up cases but thereby reducing cartel deterrence. The negative impact of a possible excessive use of leniency, on the other hand, is substantial for society, which must bear the deadweight loss from the large administration and prosecution costs of all the cases, in addition to those of cartels that are not deterred.

The widespread adoption and use of leniency policies brought with it a vast and rapidly growing strand of economic research. Theoretical studies have sought to examine the effects of these programs, as tools to enhance the detection, prosecution and deterrence of cartel conduct. The research has highlighted the strong potential for well-designed and well managed leniency policies to contribute to social welfare, but it has also highlighted the serious risk of poorly implemented leniency programs, which may intensify cartel formation and increase enforcement costs at the same time.
Of course, once theory clarified the trade-offs, finding "the right amount of leniency" becomes a mainly empirical issue, so that availability of the necessary data may be a serious problem. Indeed,

[1]If all firms could obtain almost full amnesty by self-reporting under a leniency policy, then all cartel members would all self-report all the time, the competition authority would generate and win a lot of cases, but cartel formation would go up, together with enforcement expenditures.

the secrecy of collusive agreements poses several challenges for economic research. Recent studies have tried to empirically test the effectiveness of leniency policies, particularly those administered by the US Department of Justice (*DOJ*) and the EC, given the current level of sanctions. This research has considerable potential value in assisting competition authorities to design optimal policies by having a better understanding of the impact that such policies, their specific features and manner of administration, have on the behavior of cartel participants.

However, indirect methods based on strong assumptions need to be employed to infer whether an increase or decrease in the number of convicted cartels observed after a policy change is due to better enforcement, or due to an increase in the number of cartels present in society. Therefore, evaluating the deterrence effects of leniency policies (and of the level of sanctions) remains very difficult, as cartels are not readily observable in society unless they are convicted. This makes laboratory experiments an important complementary tool which some researchers have used to test different hypothetical policies which have not actually been implemented. The drawback of these studies is that they are always subject to stronger external validity caveats than empirical studies, particularly when used to approximate firm behavior. However, in the case of cartels and analogous crimes, laboratory experiments are particularly valuable and recent work on collusive corruption by Armantier and Boly (2013) seems to suggest that external validity concerns may not be too troublesome.

The rest of this chapter develops as follows. In Section *II*, we review the theoretical studies of leniency, with a particular focus on post-2008 studies. In Section *III* we examine empirical evidence on leniency policies, having regard to both descriptive and econometric studies. In Section *IV*, we review the experimental evidence. Section *V* concludes.

II. Theoretical Studies on Leniency

A. Early theoretical studies

Let us briefly recall a few main results from the "early" literature, before 2008 (we can only consider a few of these studies here, a detailed review of this early literature is available in Spagnolo 2008). The law enforcement literature analyzed leniency and self-reporting, focusing on individual wrongdoers committing occasional crimes (Malik 1993, Kaplow and Shavell 1994, Innes 1999). In particular, Koffman and Lawarrèe (1996) offer the first model of how collusion in a hierarchy can be prevented by leniency. However, these papers present static models, mostly of single agent crimes, which cannot capture deterrence originated by the dynamic effects of leniency on cartels. The plea bargaining literature is also related to leniency, since it explores the efficiency of fine reductions in exchange for post-prosecution cooperation from cartel members (Kobayashi 1992; Grossman and Katz 1983; Reinganum 1988). However, this literature cannot capture the ex-ante effect of leniency on wrongdoers which have not been prosecuted.

The theoretical literature on leniency programs is vast and growing due to the increasing use of leniency in the EU and the US and its adoption in other jurisdictions. The pioneering paper by Motta and Polo (2003) was the first to address the effect of leniency on cartels, in a dynamic analytical framework, focused on the effects of leniency programs on the prosecution stage and the allocation of the budget of a competition authority. The crucial result of the model is that in a second-best, in which the competition authority needs to introduce leniency policies because of lack of internal resources, the positive effect of leniency on deterrence, through faster, cheaper (freeing up resources for cartel detection) and more effective prosecution, tends to dominate the negative effect on deterrence, i.e. the reduction of overall sanctions. This first model assumed, to simplify, that if a cartel member defects, it immediately becomes not liable anymore, and therefore cannot account for the incentives firms may have to report when they want to leave/deviate from a cartel, when in reality a deviating cartel member remains liable for several years; nor for the incentives to report first, generated by leniency and linked to the fear of being sanctioned because somebody else reports

instead. By disregarding these forces (crucial according to experimental evidence), this first model led to a series of other results/implications that clashed with the intuition of practitioners and legal scholars, including that leniency before an investigation cannot have deterrence effects, it only has effects if it is available after an investigation has been opened; that all cartel members should be awarded leniency if they apply, not only first applicants; and that leniency is a second-best, and should not be introduced if the competition authority has a sufficiently large budget.

By assuming away the ability of well administered leniency policies to induce non-detected cartels to come forward and self-report before an investigation is opened, which is instead the core aspect that distinguishes leniency policies from plea bargaining (see e.g. Lewis 2006), this first model focused entirely on leniency for already detected cartels and the prosecution phase. Also, its policy prescriptions to award leniency to many applicants after the cartels' discovery were rather divergent from the DOJ's view on the crucial features of the LP (Hammond 2004b). To improve on all these grounds, Spagnolo (2000a, 2004), Rey (2003) and Aubert et al. (2006) developed models that, on the contrary, focused on the potential direct incentives' effects of leniency highlighted by legal scholars and the DOJ but not accounted for in Motta and Polo (2003), including ex-ante deterrence from spontaneous self-reporting, thereby bringing the analysis closer to the modern literature on optimal law enforcement, started by Becker (1968). In particular, Spagnolo (2000a, 2004) builds a model that focuses on general deterrence and the ability of leniency to induce undetected cartels' members to report their conspiracy, and shows that leniency programs open to firms reporting before an investigation can have a powerful deterrence effect not accompanied by prosecution costs. This follows from the model accounting for a) the fact that firms that deviate from a cartel and report under leniency programs are protected by public antitrust enforcement afterwards instead of remaining liable for years (the "protection from fines" effect); and b) the fact that a well-designed leniency policy that rewards with immunity the first reporting party and exposes its partners to harsh sanctions can generate general deterrence through the fear of being betrayed without any cost of prosecution (the "strategic risk" effect). Then, the model shows that: (i) having a leniency policy for firms reporting before an investigation is always optimal; (ii) these programs must be strict, i.e. they must restrict (full) leniency to the first reporter only, so as not to shut down the two most crucial deterrence channels; (iii) if accompanied by severe enough sanctions, they could completely deter cartels - at a finite level of fines -, even if the probability of detection of the cartel without a leniency application goes to zero; (iv) general deterrence is particularly powerful if rewards are introduced, funded by a fraction of the fines paid by firms that did not apply for leniency (so that the first-best – costless and complete deterrence – could theoretically be achieved); and (v) the additional deterrence channel opened by well run, strict leniency programs – with or without rewards – because they increase distrust/fear of being betrayed by other cartelists, can be captured by an extended notion of "riskiness" related in spirit to Harsanyi and Selten's (1998) concept of risk dominance. This novel deterrence channel adds to the deterrence channels linked to the participation constraint, identified by Becker (1968), and to the one linked to the cartel's incentive constraint identified by Stigler (1964), and is the crucial one to take into account when designing leniency programs, as it becomes active earlier than the other, hence at much lower cost to society (as also confirmed by the experimental evidence discussed later)[2].

Spagnolo's (2004) does not distinguish between colluding individuals and firms, as it focuses on the potential of these programs to fight many forms of collaborative/organized crime besides cartels, most of which involve multiple collaborating individuals, not necessarily firms. When colluding agents are firms, as is the case for cartels, and rewards can be paid to individual employees of these organizations, a number of novel issues emerge. Aubert et al. (2006) focus on the direct, general deterrence effects of leniency and rewards, and more precisely on those crucial "organizational" aspects. The model shows that (i) allowing whistleblowers of colluding firms to obtain leniency and

[2] See Blonski and Spagnolo (2014), Blonski, Ockenfels and Spagnolo (2011), Bigoni, Casari, Spagnolo and Skrypacz (2015), and Breitmoser (2015) for clarifications on the game theoretic foundation of the strategic risk channel and robust experimental support for it.

cash a reward increases the number of potential informants that a colluding firm must "bribe" to keep silent, thus increasing the cost of collusion and indirectly, the general deterrence effect of any given reward scheme; and (ii) individual rewards tend to be complementary to corporate leniency programs, as they make a colluding firm's strategy to defect, report, and stop "bribing" its own informed employees even more attractive, further destabilizing collusion.

The authors also consider several potential costs from offering individual rewards, based on the possible negative effects on firms' internal organization and performance: deterrence of productive cooperation, which could be untruthfully reported in the attempt to cash a reward; inefficient reduction of the turnover to minimize the number of informed parties; and adoption of "innocent" attitudes, such as increasing investment in productivity enhancing technology.

Potentially negative effects of leniency policies have also been noted: Motta and Polo (2003) focused on one negative effect of leniency: reduced overall cartel sanctions; Spagnolo (2000a, 2004) a second one: “exploitability” by repeat offenders (if the program is poorly designed). Buccirossi and Spagnolo (2006) highlight the importance of leniency policies for other forms of collaborative crimes like corruption and financial fraud, and identify a third negative side effect of poorly designed programs. Focusing on leniency on bilateral, sequential, asymmetric illegal transactions, such as corruption or manager/auditor collusion, they show that “moderate” forms of leniency typically implemented in the real world could facilitate the enforcement of occasional illegal transactions by making the threat to report under the leniency program when one party violates the illegal agreement credible (see Spagnolo (2000b) for the case of multi-unit auctions). Related counterproductive side effects of leniency are discussed in several other models (Ellis and Wilson’s 2003, Brisset and Thomas 2004, Motchenkova 2005, Aubert et al. 2006, Harrington and Chen 2006), confirming and reinforcing the message that leniency programs must be carefully designed and implemented, as they may otherwise produce rather negative side effects. To close the “early studies” section, Harrington (2008) removes the assumption of a fixed and/or restricted[3] probability of detection (and conviction) over time. In earlier papers, this assumption produced the counterfactual that, in equilibrium, colluding firms do not use the leniency program. In this study, the model setup includes a dynamic setting in which the probability of detection varies stochastically over time. The author shows that the overall effect of leniency programs depends on firms’ incentives and the size of the fine reduction. In particular, a more generous fine reduction makes the cartel less stable, such that it is best to offer immunity to the first self-reporting firm only[4].

B. More recent theories

The relationship between the leniency rate and the number of reporting firms is examined by Sauvagnat (2014) who extends Spagnolo’s (2004) model to allow the competition authority to offer leniency rates contingent on the number of reporters. In this case, the optimal solution is not restricting leniency to the first reporter but instead only grant leniency if there is only one reporter. This is because this rule increases the expected sanctions of cartel members and thus, increases deterrence. Unfortunately, the model does not analyze the effects of these rules (single-reporter or first-reporter) on prices and, more importantly, on cartel formation.

Harrington and Chang (2009) design a dynamic model of cartel formation and dissolution, where an industry of firms interact repeatedly in an infinite time horizon, the population of cartels and of discovered cartels is endogenized and industry heterogeneity is captured by a stability parameter. At the start of each period, an industry may be cartelized or not, depending on whether it was cartelized in the previous period or not, and in the latter case there is uncertainty as to its cartelization in the

[3] Motta and Polo (2003) allow the probability of detection to change over time but it is restricted to only two values, one of which is zero. Feess and Walzl (2004) also allow this probability to be random but the setup is static and therefore, collusion is not endogenized.

[4] This statement holds if the cumulative distribution function of the probability of detection is weakly concave and the probability of a conviction, without self-reporting, is less than 50%.

current period. Firms realize profits and at the end of the period, a competition authority may arbitrarily start an investigation. If convicted, the severity of the fines depends on the number of collusion periods, given that there is only one collusive price in the model. This study shows how changes in the duration of cartels discovered can be instructive in assessing the effectiveness of the leniency policy in reducing the true rate of cartels. This is because if discovered cartels tend to be longer in duration following a policy change, then this change is likely to be reducing cartel formation. While informative, the model assumes that there is no (threat of) entry or exit in each industry and the detection probability is exogenous. The latter issue is addressed in two extensions of this study: Harrington and Chang (2013) endogenize non-leniency enforcement and Harrington and Chang (2015) allow the competition authority to decide on its caseload.

The first extension shows that a leniency program is able to lower the cartel rate when the case requires sufficiently few resources or when enforcement was initially very weak. Otherwise, the program may actually increase the cartel rate. However, this negative effect can be mitigated if leniency programs are complemented by high penalties and a sufficiently large budget for competition authorities.

In the second extension, Harrington and Chang show that changes in the average duration of convicted cartels should follow a precise temporal pattern, after a policy is introduced. If the policy innovation is successful in increasing cartel deterrence, we should observe an increase in the average duration of convicted cartels in the short-run. This is because less stable cartels, with lower expected duration, immediately disintegrate; ensuing cartel detections will therefore come from a population of more stable cartels, which typically last longer.

C. Leniency with asymmetric firms

Recently, some authors have formally examined the effect of asymmetric firms and emphasized that the deterrent effect of leniency programs depends, to some extent, on the heterogeneity of the cartel members. In this sub-section, we discuss articles which consider heterogeneous firms in terms of (i) their size (Motchenkova and Van der Laan 2011, Motchenkova and Leliefield 2010), (ii) their role as instigator and/or leader of the cartel (Herre et al. 2012, Bos and Wandschneider 2012, Chen et al. 2015, Blatter et al. 2014), or (iii) the possession of private information (Feess and Walzl 2010, Silbye 2010, Pinna 2010, Harrington 2013, Marvão 2014).

Motchenkova and Van der Laan (2011) extend the model by Motta and Polo (2003) to include firms which collude in one market but differ in their diversification in other non-cartelized markets. Therefore, the novelty in the model setup is that firms have different size and operate in several markets, but collude in (only) one of them. This setup generates an additional cost in case of reporting of the cartel, due to the possibility of asymmetric punishments, i.e., punishing the reporter in a different market.

In this study, leniency programs are shown to be more effective for smaller firms (where inducing self-reporting requires a lower rate of law enforcement), and require larger fine discounts where resources are limited, as shown in previous work. In addition, the model suggests that larger firms prefer not to enter a collusive agreement than to collude and report and so, the competition authority is more able to prevent them from collusive activities.

A different source of heterogeneity is examined by Motchenkova and Leliefield (2010). The authors use a similar structure to Houba et al. (2011) but in their duopoly model, firms have different accumulated profits (i.e. market shares). In this setting, a small firm decides whether or not to report the cartel, after which a large firm decides to retaliate or not. As such, the large firm can use the leniency program to coerce and prevent the small firm from reporting. Those with higher accumulated profits are able to prevent the other (smaller) cartel members from reporting, through predation. In this case, leniency is not effective, as it strengthens cartel stability and leads to an abuse of a dominant position. As previously shown in Ellis and Wilson (2003), the results emphasize that leniency programs

may serve as a disciplining device to hinder defections from the collusive agreement, unless reporting firms are protected from possible retaliation by the other cartel members.
Both these studies assume that all firms are equally efficient (same production cost); the firm asymmetry does not allow for bargaining power within the collusive agreement; and both collusive prices and profits are fixed. Removing these assumptions would make these models more realistic. Even more, the reasons underlying the heterogeneity in firm size are not explored. One possibility is that firm size is related to being the cartel instigator and/or leader.

The US Leniency Program confines leniency applications to firms that "*did not coerce another party to participate in the illegal activity and clearly was not the leader in, or originator of, the activity*"[5]. However, some jurisdictions (the EU in 2006 and Canada in 2010) have removed such a restriction.
To compare leniency regimes where the ringleader is excluded or not, Herre et al. (2012) extend the model by Motta and Polo (2003) in which firms set quantities and then decide to report or not, and the competition authority secures a conviction, as long as a cartel member reports. In this study, each cartel member has some evidence which affects the probability of conviction but no firm has sufficient evidence to guarantee a conviction. In addition, side-payments between cartel members are permitted. The authors show that the introduction of a "no immunity to instigator (or ringleader) clause" has little effect if the instigator has a large amount of evidence to provide authorities with, particularly if the probability of an investigation is low. This is because the dominant collusive agreement between the members specifies that the ringleader never reports and is compensated for its silence. However, if the ringleader's information is unimportant, the results show that he should be excluded from leniency.
Other authors have found a less subtle effect from excluding ringleaders. The model of Motta and Polo (2003) is also extended by Chen et al. (2015) and Blatter et al. (2014). The first study adds an instigation stage whereby a firm may elect to suggest a collusive agreement, and a special treatment of instigators whose exclusion from the leniency program eliminates their incentive to report. If both firms simultaneously decide to collude, one is randomly assigned the role of instigator. In the second study, the model is extended so as to consider the minimum standard of evidence and instigator discrimination, such that firms have asymmetric and imperfect cumulative evidence of the collusion.
Chen et al. (2015) formally show the dual effect on firms' incentives. Excluding instigators from leniency decreases the destabilizing effect of leniency programs on cartels, thus increasing cartel stability. However, by imposing a more severe punishment on the instigator, it may reduce the incentive for cartel instigation. These results hold for perfect and symmetric information. Blatter et al. (2014) corroborate the results from Herre et al. (2012)'s study and add the result that asymmetric evidence increases the cost of deterrence if the firm with most evidence is excluded from the program and thus, does not report.
Bos and Wandschneider (2012) add to this result. The authors extend the price setting supergame with capacity constraints framework from Bos and Harrington (2010) and endogenize the composition of a cartel in the context of an infinitely repeated game with heterogeneous firms. The collusive price levels depending on the exclusion or not of the ringleader are analyzed and it is shown that introducing such a clause will generally (although not always) lead to lower cartel prices.

The issue of a two-firm cartel where firms have imperfect and asymmetric evidence is explored by Silbye (2010)[6]. In his framework, two firms possess different amounts of evidence but only one is allowed to apply for leniency, and the competition authority sets a fine that decreases with a larger amount of provided evidence. The author assumes that the likelihood of detection of the cartel is common knowledge but each firm has evidence that could submit to convict the other firm if it applied for leniency. The findings are in line with the current EU leniency program: firms who provide more

[5] U.S. DOJ, Antitrust Division, Corporate Leniency Policy at A.6 (http://www.justice.gov/atr/public/guidelines/0091.htm).
[6] See also Feess and Walzl (2010) where a similar issue is addressed but in a static model of collusion. Silbye's (2010) analysis extends their analysis to a setting with repeated interactions.

evidence should receive a larger leniency reduction, and evidence should be significant and relevant in order to lead to a larger reduction, provided that fines are not too low.
In Harrington (2013), each cartel member has private signals on the probability of being detected by a random audit and will only apply for leniency if its signal is above a given threshold. The model examines the effect of leniency in this scenario and it emphasizes a problem which is denoted "pre-emption effect", in the sense that a firm may apply for leniency because it fears another firm will apply. This channel is related to the strategic risk channel analyzed in Spagnolo (2004) but the introduction of private information means that the fear of being cheated upon by a cartel partner may as well induce reporting along the equilibrium path, which is very important for connecting to empirical studies.
The assumption of symmetric firms in Harrington (2013) was later removed by Marvão (2014) who shows that the optimal reporting strategy of cartel members is no longer symmetric but it is the firm which expects to receive the largest fine (due to larger sales, recidivism or other aggravating circumstances) which reports the cartel first.
The role of private information is also examined by Sauvagnat (2015). The novelty in this infinitely repeated Bertrand game is that the competition authority has private information on the strength of a case, and it is a strategic decision to open a case. This leads to the result that leniency should be granted even when the probability of conviction is high, as it increases the rate of success of the cartel investigation. Conversely, the authority is also able to exploit firm's uncertainty regarding the likelihood of conviction and it may open an investigation even when its strength is low, as that may induce firms to apply for leniency.

D. Leniency and investigative effort by competition authorities

The trade-off between leniency programs and the effectiveness of antitrust investigations is analyzed by Chen and Rey (2013). The authors use a two-firm infinitely repeated Bertrand game in the spirit of Spagnolo (2004) to study when it is beneficial to allow leniency to be also awarded after a cartel is detected and an investigation started, and when it is instead better to only offer leniency before an investigation started. As in Spagnolo (2004), and in contrast to Motta and Polo (2004) they show that leniency should be restricted to the first reporting firm (regardless of recidivism), that it is always beneficial to offer leniency before an investigation started, and imply that rewards for the first spontaneously reporting party may be optimal. Their most novel contribution is the full characterization of the conditions under which it is also optimal for society to allow competition authorities to offer some leniency after a cartel is detected and an investigation has started, as done in reality. They show that in the case where investigations are infrequent but likely to succeed, it is optimal to offer less leniency once an investigation is ongoing; whereas when investigations are frequent but unlikely to succeed, it may be optimal to offer more amnesty once an investigation is initiated, so as to increase its effectiveness. The authors also compare different characteristics of leniency programs, providing some support for the "first informant" and the "post investigation amnesty" rules, which are present in the US leniency program. However, no support is found for not offering leniency to repeat offending firms.
Gartner (2013) extends this framework to include the feature of memory in the stochastic process, i.e., the probabilities of detection evolve over time. Adding this persistence feature pushes firms into pre-emptive leniency applications, which occur much before the risk of independent detection is impending. This pre-emptive effect is larger if there is little discontinuity in time and state, low level of firms' patience, and a relatively severe punishment of firms which fail to pre-empt others. These results hold even in the absence of rewards or large absolute levels of leniency reductions.
The literature above assumed that competition authorities are able to commit to an investigation effort ex-ante (or else that the probability of a conviction is exogenous). Gerlach (2013) removes this assumption and develops a model where the authority has two instruments: a self-reporting scheme and procedural investigation. An instrument is chosen in the first game stage. In the second stage,

nature draws the amount of private information of the wrongdoer, which is common knowledge and the wrongdoer then decides to commit the crime or not. If it does, then it decides to report it or not. In the following stage, if there is no report, the authority chooses its effort level and convicts or acquits the wrongdoer.
The model shows that the lack of commitment generates a negative relationship between investigative effort and self-reporting schemes, such that self-reporting is more efficient when: (i) full amnesty is offered, as wrongdoers (always) report; (ii) the level of harm is low; and (iii) authorities can convict without hard-evidence, although a hard-evidence standard provides more deterrence (and is welfare enhancing).[7]

E. Other issues related to leniency programs: multi-market contact, price effects, damages and delegation

Few papers have examined the specific case of leniency applications by multi-market firms. Choi and Gerlach (2012) are the first to examine multi-market contact in the context of cartels. In order to do so, the authors extend the framework from Motta and Polo (2003) to allow for collusion and self-reporting where firms form cartels in two geographical markets (i.e. countries) and national competition authorities may or not cooperate between themselves. If there is only one authority per market, free-rider problems arise due to positive prosecution externalities in each market. These can be solved if competition authorities are able to cooperate. However, if they share extensive (relevant) information, the incentive to self-report is decreased. Conversely, if there is no cooperation, multi-market contact allows firms to reduce the equilibrium amount of self-reporting and sustain collusion more effectively.
Under the US Amnesty Plus program, if a firm is convicted in a market, it is asked if it colludes in other markets and if it does not report these cartel(s), it can no longer apply for leniency if an investigation is open on those cartels. Unfortunately, the paper above is not able to capture the strategic effect of Leniency or Amnesty Plus programs. This is done by Lefouili and Roux (2012) who use a dynamic framework to show that amnesty plus affects collusive strategies in which firms cooperate and never report the existing cartels. The program is shown to be able to destabilize cartels where firms continue to collude after the detection (and conviction) of the first cartel (pro-competitive effect). However, it is also able to stabilize cartels where firms reveal the second cartel after prosecution of the first cartel (pro-collusive effect).
Marx et al. (2015) add to this literature by adopting a static model that allows for the use of global games techniques to capture miscoordination problems, rather than a dynamic model with self-enforcing constraints. They focus on multi-product colluders and examine their incentive to report the different cartels they are involved in, under the US Amnesty Plus program. They show that it is possible that linking leniency across products increases the likelihood of conviction in the first product investigated but reduces it in subsequent products. Thus, firms may have an incentive to form sacrificial cartels and apply for leniency in less valuable products to reduce convictions in more valuable ones.

The impact of the cartel destabilizing effect of leniency programs on maximal pricing is studied by Houba et al. (2015). The authors develop an infinitely-repeated oligopoly model where fines are a function of the illegal gains and where the probability of detection depends on the degree of collusion, and which focuses on the worst possible scenario. To solve this complex model the authors have to assume, as in Motta and Polo (2003), that if a firm deviates it immediately becomes no longer liable to antitrust fines (in most jurisdictions, instead, a cartel member that deviates and abandons a cartel remains fully liable to public and private enforcement for several years). This simplifying assumption,

[7] The effect of judicial errors in the presence of a leniency program has been analyzed by Motchenkova and Ghebrihiwet (2010) and Pavlova and Shastitko (2014), showing that judicial errors (types I and II) make antitrust enforcement less effective and ex-ante deterrence weaker.

as explained earlier, is not innocuous as it shuts down entirely the "protection from fines" (deviating and, deviating and reporting have then the same effect) and the "strategic risk/fear of betrayal" effects of leniency, crucial according to experimental evidence. Not surprisingly, assumed away these effects, the model misleadingly predicts, as in Motta and Polo (2003), that leniency before investigation can have no effects. More interestingly, when studying post-investigation leniency, the authors find that strict programs offering full immunity only to the first reporting firms are the best scenario in terms of the size of the reduction in the maximal cartel price This last result, that leniency programs should be strict, appears likely to be robust to more realistic assumptions and therefore policy relevant.

Public and private enforcement typically serve complementary purposes. However, modern antitrust engenders a possible conflict between the two due to the central role of leniency programs. Damage actions may reduce the attractiveness of leniency programs for cartel participants if their cooperation with the competition authority increases the chance that the cartel's victims will bring a successful suit. Buccirossi et al. (2015) examine the EU directive on cartel damages, adopted in November 2014, which seeks a balance between public and private enforcement. For this purpose, they develop a simple model where in addition to fines, cartel members are liable for compensation of buyers. The analysis shows that damage actions are able to improve the effectiveness of leniency programs through a legal regime in which the civil liability of the immunity recipient is minimized and full access to all the evidence collected by the competition authority, including leniency statements, is granted to claimants.

Earlier research (Spagnolo 2000a, Spagnolo 2005b) empirically observed that incentives to top managers, such as staggered stock options and bonus schemes, tend to facilitate collusive behavior. Chen (2008) adds to this strand of literature by characterizing the effectiveness of leniency programs for deterrence, in centralized and decentralized cartel hierarchical organizations. The author shows that incorporating non-contractibility issues may further facilitate collusion. However, the efficiency gains of delegation in facilitating collusion can be mitigated when the leniency program is introduced, particularly when the probability of detection, absent leniency, is low and corporate liability is much more significant than the individual one.
Angelucci and Hann (2012) build a three-tier model where an antitrust authority, a shareholder and a manager interact, in order to study a firm's internal agency problem. The shareholder monitors the manager's behavior and although he is not directly affected by its behavior, both can report the infringement but it is assumed that the manager is quicker to report than the shareholder. If neither reports, the authority can still uncover the cartel with some probability. The authors show that it is optimal to grant a partial reduction of the corporate sanction, in exchange for evidence of the misbehavior, but to fully punish the manager. Individual leniency programs are also shown to increase private compliance costs, i.e., transferring part of the cost to the shareholder, and should be offered to a reporting manager when the ability of the authority to punish management is limited.
The possibility of using leniency programs (and amnesty plus) to induce CEOs of decentralized firms to carry internal audits and report collusive agreements is analyzed by Dargaud and Jacques (2016). The authors develop a simple model where two homogeneous firms produce two different products and play an infinitely repeated Bertrand game, in the presence of an Antitrust Authority. Two scenarios are illustrated, where firms are able or not, time-wise, to report a second cartel before its detection. If they are not able to report it, in the presence of leniency programs (but not amnesty plus), CEOs will not investigate a potential second cartel and report it but the sustainability of the cartel is decreased by the presence of leniency. In the second scenario, where reporting is feasible, CEOs may start an investigation if the level of compartmentalization is not perfect. In the presence of amnesty plus, the results show that there is a pro-collusive effect for centralized firms who simultaneously collude in two markets.

III. Empirical Evidence on Leniency

The number of different models with often unrealistic simplifying assumptions and conflicting results calls loud for empirical and experimental evidence. Let's now turn to survey this.

III.A. Descriptive Studies

The empirical literature on leniency policies is recent and includes several papers which present and discuss descriptive statistics on prosecuted cartels (Bloom 2007, Connor 2007 and 2013, Carree et al. 2010, Combe and Monnier 2011, Veljanovski 2010, Dominte et al. 2013). A case study approach has also been used to examine leniency policies (Asker, 2010).[8]

A yearly analysis of leniency applications in the EU and the US clearly shows that the number of cartels reported under a leniency policy and the number of individual leniency applications have both increased dramatically in recent years. This is particularly the case in the EU. The generosity of the penalty reductions for initial and subsequent leniency applicants in the EU has also visibly increased (see Marvão 2014).

Between 1996 and March 2010, 124 firms were fined by the DOJ for participation in 39 different cartels[9] . In the EU, leniency applications in the period between 1998 and October 2014 related to 81 cartels, with a total of 385 firms. In Asia, 33 cartels were prosecuted by the Japan Fair Trade Commission, the Korea Fair Trade Commission and Taiwan's Fair Trade Commission between 1990 and 2007. Finally, 30 cartels were prosecuted in Russia between 2004 and 2011. Furthermore, the average number of cartel members in the reported cartels is smallest in the EU (8.3) and largest in Russia (11), although the latter figure is inflated by a cartel involving 51 firms in the financial services between 2003 and 2008.

Repeat offenders are a highly debated issue (see Werden et al. 2011). Connor (2010) has suggested that there is evidence of a large amount of recidivism; he identified 389 recidivists worldwide in the period between 1990 and 2009. This number constitutes 18.4 per cent of the total number of firms involved in 648 international hard-core cartel investigations and/or convictions. Werden et al. have contested Connor's definition of recidivism and his calculation of the numbers of multiple and repeat offenders. The main discrepancy between the two arguments appears to be in the examined period and in how cartel members who merge and form a new firm are dealt with. Werden et al. follow the legal practice (DOJ and EC) and therefore, they have suggested that no repeat offenders in US cartels have been fined since 1999. As for the EU, Marvão (2015) identified 89 multiple offenders and six repeat offenders[10] since 1998 when the first leniency reduction was granted. The first decision applying the leniency policy to a cartel case was in 1998, involving British Sugar.[11] The complaint was made in 1994 and, after the introduction of the leniency policy, all four cartel members applied for leniency. Three reductions of 10 per cent and one of 50 per cent were granted.

On average, a cartel member fined by the EC receives a leniency reduction of 26 per cent. Firms which receive a leniency reduction (1–99 per cent) receive first, on average, a fine increase of 32 per cent (these are granted for aggravating circumstances such as recidivism, absence of cooperation, obstruction of the investigation and for being the cartel ringleader or instigator) and a fine reduction of three per cent (for mitigating circumstances such as termination of the infringement at the time of the investigation, negligence as the cause of the cartel, limited involvement in the cartel, cooperation with the Commission outside the leniency policy, or proof of having been encouraged by public

[8] Asker has made an in-depth analysis of a US parcel tanker shipping cartel and suggested that welfare-improving effects from leniency are linked to an increased probability of private antitrust suits.

[9] See further statistics for the US in Connor and Miller (2013); for Asia in Connor (2008) and for Russia in Yusupova (2013).

[10] These are defined as any firm who was caught colluding after having received a fine for another cartel. In this sense, the definition is closer to Werden's than to Connor's.

[11] Information on the case available here:
http://ec.europa.eu/competition/antitrust/cases/dec_docs/33708/33708_6_7.pdf

authorities or legislation).[12] The average firm which does not receive a leniency reduction has a fine reduction of 16 per cent and an increase of 56 per cent, whereas firms with immunity from fines would have faced, on average, a fine increase of 22 per cent and a decrease of three percent.
Recently, Uytsel (2015) offered a first analysis of leniency in Japan, introduced in 2005 under the Japanese Antimonopoly Law. The author describes the 236 leniency applications in Japan between 2006 and 2013, where 28% of the cartel members received immunity from fines. All the leniency applicants are domestic firms (even those in international cartels), most of which are listed. This is in line with empirical studies showing that the first leniency applicant is the largest firm (see e.g. Marvão 2014). Uytsel also presents results of a survey which was sent to leniency applicants in the years of 2006 and 2012, although the response rate was very small (15/80). The article raises doubts as to the effectiveness of the leniency program, suggesting that too many unmeritorious applications reach the JFTC and that too many firms, per cartel, receive leniency reductions.
Even more recently, Wils (2016) assembled a rich descriptive analysis of the overall European experience with leniency programs, from its start to 2015.

Although descriptive statistics (and case studies) are important to show correlations and trends, they fail to identify causality and therefore cannot be used to evaluate the consequences of a policy, such as the deterrent effect of a leniency program. The real impact of leniency policies can only be addressed with econometric methods, but methodological problems (such as potential sample selection bias from only observing detected cartels) and the lack of appropriate data make empirical research scarce. The results of econometric studies, considered next, must therefore be interpreted with some caution.

III.B. Econometric Studies
(i) Deterrence Effects of Leniency Policies

As we suggested earlier in this chapter, the most important effect of leniency policies is the resulting (hopeful) decrease in the number of cartels in society. However, this is very difficult to measure because only *detected* cartels are typically observed. Two methodologies have been developed to infer the effects on cartel formation and deterrence of changing a law enforcement policy.
Harrington and Chang (2015) studied a dynamic model of cartel formation and showed that changes in the average duration of convicted cartels should follow a precise temporal pattern, as described in section *II.B* of this chapter.
The second methodology was derived by Miller (2009), who developed a somewhat simpler dynamic model of cartel behavior from which he derived predictions for successful law enforcement innovations related to the temporal distribution of the number of detected cartels conditional on the leniency policy. His model suggested that: (i) an immediate increase in the number of detected cartels is consistent with the hypothesis that a leniency policy increases the probability of cartel detection; and (ii) a subsequent decrease in the cartel detection rate and stabilization at a constant level lower than the one prevailing before the introduction of the leniency policy is consistent with it having a significant deterrence effect, that is, with the policy reducing cartel formation. The first and only two studies of which we are aware that apply these methodologies to cartel data are studies by Brenner (2009) and Miller himself.
Brenner studied EU cartel cases in the period between 1990 and 2003, a dataset that included 61 cases. He tested the evolution of the average duration and number of cartels detected around and after the introduction of the first version of the EU leniency policy in 1996.[13] He found neither an increase in average duration after the introduction of the leniency policy nor an increase in the

[12] The fine is capped at 10 per cent of the total turnover of the firm in the previous year. Special conditions are set in the case of inability to pay. For further information on cartel fines, see Guidelines on the method of setting fines imposed pursuant to Article 23(2)(a) of Regulation No 1/2003 [2006] OJ C210/2.
[13] See Commission Notice on the non-imposition or reduction of fines in cartel cases [1996] OJ C207/4-6.

number of detected cartels immediately after the policy's introduction. And he did not find a decrease in the number of detected cartels in the longer run. These findings appear inconsistent with the theoretical conditions indicating that the 1996 leniency policy had positive deterrence effects.

While Brenner's conclusions are consistent with the general perception that the 1996 EU leniency policy was rather poorly designed and implemented (see also Bloom 2007) (it was reformed in 2002[14] and again in 2006[15]), it would be interesting to subject his findings to a number of robustness checks. For example, he treated the first three years of the leniency policy's existence as the short-run, but there is no clear definition from Miller's or Chang and Harrington's studies as to how the short-run should be defined. Hence, one would want to see analogous tests for a large number of other time frames to be confident about robustness.

Miller applied his own methodology to assess the effect of the reformed US leniency policy introduced in 1993.[16] He used data from the US DOJ that cover the period between 1985 and 2005. He found that the number of cartels detected by US authorities increased after the introduction of the new leniency policy, which according to his theory is consistent with an increase in the cartel detection rate. He also observed that this increase was followed by a fall to a level below the pre-leniency policy level, a pattern that according to his theory is consistent with increased cartel deterrence. The mentioned changes in the number of detected cartels were statistically significant, of a large magnitude and consistent with several robustness checks.

Although Miller's study probably represents the most important contribution to the empirical literature on the effects of leniency policies to date, it has not escaped criticism. Cartel formation and dissolution are not endogenized in the model, although this seemed to be present in an earlier draft of the paper. Another issue is that changes in the cartel duration of detected cartels were not considered as a robustness check.

De (2010) also tested Harrington and Chang's theory. The paper focused on the precise determination of the life-span of 109 EU cartels that were the subject of an infringement decision between 1990 and 2008. Previous empirical studies on cartel duration used methods which assumed a normal distribution of the lifetime data, and they were unable to deal with a flexible probability of exit from a cartel or with more than one reason for a cartel breaking up. To overcome both of these issues, De analyzed the dataset with the help of a competing risk Cox proportional hazard model. The regression results showed that the introduction of a leniency policy was one of the causes of cartel breakdown. De argued that it is extremely difficult to empirically define the short and long-run and so her model refrains from doing so. Nonetheless, her results showed that cartels detected after the introduction of the initial leniency policy in 1996 had a lower survival probability than those cartels that were detected earlier. According to Harrington and Chang's model, this finding is not consistent with an increase in deterrence linked to the leniency policy.

Zhou (2013) applied Harrington and Chang's model to EU leniency policy data for the period between December 1985 and December 2011. Using hazard model regression estimates, he found that cartel durations increased significantly in the period immediately following the introduction of a leniency policy (consistent with enhanced detection) and subsequently fell below short-run levels (consistent with enhanced deterrence). In addition to providing results supportive of the 2002 EU leniency policy, Zhou's paper also tried to improve methodologically on previous work. He argued that De did not differentiate the short-run from the long-run impacts and that Brenner (2009) took the first three years of the leniency policy's existence as the short-run without theoretical support for doing so. Zhou differentiated the impacts by cartel start date, which is more in line with Harrington and Chang's model: the short-run impact arises only with cartels that started before the introduction of the leniency policy, and the long-run impact arises only with cartels born after its introduction.

Klein (2011) tried to identify the deterrence effect of leniency policies by directly linking their introduction to an indicator of competition intensity. His empirical analysis relied on Organization for

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[14] See Commission Notice on Immunity from fines and reduction of fines in cartel cases [2002] OJ C45/3-5.

[15] See Commission Notice on Immunity from fines and reduction of fines in cartel cases [2006] OJ C298/17.

[16] See US DOJ, 'Corporate Leniency Policy' (10 August 1993) www.justice.gov/atr/public/guidelines/0091.pdf.

Economic Cooperation and Development data for the period between 1990 and 2010 and included 23 countries. He calculated the average profitability of industries (quotient between value added and cost of capital and labor), which he then used to draw inferences about the price-cost margin, since both are directly related. Issues of sample selection bias, endogeneity and omitted variables were addressed through the use of additional control variables (changes in GDP trend, in imports and in import penetration), an instrumental variable estimation and several robustness tests. The results showed that leniency policies were associated with a decrease in the price-cost margin of three to five per cent. Unfortunately, the interpretation of the average profitability of industries is multi-faceted and its correlation with competition intensity is not entirely clear.

The instrumental variables approach used in Klein (2011) is criticized by Cloutier (2011), who argues that the estimates are biased due to endogeneity issues. Cloutier argues that for large supra-EU firms, leniency programs in other countries may affect the cartel profitability and the policy position of a country's political parties, making this an inadequate instrument. The author attempts to tackle the endogeneity concerns by using industry concentration as a proxy for industry competitiveness in a difference-in-difference regression, where the control group are low concentration industries. The results, which are consistent with Klein's, show that, for the US, between 1991 and 1997, the amendment of the 1993 LP had no significant short-run effect on price-cost margins but had a persistent effect after 1 to 2 years.

Yusopova (2013) has presented the first econometric assessment of the leniency policy that was introduced in Russia in 2007.[17] The perceived ineffectiveness of the leniency policy led to a reform in 2009, when full immunity and criminal liability were introduced.[18] The data included all 30 cartels which were fined between 2004 and 2011. There were up to 51 firms per cartel. The results from a Poisson regression showed that the 2009 revision of the leniency policy was associated with a decrease in both the size of detected cartels and their duration. The results also showed that industries[19] with low concentration have had fewer cartel convictions since the leniency policy has been in place. Yusopova concluded that the 2009 revision was effective. Harrington and Chang's theory would suggest the opposite, however: a decrease in the duration of detected cartels is consistent with the new policy causing a reduction in cartel deterrence.

Dong, Massa and Žaldokas (2014) use data on nearly 489,000 registered global firms, over the period of 1990 to 2012, to study the impact of leniency laws on firms' strategies and the overall cost of collusion, using a difference-in-difference approach. As in most previous studies, it is shown that the introduction and existence of leniency policies increase the number of firms and cartels convicted. However, this study also finds that these policies are associated to a decrease of the gross margin of firms (not necessarily cartel members) by 6 percentage points, and that this is particularly strong in industries where collusion tends to be less stable. While these results suggest that leniency policies are effective, the study finds that after their introduction, firms pursue more mergers and acquisitions with firms in the same industry. That is, horizontal mergers seem to counterbalance the negative effect of leniency on prices, particularly when the acquirer had already been convicted for collusion.

This dynamic of mergers on detected cartels is also examined by Davies et al. (2014) and Marx and Zhou (2014). The first authors restrict their sample to post-collusion periods (84 EC decisions taken between 1984 and 2009), to focus on the firm's post-dissolution activity, while the latter expands the sample to mergers that took place before the dissolution of the cartel (151 EC decisions taken between 1985 and 2013). To identify the impact of the leniency program, Davies et al. use the cause of the

[17] The leniency policy was established by Federal Law No 45 'On Amendments to the Russian Federation Code of Administrative Offences'. A previous discussion of the Russian leniency program is carried in Shastitko and Avdasheva (2011).

[18] See Code of the Russian Federation on Administrative Violations, art 14.32 notes (civil liability); Criminal Code, art 178 note 3 (criminal liability). See generally Federal Antimonopoly Service of the Russian Federation, 'Report Cartel Collusion!', http://en.fas.gov.ru/report-cartel-collusion; and Yeremin et al. (2011).

[19] The 7 industries are defined according to the cartel reports from the Federal Antimonopoly Service and the concentration of each industry is categorized into high, medium or low.

investigation in a continuous time method whereas Marx and Zhou use the date of the policy introduction with a discrete-time method, to tackle issues of reverse causality and measurement.
The results from the recurrent event survival analysis in Davies et al. show that mergers are more frequent after the cartel breakdown, particularly in less concentrated markets. However, the authors are not able to disentangle coordinated effects' mergers from those caused by market restructuring and which may be pro-competitive and thus, the effect of leniency is not well established.
Marx and Zhou are able to test how the leniency program affects post-cartel merger activity. This is done by using a reduced-form Poisson regression to test merger rates following leniency introduction (or a settlement procedure) and a discrete-time hazard regression to test if leniency is able to expedite mergers (and if settlements delay mergers). The model shows that the EC leniency program expedites mergers (while settlements delay them) and mergers occur at a faster rate post-cartel, in line with the results found by Dong, Massa and Žaldokas (2014).

Finally, Bos et al. (2016) study the impact of competition enforcement on cartels. A theoretical model is developed, where firms produce differentiated products, at a given level of overcharges, and compete in an infinitely repeated Bertrand game. The model predicts that effective anti-cartel enforcement deters cartels with low overcharges and leads to lower collusive prices in the cartels that do form. This suggests that effective cartel policies should translate into fewer cartels with low overcharges and fewer cartels with high overcharges. This hypothesis is tested using John Connor's PIC dataset, which includes data on 1500 overcharges for 500 cartels, and the authors use a quantile regression to compare the distributions of legal and illegal overcharges. The empirical results corroborate the theoretical prediction and show that illegal cartels are less likely to set either low or high overcharges, providing some evidence of a deterrent effect from competition policies.[20]

(ii) Other Issues Related to Leniency Policies

In his 2009 study, Brenner also estimated the factors that influence the absolute amount of the fine (and the fine reduction) and the duration of the investigation. Using Ordinary Least Squares estimations, Brenner showed that the leniency policy increased the average reduced and total fines by around €16.5 million and €30.9 million respectively. Furthermore, the introduction of the leniency policy decreased the average duration of cartel investigations by around 1.48 years. The duration of the cartel and the number of firms and countries involved in each seemed to play no role in determining the fine, the fine reduction and the duration of the investigation. However, the number of cartel members presented a negative coefficient in the model for investigation duration.
While these extra results advance our knowledge on the effects of the 1996 EU leniency policy, Brenner's analysis could be improved by using a data deflation process for the absolute amount of the fine and by weighting the absolute value of the fines with the turnover of the firms in the cartel.
A later paper by Brenner (2011) examines the resource advantage of leniency applicants. Using the same dataset, the author uses a logit model to establish the differences in the decision to report, between large multinational and other firms. The results show that the former are more likely to report and cooperate with an investigation but no other characteristics of reporting and cooperating firms are identified as being significant.
A master's thesis by Arlman (2005) presented a second analysis of the EU leniency policy of 1996, using a dataset of 67 cartel cases convicted by the EC between 1990 and 2004. Arlman found that the leniency policy, measured by a dummy for whether or not a firm received maximum leniency, is positively correlated with the number of words in a decision (a proxy for the amount of information in the Commission's possession) and the gravity of the infringement, and negatively correlated with the duration of the investigation. In line with Brenner's finding, the paid fine was also found to be higher once the leniency policy was introduced, although Arlman measured the paid fine as a share of

[20] Marvão and Spagnolo (in progress) apply this methodology to a similar cartel overcharge dataset to test how deterrence changed with the introduction of the US and EU leniency programs, with mixed (preliminary) results.

the firm's turnover, which is problematic because it creates a bias between more and less diversified firms. Given these results, the author concluded that the leniency policy was moderately effective.
Gärtner and Zhou (2012) focused on the delay with which a cartel is reported relative to the time of collapse of the cartel. They analyzed 96 EU cartel cases, of which 78 included leniency applications. Between July 1996 and 2006, 40 per cent of the leniency policy applications experienced delays, often longer than 10 months, relative to the time of collapse of the cartel. A hazard model, where spells correspond to periods of application delay, was used in the analysis of the leniency application. They found that the introduction of the EU leniency policy in 2002 had a negative effect on the decision to apply for leniency. Delayed leniency applications were also shown to be correlated with the severity of the punishment and with business cycles. These results were corroborated by probit model estimates and robustness checks.
Zhou (2016) adds to these findings by analyzing how firms' incentives for leniency applications change over time and how they are affected by different enforcement and institutional parameters. The author analyses EC data between October 1996 and December 2014 through a multiple-spell discrete-time hazard regression. The main result of the study is that the start of an EC investigation does not affect the rate at which cartel members apply for leniency in the investigation market, but it does increase the rate of leniency applications in other markets in which one or more cartel members also engage in collusive activities.

Marvão (2015) has provided a more recent assessment of the EU leniency policy by examining the factors that encourage cartel members to self-report. The self-compiled data employed in the empirical analysis included all cartels up to October 2014 where there was at least one successful leniency policy application (87 cartels involving 510 firms). The study distinguished firms that started to participate in a cartel after being previously fined (4), those which ended their collusive behavior after being fined for participating in another cartel (6) and firms which ended their participation in a cartel after being investigated for a second cartel of which they were a participant (22). A total of 89 firms participated, contemporaneously or not, in at least two cartels (that is, they were multiple offenders). The econometric analysis, using double-sided Tobit and Heckman two-stage models, showed that the first reporter received much higher fine reductions, whether or not the reporting of the cartel took place before the EC started an investigation. The predicted leniency reductions were also larger for firms in smaller cartels, in cartels with a wide geographical impact and for firms which received lower fine reductions outside the leniency policy. The main result of this study is that repeat offenders appeared to receive higher leniency reductions, which suggests that firms can learn the 'rules of the game', repeatedly colluding and reporting the cartel, and thus substantially damage their partners.
In a subsequent paper, Marvão (2014) studied the characteristics of the firms reporting under the leniency policy and the cartels in which they take part. Probit estimates were carried out using self-collected EU data as in the earlier study (Marvão 2015) together with US data from John Connor's private international cartel database. In the US, in the period between 1984 and 2009, 2310 firms were convicted for their participation in cartel activities. The empirical analysis showed that EU firms that report the cartel and receive immunity from fines under the leniency policy are typically repeat or multiple offenders and are less likely to have received other fine reductions, while in the US the reporting firms are more likely to be the cartel leader as defined in Connor's database[21]. Repeat offenders were also more likely to receive immunity if they report once the collusive agreement

[21] This result contrasts with the US leniency policy's statement that ringleaders cannot receive leniency (See US DOJ, 'Corporate Leniency Policy' (10 August 1993) www.justice.gov/atr/public/guidelines/0091.pdf.), which suggests that different definitions of ringleaders are used, or that the rule is not always enforced. Connor's database (used in the analysis) identifies the leader in each cartel, according to US DOJ reports, as a 'cartelist mentioned in decision as a ringleader or a history of the case says one cartel member was the cartel disciplinarian/bully'.

ended. In contrast, firms which received other reductions were less likely to apply for and be granted immunity if the cartel is over.[22]

Some of the characteristics of the cartels in which pre-investigation reporting occurs were also unveiled. In the EU, these cartels tended to be smaller in terms of the number of members (and also number of repeat and multiple offenders) and tended to impact a geographical area wider than the European Economic Area. Reporting was also more likely to occur in the fine art auctions sector, which has a small number of firms and where reporting will significantly damage the competitors that also took part in the cartel. In the US, the predicted probability of immunity was much larger in the rubber and plastic sector and the paper and printing sector, and in markets with a moderate number of buyers.

On the issue of ringleaders, Davies and De (2013) empirically examined the frequency and characteristics of ringleaders in the EU and how they were treated when a leniency policy was introduced in 1996. Ringleaders were identified in one-fifth of 89 EU cartels convicted between 1990 and 2008. They were often the largest cartel member(s) and formed agreements in markets with weak or no trade associations. The authors concluded that, although ringleaders were penalized more heavily after the introduction of the leniency policy, ringleader discrimination present in the 1996 EU leniency policy and removed from the 2002 version has not prevented the emergence of ringleaders.

On a related issue, Marvão and Spagnolo (2016) consider the debate on whether the introduction of criminal penalties in the EU, for individuals who engage in cartel activity, can strengthen antitrust enforcement. The authors document a recent phenomenon termed "leniency inflation" at the EU level and the fact that CEOs of convicted cartel members do not seem to be punished by shareholders as they often remain in the position or receive large severance packages. In addition, an empirical analysis of the criminal sanctions imposed in the US suggests that repeat offenders are less likely to receive a prison sentence, in line with previous results suggesting that recidivist firms can use leniency in their own advantage. The authors interpret these results as suggestive of the need to introduce criminalization, in particular for infringements in the financial industry, possibly complemented by a moderate use of more expensive but proactive enforcement tools, such as screens and whistleblower rewards.

IV. Experimental Evidence on Leniency

As previously discussed, cartels, like other white collar crimes, typically are not observed unless they have been detected. Since every instance of collusion cannot be observed, interpreting an increase in the number of convicted cartels following a policy innovation as a 'success' — an interpretation adopted by some in relation to the reform of the US leniency policy in 1993[23] — is an elementary logical mistake. An increase in the number of convictions may be generated by an increase in cartel formation, itself the result of more lenient law enforcement. As noted in Part III.B, complex empirical methods need to be employed to try to understand whether the increased number of convicted cartels is associated with a fall or an increase in the total amount of such crimes in society. Not only are such studies necessarily complex and indirect (since the population of cartels is not directly observable, as is the case e.g. for violent crimes, most of which are reported), they are also of somewhat limited value when attempting to evaluate the effects of different policy designs which have not yet been implemented. Laboratory experiments are thus a crucial complementary empirical method because they overcome these drawbacks. They allow behavior to be observed in a controlled environment, including changes in the rate of overall cartel formation, and different policy designs to be tested at a reasonable cost.

Obviously, laboratory experiments themselves have several well-known drawbacks that offset their advantages to some extent. The results of laboratory experiments must therefore be carefully

[22] After Marvao's paper was widely circulated, a later paper uses the same EU specification on a shorter dataset and finds the same results (Hoang et al. 2015).

[23] See DOJ ´Corporate Leniency Policy´ (1993) http://www.justice.gov/atr/public/guidelines/0091.htm

examined, particularly when assessing firm behavior based on the behavior of subjects in the laboratory. Because subjects are typically students and interaction is artificially simulated, the external validity of the results achieved cannot be taken for granted. With this caveat in mind, the following section reviews the available evidence from laboratory experiments on leniency and whistleblowers in competition law.

IV.A. Leniency, Rewards, Cartels and Prices: Early Studies

The first laboratory experiment on leniency policies of which we are aware was carried out by Apesteguia, Dufwenberg and Selten (2007). They studied competitive outcomes in a one-shot homogeneous good Bertrand oligopoly with three firms and a discrete demand function. They embedded this market game in four legal frameworks: Ideal, Standard, Leniency and Bonus. In the 'Ideal' framework, there was no antitrust law and communication across competitors (forming cartels) was not possible. In 'Standard', convicted firms faced fines equivalent to 10 per cent of their revenue (accordingly, no fines were imposed if the firm has no revenue). In 'Leniency', firms which reported their participation in a cartel received a fine reduction (if they had some revenue and therefore faced a positive fine). And in 'Bonus', reporting cartel members received part of the fines paid by other firms as a reward. In this set up (homogeneous Bertrand and fines set at 10 per cent of revenue), if a cartel member defected, its partners had zero revenue and therefore faced zero fines. For this reason, the presence or absence of leniency made no difference in terms of incentives to report, and strategically equivalent collusive sub-game perfect equilibria existed (in fact, full folk theorems hold) both in 'Standard' and 'Leniency', sustained by the threat of reporting if a defection occurs.

The experimental analysis which tested the effects from the theoretical model confirmed that agents understand and use the threat of reporting to sustain collusion, more so in 'Standard' than in 'Leniency', where both market prices and the percentage of cartel formation were lower. Additionally, 'Leniency' was the framework which minimized the share of cartel formation. The analysis also did not find that deterrence increases with the introduction of rewards, since the 'Bonus' framework presented the highest levels of market prices and cartel formation. However, in 'Bonus', incentives to report were stronger and there were no collusive equilibria sustained by the threat of reporting. This may suggest that the counterintuitive finding may not hold if subjects are allowed to gain experience. This leaves some space for follow-up work.

The stylized framework and particular setup used in this pioneering study raises some issues for the interpretation of its results. The oligopoly game in the experiment allowed for only one round of decisions, leaving agents no opportunity to learn the game. Coupled with the subtlety of the differences between 'Standard', 'Leniency' and 'Bonus', it is possible that some of the counterintuitive results, such as agents not reacting to rewards, were driven by subjects not fully grasping the situation.

While Apesteguia, Dufwenberg and Selten's study tests the empirical relevance of theory, Hinloopen and Soetevent (2008b) approach the same issue but with a different methodology so as to make the lab look like the real world and thus, derive insights by analogy. They repeated the underlying oligopoly game and controlled for communication, allowing it to include different degrees of a range of electronically accepted market prices. Subjects were also free to choose whether or not to agree on a collusive price. When leniency was introduced, cartel members could only report and obtain a fine discount before an investigation was initiated. The first reporting party received full immunity and the second a 50 per cent fine reduction; the remainder received no fine reduction at all. In this way, the study addressed both direct general deterrence and desistance effects. The study used the oligopoly model from Apesteguia, Dufwenberg and Selten's study as a stage game of a repeated game with an uncertain horizon, and added a small fixed cost of reporting to the legal framework. This cost had to be paid even when revenue was zero because a cartel partner undercut the price and took all customers. Although an additional fixed cost/fine, limited to no-leniency treatments, would have further approximated real world conditions, this positive reporting cost partly captured the real world feature that, absent a leniency policy, a cheated-upon cartel member which reports is still subject to

a fine. In this more realistic framework, the study confirmed the potential of the positive ex-ante deterrence effects of the US leniency policy, restricted to the first 'spontaneously' reporting party.
Contrary to what the first models of leniency assumed (e.g. Motta and Polo 2003), Hinloopen and Soetevent showed that substantial cartel deterrence can be achieved with the introduction of a leniency policy that is only available to spontaneous reports before an investigation is opened. The average price in 'Leniency' is significantly lower because cartels which do form are less successful in charging prices above the Nash equilibrium and because of the lower rate of decisions in favor of price discussions. This leads to a higher rate of defection and of price undercutting. Therefore, significantly fewer cartels are established and the life-span of cartels that were not deterred is reduced.
A second notable result of the study is that there exists a constant high rate of recidivism —the same percentage of detected and convicted cartels start colluding again, after some time, with or without leniency policies. Desistence (that is, specific deterrence) is not effective. The lack of desistance effects implied by recidivism may be a consequence of the absence of higher fines or the higher probability of detection for repeat offenders. Therefore, after a conviction, collusion remains practically as attractive as before for the convicted cartel. Unfortunately, the study did not consider rewards.
The above mentioned studies focus on non-exploitable leniency policies.[24] In another study by Hinloopen and Soetevent (2008a), they used a similar setting (repeated Bertrand game, where subjects report before an investigation) but restricted it to a duopoly where communication was done through colored cards. They introduced an 'exploitable' (overly generous) leniency policy treatment where agents could self-report and receive immunity from fines if they were the only reporter and a 90 per cent reduction where they both reported. There were no penalties in the 'benchmark' treatment, while in 'Antitrust', cartels were detected with a 40 per cent probability (much higher than the 15 per cent in their other study) and they paid a fine equal to the cartel gains (compared to 10 per cent of the revenue over the same period as in their other study). This simpler setting allowed Hinloopen and Soetevent to isolate the effects of exploitable leniency and non-exploitable leniency policy treatments.
The results in the paper showed that when there is an exploitable leniency policy, it is in fact exploited; 70 per cent of the pairs reported simultaneously and there was some evidence that overt collusion became more appealing. It was also shown that a non-exploitable leniency policy treatment leads firms to turn to tacit collusion, which is not illegal and is thus free from fines. The non-exploitable leniency policy treatment led to an increase in overt collusion but of a much smaller magnitude than the exploitable leniency policy. The non-exploitable leniency policy treatment's earnings were larger than in the benchmark treatment and no lower than in the exploitable leniency policy treatment. In conclusion, in this experiment, leniency policies always reduce welfare.
Hamaguchi, Kawagoe and Shibata (2009) considered the effects of cartel size (in terms of the number of members), the fine schedule and the degree of leniency (partial reduction, immunity or rewards) on the likelihood that a cartel is reported. In this study, subjects did not play a market game and did not chose prices or quantities. All subjects were initially assumed or forced to be part of a cartel, but were given incentives to maintain collusion. The players were then left with the choice of whether to report collusion or not under different treatments, in which the leniency program is not necessarily strong enough to dissolve cartels. It was further assumed that cartels that are reported do not form again. The study found that the initial cartel was reported more frequently when the number of members was higher and that the frequency of reporting was not affected by either the fine schedule nor by whether only the first party or all parties that self-report were eligible for leniency. The study also found that the possibility of reporters receiving a reward had a large positive impact on dissolving cartel activity.
While these results on the likelihood of reporting are in themselves interesting, their interpretation in terms of the effects of leniency policies and their possible policy prescriptions is somewhat problematic. What matters for welfare is deterrence and prices, not the number of reports, which by

[24] On exploitable leniency policies, see Spagnolo (2004).

themselves increase the workload of competition authorities and prosecution costs[25]. Experiments that include a market game show that there is a strong interdependence between the legal environment and the way firms behave in the market (Hinloopen and Soetevent 2008b). This interaction is excluded by construction in the study by Hamaguchi, Kawagoe and Shibata. Therefore, it is not known if these reporting patterns would change if subjects were also involved in a market game as in reality. Also, ex-ante deterrence effects and prices cannot be studied in this experiment because there is no cartel formation stage and no pricing decisions before or after the reporting stage.

IV.B. Deviations, Pre-Emption and the Level of Fines: Reaching the First Best

In Hinloopen and Soetevent's first study, subjects could report only in a simultaneous stage that took place after price choices were made public. Given this setup of the study, it was not possible for a cartel member that decides to abandon the cartel to 'rush to the courtroom' before other cartel members realize they intend to do so. And it was therefore not possible to stop colluding and self-report before an opponent realizes that one of the cartel members wants to stop colluding and self-report. Yet this is a crucial feature of real world leniency policies, both according to practitioners (e.g. Hammond 2004a, 2004b and 2008) and according to theory: the 'protection from fines' effect (Spagnolo 2005a) and the 'race to the courtroom effect' (Harrington 2008) are severely limited by the impossibility of deviating from the cartel's price and reporting before the opponent realizes that deviation took place. Moreover, most leniency policies require the cessation of collusive conduct when applying for leniency, while the leniency application is kept secret (unless another firm applies) for quite some time so as to allow the competition authority to prepare for dawn raids and other actions. This means that leniency policies *require* secret deviation when secretly applying for leniency — something Hinloopen and Soetevent excluded. Finally, the fact that applications for leniency can only be submitted after the prices set by all competitors become public information makes the possibility of using leniency to punish price deviations particularly salient. As some have theorized, this may unduly enhance cartel stability (see Spagnolo 2005a and Buccirossi and Spagnolo 2006).
To overcome these problems, which make it difficult to relate Hinloopen and Soetevent's results to real world leniency policies, Bigoni et al. (2012) developed a dynamic experimental setting in which parties could apply for leniency, either before or after the price choices were observed by all players, in each stage game. This timing allowed a subject that wants to leave the cartel to both stop colluding on prices and apply for leniency confidentially before the other cartel members realize, as is possible in reality. This timing captured the 'race to the courtroom' and 'protection from punishment' effects (if you deviate on the price, you can apply for leniency at the same time so your competitors cannot punish your deviation by applying for leniency after they observe it). It also made it possible to disentangle and quantify reports linked to defections and reports linked to punishments. The setup also adopted a re-matching methodology developed in the literature on experimental repeated games that allows subjects to face a constant discount factor and, most crucially, to play several supergames and learn.[26] It simplified the framework by using fixed fines so as to be able to control subjects' expectations on their level and how these change across treatments. The impact of these expectations on the effectiveness of leniency policies could therefore be studied.[27] Bigoni et al. also used a differentiated price game to avoid the non-generic and unrealistic discontinuities of the homogeneous-good Bertrand game (where a deviation implies zero profits — and in previous

[25] We recognize that self-reporting increases cartel convictions, which is particularly advantageous in the case of a limited number of investigating officers. However, the ultimate focus of competition authorities should be improving welfare by increasing cartel deterrence and lowering prices.
[26] See e.g. Dal Bó (2005), Blonski, Ockenfels and Spagnolo (2011), Dal Bó and Fréchette (2011) and Bigoni et al. (2014).
[27] When fines are set as a share of the profits realized in a previous period, as in Hinloopen and Soetevent (2008b), it is hard for subjects to predict what the fine will be and for the experimenter to control for what subjects' expectations are, because cartels are often detected and fined after they have stopped sustaining high prices. The fine is often therefore a fraction of competitive, rather than collusive, profits. This feature makes it impossible to control for the level of fines and study how this interacts with the leniency policy.

experiments zero fines — for all other firms), and a duopoly to minimize the risk highlighted by Holt (1995) that, with more than two subjects, punishment of deviators — which is crucial in studies of collusion — is biased or softened by the concern that the other, innocent subject will also be harmed by the punishment.

Bigoni et al. (2012) used this setup to study how standard antitrust enforcement (without leniency), leniency policies and monetary rewards for the first reporting party affect cartel formation and prices. They found that antitrust enforcement without leniency reduces cartel formation but increases cartel prices: subjects use costly fines as punishment against deviators. Leniency improves antitrust enforcement by strengthening deterrence, as fewer cartels are formed and existing cartels that are detected through leniency do not form again (leniency eliminates recidivism[28]). However, leniency policies also stabilize surviving cartels: subjects appear to anticipate the lower post-conviction prices and lack of recidivism after self-reports or leniency. Therefore, overall average prices do not fall significantly. Conversely, with rewards, prices rapidly fall to the competitive level. Overall, the results suggest a strong cartel deterrence potential for well-run leniency policies, where firms self-report before an investigation is opened. The results also suggest rewards should be introduced to obtain substantial welfare gains in terms of lower prices.

In a subsequent study, Bigoni et al. (2014) used this same setup to study the effect of separately changing the level of the fines and the probability of exogenous detection on cartel deterrence, with and without leniency. For occasional crimes committed by single and risk-neutral subjects, changing the mix between fines and exogenous probability of detection, keeping the expected fine constant, should not affect deterrence. The paper developed a model showing that in a dynamic multi-agent setup, this equivalence is lost and fines are much more important with leniency. The experiment confirmed the theoretical finding. Without leniency, the probability of exogenous detection and fines both have similar effects for deterrence. With leniency policies in place, the absolute level of the fine is much more important in producing deterrence, while the probability of exogenous detection becomes practically irrelevant. This indicates that deterrence is mainly driven by 'distrust' or strategic risk, that is, by the fear of partners deviating and reporting. This study even found a large deterrence effect of fines in the presence of a leniency policy when the probability of exogenous detection is zero. As theorized by Spagnolo (2004), this implies that the 'distrust' deterrence channel is powerful and that the first-best (full deterrence with zero deadweight/ inspection costs) could now be achieved at finite levels of fines. It also implies that recently voiced concerns that the large number of leniency applications may be reducing antitrust effectiveness by exhausting the resources of competition authorities, making it impossible for them to undertake random industry audits, may be misplaced (see Abrantes-Metz 2013). On the contrary, these findings suggest that the efficiency of competition law enforcement can be considerably improved by strengthening sanctions and the management of the leniency policy while reducing the expenditure of competition authorities' resources on random inspections.

Of course, it is important to ensure that these results are robust before translating them into policy prescriptions. Positive news in this respect are found in a recent experiment by Chowdhury and Wandschneider (2015). This study also considered the effect of changing the mix between fines and the exogenous detection probability in the absence and presence of a leniency policy, as studied by Bigoni et al. (2015), although it did not consider the case of zero probability of detection. However, it did so in an environment similar to the one in Hinloopen and Soetevent's (2008b), where matching was fixed and cartels could only be reported after price choices were made public, so that — as in Hinloopen and Soetevent's work — the 'protection from punishment' and 'race to the courtroom' effects could hardly be active. Bigoni et al.'s finding was confirmed by this experiment: increasing the absolute fine and reducing the probability of exogenous detection (absent self-reporting) increased the deterrent effect of leniency policies in this environment also. The conclusion that the efficiency of competition law enforcement can be improved by strengthening sanctions and the management of

[28] Against Hinloopen and Soetevent (2008b).

the leniency policy while reducing competition authorities' efforts in conducting random inspections of industries seems rather robust.
Additional support to Spagnolo's (2004) and Bigoni et al. (2015)'s "strategic risk/distrust" deterrence channel is found in Kindsgrab (2015), where an experiment that extends Bigoni et al. (2015) is run with the purpose to examine how changes in the expected fines and reporting costs affect that type of deterrence. The author finds that suboptimal leniency policies increase deterrence more than a fine policy (without leniency) with an equivalent expected fine, and that this result is exclusively driven by this novel distrust channel.

IV.C. Additional issues
(i) Ringleaders

One debated issue is whether ringleaders should be excluded from leniency policies (as in the US) or included (as in the EU). On the one hand, excluding ringleaders from the leniency policy may increase deterrence by introducing 'free riding' on who should lead. Excluding ringleaders may discourage firms from taking the lead and induce them to wait for others to do so, thereby delaying and reducing cartel formation. On the other hand, this policy may reduce deterrence by creating one firm that can be trusted by the others as it will never (be able to) 'run to the courtroom' and report them.
Bigoni et al. (2012) undertook a preliminary investigation of this trade-off by introducing treatments where the ringleader, defined as the subject that first asked the others to communicate, could not apply for leniency. This was announced to subjects, who therefore knew that they would lose the opportunity to receive leniency if they communicated first. The authors found that in treatments where the initiator of the cartel could not apply for leniency, the deterrence effect of leniency is unaffected, although prices increase. They argued, however, that this was a preliminary result that should be treated with caution, as the experimental setup was not explicitly designed to address this question and was particularly unfavorable to excluding ringleaders. With a duopoly, excluding the ringleader leaves only one party able to report and obtain leniency, which eliminates the fear of others reporting that is, according to Spagnolo (2004), a crucial determinant of deterrence. Bigoni et al. therefore invited more work on the subject. The invitation was taken up by a number of authors.
Hesch (2012) used a simplified version of Hinloopen and Soetevent's (2008b) where reporting could only take place after price choices became public and where liability expired after each period. He introduced a ringleader role, which was assigned randomly by a computer in each period. It was found that, in treatments where the randomly assigned ringleader was not allowed to apply for leniency, cartel formation was more intense and prices were higher. Unfortunately, an exogenous and random assignment of the role of ringleader eliminates, by design, coordination problems in the formation of the cartel, which is where a positive effect of excluding ringleaders could occur. By removing the possibility that coordination issues could be worsened by the exclusion of ringleaders, inducing subjects to delay or avoid taking the lead hoping that others would do it first, the experiment allowed for only the negative effects of the policy. This reduces the validity of the result.
Wandschneider (2014) improved the mechanism to identify the leader. In his setup, the ringleader was the subject whose suggested cartel price during the communication stage had been accepted by the two other group members. As in earlier work (Bigoni et al. 2012), this made the identity of the (at least partial) leader endogenous. A form of 'free riding effect' could then in principle present itself, not in the form of delayed or reduced cartel formation but in the form of lower prices suggested by those who do not want to be the leader, which could possibly induce lower cartel prices.
The study found that more cartels are formed when the leader is not able to obtain leniency. However, it also found that prices do not increase when ringleaders are excluded from the leniency policy, which might be due to the above mentioned free riding effect. An in-depth analysis of behavior in the price proposal stage is needed to verify this conjecture. Finally, it found that ringleader exclusion destabilizes the collusive agreement, as more firms deviate. This was expected, as this study follows Hinloopen and Soetevent (2008b) in only allowing applications for leniency after price defections are

made public. As we have explained, this ensures that the leniency policy is mainly used to discipline price defections, as it excludes the pro-competitive effects linked to the optimal 'deviate and report' strategies. Since excluding ringleaders allows only the deviator and one more firm to report, the punishment for non-ringleaders that deviate on price is reduced; when they report, they expect half of the fine reduction instead of one third. Before drawing any policy conclusions from these results, it is therefore important to wait for more realistic studies that allow subjects to apply for leniency when deviating on prices and be re-matched to play several supergames and learn.

More recently, Clemens and Rau (2014) studied the ringleader issue in a reduced form participation-revelation game in which ringleaders may or may not emerge. They implemented a cartel formation game where the cartel is established in a multi-stage decision game preceded by a communication stage. If some cartel members chose to open a communication window that is not necessary for the cartel to be formed, these cartel members became the ringleaders. The experimental design did not include any form of market interaction, whether static or dynamic, nor pricing decisions. Subjects that chose to take part in a cartel were then always bound to the joint-profit-maximizing strategy, while outside firms played best-response. They then implemented treatments without leniency, with leniency open to all, and with leniency only open to non-ringleaders. They found that excluding ringleaders from obtaining leniency reduced the number of reports, increased the number of cartels formed, and even increased the number of subjects becoming ringleaders. They concluded that excluding ringleaders from the leniency policy is likely to reduce its effectiveness.

These results (in complement to the empirical work of Davies and De 2013 and the theoretical work on ringleaders mentioned in section II.C) are instructive, as they isolate the effect of ringleader exclusion on reporting, from their interaction with market strategies. However, in terms of evaluating the effectiveness of a leniency policy, they suffer from a similar limitation as the study by Hamaguchi, Kawagoe and Shibata (2009). As previously discussed in relation to that paper, it is difficult to interpret and translate into policy prescriptions the results of an experimental design that does not include any form of market interaction. Clemens and Rau (2014) took the view that not including a market game was 'necessary as defection from the cartel price by a shirking firm might influence the decision to form a cartel as much as the possibility to opt for leniency'. Indeed, we know from the previously described experiments that market behavior and reporting behavior interact in important ways. From a policy point of view, however, we are interested in these interactions, as it is cartel formation and prices that determine changes in welfare, not the number of reports (which in themselves typically lower welfare by increasing prosecution costs). If we exclude market interactions from the design, it becomes difficult to understand if and how the measured reporting behavior would change in the presence of market interactions, and how market outcomes and welfare are likely to be affected by leniency.

To conclude, taken together, these available experimental results suggest that ringleaders should be allowed to apply for and obtain leniency. However, given the caveats in all these studies, further research appears necessary to investigate the robustness of this conclusion.

(ii) Leniency and Auctions

Hamaguchi et al. (2007) studied collusion in a repeated procurement auction game and the effectiveness of leniency policies in that environment. They considered cartel creation at first-price sealed-bid auctions and allowed for unrestricted communication before bidding. The experiment allowed for five competitors and the formation of partial cartels. In addition, the competition authority could detect individual cartel members (but not the entire cartel) and the fine imposed was a share of the individual's gross earnings in the last three periods. No communication was allowed before the bid in the 'benchmark' treatment, whereas in 'communication', a three-minute chat where subjects decided whether or not to enter the chat room preceded the possible bid. In 'antitrust', communication was allowed and there was a 15 per cent probability of detection by a competition authority. In 'communication', virtually all bids were set at the monopoly price, so bidders clearly

colluded and did not cheat on the agreement reached in this phase. Leniency policies turned out to be ineffective in decreasing the number of cartels in the auctions, and the average winning bid did not change. However, there was some evidence that leniency policies may be effective to dissolve pre-existing collusion and decrease the contract price. In 'antitrust', most of the pre-collusive groups bid their reserve price and were then dissolved by defectors before the end of the experiment.

Hinloopen and Onderstal (2013) studied cartel formation and leniency policies at first-price sealed-bid and English auctions. In their experiment, each subject started by choosing between 'yes' or 'no' buttons that indicated their willingness to join a possible cartel. They were then told whether a cartel formed, but not about individual votes. If a cartel was established, a winner was randomly assigned by the computer and was the only subject who could submit a bid. The highest bidder won the object. In subsequent rounds, subjects needed to bid higher than the winning bid, and the rounds ended when no subject bids or when one bids the maximum possible bid. There was no competition authority in 'agreement', but the 'detect and punish' and 'leniency' treatments entailed a 15 per cent chance of detection and prosecution. In the latter, firms could also report the cartel once the auction ended for a small cost, and they did so ignorant of the other player's reporting decision. Hamaguchi et al.'s (2007) result on the ineffectiveness of the leniency policy in first-price sealed-bid auctions was corroborated. Nonetheless, in English auctions, a traditional antitrust policy (with no leniency policy) seems able to deter and destabilize cartels, but it also has the negative effect of reducing the average winning bid (that is, the price). Although the introduction of a leniency policy seems to have had no impact on cartel formation or recidivism, it did have two undesirable effects: it increased cartel stability and reduced the winning cartel bid, in line with the results from Bigoni et al. (2012).

(iii) Leniency after an investigation initiated and avoidance activities

All the experimental work discussed to this point in the chapter does not specify whether or not an investigation of the cartel had been started at the time a leniency application is made. The assumed positive probability of exogenous detection can be interpreted both as the probability of a successful investigation and as the probability that an existing investigation, started with the formation of the cartel, will be successful. The presence of robust deterrence effects in many of these experiments demonstrates that the assumption on which early studies of leniency policies are based — that programs restricted only to spontaneous reports before an investigation is open cannot be effective — is incorrect both logically and empirically. These experiments cannot tell us, however, how opening leniency policies to reports coming after an investigation is opened or announced will affect deterrence and welfare.

This question was the focus of a study by Dijkstra, Haan and Schoonbeek (2014), in which firms could apply for leniency once an antitrust investigation had been announced and could also communicate freely. In the common setting of a repeated and homogeneous Bertrand duopoly, if firms chose to communicate and set prices, an investigation may (or not) be opened. Subjects could apply for leniency once they learned about this, thereby ensuring conviction. Otherwise, conviction occurred with some probability. If convicted, a fixed fine was paid. The experiment showed that individuals are able to fix and keep prices high by agreeing on prices and reporting and by agreeing on future communication strategies. Some evidence of desistance and destabilization effects, due to the leniency policy, was found in the very short-term, but these disappeared over time.

Finally, an interesting recent experiment by Chowdhury and Wandschneider (2013) looked at the effect of leniency policies when firms can invest in costly avoidance activities, an important and under-researched topic in competition law. They augmented the stage game from their earlier work with the possibility, in some treatments, of cartel members undertaking a costly investment that would permanently reduce the (absolute) fine they would face in future periods if convicted. The authors found that avoidance activities increase cartel formation (by risk-averse subjects) and that firms which invest in avoidance charge higher prices. They also found that such firms deviate and self-report more often when a leniency policy exists. This indicates that in the presence of a leniency policy, some firms

use avoidance to reduce their punishment for price deviations. This is what should be expected in a setup similar to that of Hinloopen and Soetevent (2008b), where firms can only self-report after prices (deviations) become known. In such a setup, the leniency policy mostly acts as a punishment device. Understanding how their results would change in a more realistic setup, where firms can also report before their price deviations become common knowledge, appears to be an exciting avenue for further research.

V. Conclusion

There is no doubt about the increasing importance of leniency policies for competition authorities' daily enforcement work. This is clearly reflected in the growing number of firms applying for leniency reductions in exchange for information and cooperation with an ongoing investigation.

Having reviewed the literature on leniency programs, it seems fair to conclude that if these are well designed and well administered programs, they can be a powerful policy instrument to combat illegal cartels and should be present in the toolkit of any competition authority, regardless of their budget.

However, the literature has also pointed out that if these information revelation mechanisms are poorly designed and/or too generously administered, they can have serious counterproductive effects, by providing an easy way for cartelists to escape or reduce fines, and potentially encouraging cartels that would not otherwise form, while merely making it easier for competition authorities to detect and prosecute cartels. In addition, these programs seem to be used by cartel members as punishment strategies (grim-trigger versus "stick and carrot") to sustain collusion.

There are clear signs that the perceived "pros" of leniency are leading the European Commission to overuse leniency, as if it was a form of plea bargaining. This is natural since the number of convicted cartels is used as a performance measure, and may be efficient in some specific (but rare) cases given that plea bargaining is not available and settlements can only award a limited discount on the fine. The fact that leniency reductions have been granted in 52% of all EC cartel fines (1998-2014), and that this percentage, corresponding to an average of 4 leniency recipients per cartel, is on the rise, reveals that this bias is increasing, together with the excessive deadweight loss for society.

Evaluating how these policies are implemented in reality, and how their design and management could be improved, is therefore crucial. A much stricter implementation of leniency policies, complemented by strengthened sanctions (including damage payments) and possibly a moderate use of more expensive but proactive enforcement tools, such as screens, appears to be the way forward.

A large and growing body of research has studied the impact of leniency programs on cartel stability, most of which agreeing on some of the optimal features of leniency programs. The theoretical literature suggests that these features include: full amnesty and limited liability for the first reporting firm only, limited leniency reductions to subsequent reporters if the authorities don't have sufficient information (or sufficient budget) to guarantee a conviction, enabling the cartel leader to be awarded leniency but increasing the punishment of repeat offenders, transparency and predictability in the setting of leniency reductions, and possibly a reward scheme to (individual) whistleblowers, financed by the fines imposed on all other cartel members. Implementing such policies will avoid that leniency programs are used as a disciplining device to hinder defections, particularly in the context of multi-market contact, or as a strategic device to escape fines and damage the reporter's competitors, which is mostly important when there is a large asymmetry of information between firms and the competition authority (causing them to commit type I and type II errors) or amongst cartel members. Recent theories also suggest that the opening of an investigation may exhibit a knock-on effect on leniency applications across multiple markets; and call for cooperation amongst competition authorities in such a context.

The existing empirical studies provide mixed results. Our conclusion from reviewing the empirical work is that much more empirical work is required. Judging from the very limited empirical evidence

available, it is still not well established whether leniency policies, as currently designed and implemented in different countries, are doing any more than facilitating competition authorities' work. That is, it is unclear whether they are actually increasing welfare by generating a strong deterrence effect, or whether they are actually reducing welfare through the larger administration and prosecution costs they generate, without any compensating increase in deterrence. The most favorable evidence available is for the United States, where sanctions are much tougher, and this is consistent with what theory would predict. But overall, the evidence is in general rather weak.

An increasing number of experimental studies clearly demonstrate that the assumption on which some early economic analyses were based — that leniency policies are only effective if they allow reports from firms under investigation — is not only ad-hoc and unjustified, but also empirically counterfactual. Although this is not to say that, given constraints on sanctions and rewards, it is not optimal to open leniency policies to reports after an investigation. The bulk of experiments also suggests, consistent with the available empirical evidence, that cartel deterrence effects of well-designed and well-administered leniency policies tend to be positive — whether or not the policy is open to reports after an investigation opened — but rather modest unless sanctions for non-applicants are severe or monetary rewards are introduced. Most recent experiments suggest that severe sanctions are the crucial precondition for the effectiveness of a leniency policy, allowing it to produce substantial cartel deterrence effects even when the probability of a cartel being detected without reports is zero.

Experiments also show that subjects quickly understand how to play these schemes, if they can be played, so that poorly designed and loosely administered real world leniency policies are likely to reduce social welfare considerably.

Some experiments tend to have rather loose connections with both the theory and the practice of leniency policies, making it hard to use their results as guidance for policy-making. Future experimental work should pay more attention to both theory and reality. Several open questions are waiting for more careful examination, starting with the introduction of fines or damage payments which are a function of accumulated cartel profits.

The lack of stronger evidence — whether in favor or against the hypothesis that leniency policies are increasing cartel deterrence and with it social welfare — is undoubtedly linked to the difficulty of identifying how the total population of cartels changes when leniency policies are introduced or modified. But it is also clearly linked to an endemic lack of data. The development of meaningful research on leniency would be facilitated if competition authorities or agencies in charge of supervising them start to implement more consistent data collection and data disclosure policies.

References

1) Abrantes-Metz, Rosa, (2013), “Proactive vs Reactive Anti-Cartel Policy: The Role of Empirical Screens”, Working paper, available at SSRN.
2) Angelucci, Charles and Martijn Han, (2011), “Private and Public Control of Management”, Amsterdam Center for Law & Economics Working Paper No.2010-14.
3) Apesteguia, Jose, Martin Dufwenberg and Reinhard Selten, (2007), “Blowing the Whistle”, Economic Theory 31, 143-166.
4) Arlman, Sjoerd, (2005), “Crime but No Punishment: An Empirical Study of the EU’s 1996 Leniency Notice and Cartel Fines in Article 81 Proceedings”, MSc thesis, University of Amsterdam.
5) Asker, John, (2010), “Leniency and Post-Cartel Market Conduct: Preliminary Evidence from Parcel Tanker Shipping”, International Journal of Industrial Organization 28, 407-414.
6) Aubert, Cecile; William Kovacic and Patrick Rey, (2006), "The Impact of Leniency Programs on Cartels", International Journal of Industrial Organization 24(6), 1241-1266.
7) Becker, Gary, (1968), "Crime and Punishment: An Economic Approach", Journal of Political Economy 76(2), 169-217.
8) Bigoni, Maria, Marco Casari, Andrzej Skrzypacz, and Giancarlo Spagnolo, (2015), “Time Horizon and Cooperation in Continuous Time”, Econometrica 83(2), 587-616.
9) Bigoni, Maria, Sven-Olof Fridolfsson, Chloé Le Coq and Giancarlo Spagnolo, (2012), “Fines, Leniency, and Rewards in Antitrust”, RAND Journal of Economics 43(2), 368-390.
10) Bigoni, Maria, Sven-Olof Fridolfsson, Chloé Le Coq and Giancarlo Spagnolo, (2015), “Trust, Leniency and Deterrence”, Journal of Law, Economics and Organization 31(4), 663-689.
11) Blatter, Marc, Winand Emond and Silvio Sticher, (2014), “Optimal leniency programs when firms have cumulative and asymmetric evidence”, Discussion Paper University of Bern
12) Blonski, Matthias, Peter Ockenfels and Giancarlo Spagnolo, (2011), “Equilibrium Selection in the Repeated Prisoner’s Dilemma: Axiomatic Approach and Experimental Evidence”, American Economic Journal: Microeconomics 3(3), 164-92.
13) Bloom, Margaret, (2007), “Despite Its Great Success, the EC Leniency Programme Faces Great Challenges” in C-D Ehlermann and I Atanasiu (eds.), European Competition Law Annual 2006: Enforcement of Prohibition of Cartels, Oxford, Hart Publishing.
14) Bos, Iwan, Stephen Davies, Joseph Harrington and Peter Ormosi, (2016), “Does enforcement deter cartels? A tale of two tails”, CCP Working Paper 14-6 v2.
15) Bos, Iwan and Frederick Wandschneider, (2012), “Cartel Ringleaders and the Corporate Leniency Program”, CCP Working Paper 11-13.
16) Bos, Iwan and Joseph Harrington, (2010), “Endogenous cartel formation with heterogeneous firms”, The RAND Journal of Economics, 41(1), 92-117.
17) Brenner, Steffen, (2009), “An Empirical Study of the European Corporate Leniency Program”, International Journal of Industrial Organization 27, 639-645.
18) Brenner, Steffen, (2011), “Self-disclosure at international cartels”, Journal of International Business Studies 42(2), 221-234.
19) Brisset, Karine, and Lionel Thomas, (2004), "Leniency program: A new Tool in Competition Policy to deter Cartel Activity in Procurement Auctions", European Journal of Law and Economics, 17(1), 5-19.
20) Buccirossi, Paolo, and Giancarlo Spagnolo, (2001), "Leniency Programs and Illegal Exchange: How (Not) to Fight Corruption", Working Papers in Economics and Finance No. 451, 20 Stockholm School of Economics, part of it in the Journal of Public Economics (2006), 90(6-7), 1067-1105.
21) Buccirossi, Paolo, and Giancarlo Spagnolo, (2006), “Leniency programs and illegal transactions”, Journal of Public Economics 90 (6-7), 1281-1297.
22) Buccirossi, Paolo, Catarina Marvão and Giancarlo Spagnolo, (2015), “Leniency and Damages”, CEPR Discussion Paper DP 10682.

23) Carree, Martin, Andrea Günster and Maarten Pieter Schinkel, (2010), “European Antitrust Policy 1957—2004: An Analysis of Commission Decisions”, Review of Industrial Organization 36(2), 97-131.
24) Chen, Zhijun and Patrick Rey, (2013), “On the Design of Leniency Programs”, The Journal of Law and Economics, 56(4), 917-957.
25) Chen, Zhijun, (2008), “Cartel Organization and Antitrust Enforcement”, CCP Working Paper 08-21
26) Chen, Zhiqi, Subhadip Ghosh and Thomas Ross, (2015), “Denying Leniency to Cartel Instigators: Costs and Benefits, International Journal of Industrial Organization” 41, 19-29.
27) Choi, Jay Pil, and Heiko Gerlach, (2012), “Global Cartels, Leniency Programs and International Antitrust Cooperation”, International Journal of Industrial Organization 30(6), 528–540.
28) Chowdhury, Subhasish and Frederik Wandschneider, (2013), “Anti-Trust and the ‘Beckerian Proposition’: The Effects of Investigation and Fines on Cartels”, CCP Working Paper 13-9.
29) Clemens, Georg and Holger Rau, (2014), “Do Leniency Policies Facilitate Collusion? Experimental Evidence”, DICE Discussion Papers No.130
30) Cloutier, Mike, (2011), “An empirical investigation of the U.S. corporate leniency programme”, Working Paper Queens University.
31) Combe, Emmanuel and Constance Monnier, (2009), “Fines against Hard Core Cartels in Europe: The Myth of Overenforcement”, Antitrust Bulletin 56(2), 235-.
32) Connor, John and Douglas Miller, (2013), “Determinants of U.S. Antitrust Fines of Corporate Participants of Global Cartels”, Working paper, available at SSRN.
33) Connor, John, (2007), “Global Antitrust Prosecutions of International Cartels: Focus on Asia”, World Competition, 31(4), 575-605.
34) Connor, John, (2010), “Recidivism Revealed: Private International Cartels 1991-2009”, Competition Policy International 101 (Autumn 2010).
35) Connor, John, (2013), “Cartel Fine Severity and the European Commission: 2007-2011”, European Competition Law Review 34, 58-77.
36) Cooter, Robert and Ulen, Thomas, (1988), “Law and Economics”. Glenview, IL: Scott, Foresman & Co.
37) Dal Bó, Pedro and Guillaume Fréchette, (2011), “The Evolution of Cooperation in Infinitely Repeated Games: Experimental Evidence”, American Economic Review 101(1), 411-429.
38) Dal Bó, Pedro, (2005), “Cooperation under the Shadow of the Future: Experimental Evidence from Infinitely Repeated Games”, American Economic Review 95(5), 1591-1604.
39) Dargaud, Emilie and Armel Jacques, (2016), “Endogenous firms’ organization, internal audit and leniency programs”, Working Paper, presented at EARIE Conference 2016.
40) Davies, Stephen and Oindrilla De, (2013), “Ringleaders in Larger Number Asymmetric Cartels”, Economic Journal 123(572), F524-544.
41) Davies, Stephen, Peter Ormosi and Martin Graffenberger, (2014), “Mergers after cartels: How markets react to cartel breakdown”, Working paper, available at SSRN.
42) De, Oindrilla, (2010), “Analysis of Cartel Duration: Evidence from EC Prosecuted Cartels”, International Journal of the Economics of Business 17(1), 33-65.
43) Dijkstra, Peter, Marco Haan and Lambert Schoonbeek, (2014), “Leniency Programs and the Design of Antitrust: Experimental Evidence with Rich Communication”, Working paper, available at SSRN.
44) Dominte, Oana, Daniela Şerban and Alina Dima, (2013), “Cartels in EU: Study on the Effectiveness of Leniency Policy”, Management & Marketing 8(3), 529-552.
45) Dong, Ailin, Massimo Massa and Alminas Zaldokas, (2014), “Busted! Now What? Effects of Cartel Enforcement on Firm Policies”, INSEAD Working Paper 2014/38/FIN.
46) Ellis, Christopher and Wesley Wilson, (2003), "Cartels, Price-Fixing, and Corporate Leniency Policy: What Doesn't Kill Us Makes Us Stronger", mimeo.
47) Feess, Eberhard and Markus Walzl, (2004), “Self-reporting in Optimal Law Enforcement when there are Criminal Teams", Economica 71(283), 333-348.

48) Feess, Eberhard and Markus Walzl, (2010), “Evidence Dependence of Fine Reductions in Corporate Leniency Programs”, Journal of Institutional and Theoretical Economics 166(4), 573-590.
49) Gärtner, Dennis and Jun Zhou, (2012), “Delays in Leniency Application: Is There Really a Race to the Enforcer’s Door?” GESY Discussion Paper No 395.
50) Gärtner, Dennis, (2013), “Corporate Leniency in a Dynamic World: The Preemptive Push of an Uncertain Future”, Working Paper, available at SSRN.
51) Gerlach, Heiko, (2013), “Self-reporting, investigation and evidentiary standards”, Journal of Law and Economics 56(4), 1061-1090.
52) Grossman, Gene and Michael Katz, (1983) "Plea Bargaining and Social Welfare", American Economic Review, 73, 749-57.
53) Hamaguchi, Yasuyo, Toshiji Kawagoe and Aiko Shibata, (2009), “Group Size Effects on Cartel Formation and the Enforcement Power of Leniency Programs”, International Journal of Industrial Organization 27(2), 145-165.
54) Hamaguchi, Yasuyo, Toshiko Ishikawa, Masayuki Ishimoto, Yuji Kimura and Tadanobu Tanno, (2007), “An Experimental Study of Procurement Auctions with Leniency Programs”, CPRC Discussion Paper Series CPDP-24-E January 2007.
55) Hammond, Scott, (2004a), “Detecting and Deterring Cartel Activity through an Effective Leniency Program”, presented at the International Workshop on Cartels, Brighton, 21–22 November 2000.
56) Hammond, Scott, (2004b). “Cornerstones of an effective Leniency Program”, presented at the ICN Workshop on Leniency Programmes, Sydney, 22-32 November 2004.
57) Hammond, Scott, (2008), “Cornerstones of an Effective Cartel Leniency Programme”, Competition Law International 4(2).
58) Harrington, Joseph and Joe Chen, (2006), “Cartel Pricing Dynamics with Cost Variability and Endogenous Buyer Detection, International Journal of Industrial Organization, 24(6), 1185-1212.
59) Harrington, Joseph and Myong-Hun Chang, (2009) “Modelling the Birth and Death of Cartels with an Application to Evaluating Antitrust Policy”, Journal of the European Economic Association, 7, 1400-1435.
60) Harrington, Joseph and Myong-Hun Chang, (2013), “Endogenous Antitrust Enforcement in the Presence of a Corporate Leniency Program”, Cleveland State University Working Paper 26/2012.
61) Harrington, Joseph and Myong-Hun Chang, 2015, When Should We Expect a Corporate Leniency Program to Result in Fewer Cartels?, The Journal of Law and Economics, 58(2), 417-449.
62) Harrington, Joseph, (2008), "Optimal Corporate Leniency Programs", The Journal of Industrial Economics, 56(2), 215-246
63) Harrington, Joseph, (2008), “Optimal Corporate Leniency Programs” Journal of Industrial Economics 56(2), 215-246.
64) Harrington, Joseph, (2013), “Corporate Leniency Programs when Firms have Private Information: The Push of Prosecution and the Pull of Pre-emption”, The Journal of Industrial Economics 61(1), 1–27.
65) Harsanyi, John, and Reinhard Selten, (1998), "A General Theory of Equilibrium Selection in Games" Cambridge MA: MIT Press.
66) Herre, Jesko, Wanda Mimra and Alexander Rasch, (2012), “Excluding Ringleaders from Leniency Programs”, Working Paper, available at SSRN.
67) Hesch, Michael, (2012), “The Effects of Ringleader Discrimination on Cartel Stability and Deterrence – Experimental Insights”, Journal of Advanced Research in Law and Economics 3(1), 26-39.
68) Hinloopen, Jeroen and Adriaan Soetevent, (2008a), “From Overt to Tacit Collusion: Experimental Evidence on the Adverse Effects of Corporate Leniency Programs”, Tinbergen Institute Discussion Paper TI 2008-059/1.
69) Hinloopen, Jeroen and Sander Onderstal, (2013), “Going Once, Going Twice, Reported!”, Tinbergen Institute Discussion Paper TI 2009-085/1.

70) Hinloopen, Jeroen and Soetevent, Adriaan (2008b), “Laboratory Evidence on the effectiveness of corporate leniency programs”, RAND Journal of Economics, 39(2), 607-616.
71) Hinloopen, Jeroen, (2003), "An Economic Analysis of Leniency Programs in antitrust Law", De Economist 151, N. 4
72) Hoang, Cung, Kai Huschelrath, Ulrich Laitenberger and Florian Smuda, (2014), “Determinants of self-reporting under the European corporate leniency program”, International Review of Law and Economics, 40, 15-23.
73) Holt, Charles, (1995), “Industrial Organization: A Survey of Laboratory Research” in JH Kagel and AE Roth (eds.), The Handbook of Experimental Economics (Princeton, Princeton University Press, 1995).
74) Houba, Harold, Evgenia Motchenkova and Quan Wen, (2011), “Antitrust enforcement and marginal deterrence”, Tinbergen Institute Discussion Paper 11/166/I.
75) Houba, Harold, Evgenia Motchenkova and Quan Wen, (2015), “The effects of leniency on cartel pricing”, The B.E. Journal of Theoretical Economics, 15(2), 351-389.
76) Innes, Robert, (1999), "Self-Policing and Optimal Law Enforcement When Violator Remediation is Valuable", Journal of Political Economy 107(6), 1305-1325.
77) Kaplow, Louis, and Steven Shavell, (1994), "Optimal Law Enforcement with Self-Reporting of Behavior", Journal of Political Economy 102(3), 583-606.
78) Kindsgrab, Paul, (2015), “Deterrence and suboptimal Leniency: An experiment”, BSc. Thesis, University of Mannheim.
79) Klein, Gordon, (2011), “Cartel Destabilization and Leniency Programs – Empirical Evidence”, ZEW Discussion Paper No 10-107.
80) Kobayashi, Bruce, (1992), "Deterrence with Multiple Defendants: An Explanation for "Unfair" Plea Bargains”, RAND Journal of Economics 23(4), 507-517.
81) Koffman, Fred, and Jacques Lawarée, (1996), "A Prisoner's Dilemma Model of Collusion Deterrence", Journal of Public Economics 59(1), 117-136.
82) Lefouili, Yassine, and Catherine Roux, (2012), “Leniency programs for multimarket firms: the effect of amnesty plus on cartel formation”, International Journal of Industrial Organization 30(6), 624–640.
83) Lewis, David, (2006) Lewis, D. 2006. Speech of David Lewis, Chairperson of the Competition Tribunal of South Africa on Competition and Development, 2 May 2006, Cape Town, South Africa. www.internationalcompetitionnework.org/media/library, cited 11 Feb. 2008.
84) Malik, Arun, (1993), "Self-Reporting and the Design of Policies for Regulating Stochastic Pollution", Journal of Environmental Economics and Management, 24(3), 241-257.
85) Marvão, Catarina, (2014), “Heterogeneous Penalties and Private Information”, Konkurrensverket Series in Law and Economics Working Paper 2014:1.
86) Marvão, Catarina, (2015), “The EU Leniency Programme and Recidivism”, Review of Industrial Organization 48(1), 1-27.
87) Marvão, Catarina and Giancarlo Spagnolo, (2016), “Should Price Fixers finally go to Prison? - Criminalization, leniency inflation and whistleblower rewards in the EU”, Working Paper
88) Marvão, Catarina and Giancarlo Spagnolo, (in progress), “Deterrence effects of leniency programs: another tale of tails”.
89) Marx, Leslie and Jun Zhou, (2014), “The dynamics of mergers among (ex)co-conspirators in the shadow of cartel enforcement”, TILEC Discussion Paper No. 2014-013.
90) Marx, Leslie, Claudio Mezzetti and Robert Marshall, (2015), “Antitrust leniency with multiproduct colluders”, American Economic Journal: Microeconomics, 7(3), 205-240.
91) Miller, Nathan, (2009), “Strategic Leniency and Cartel Enforcement”, American Economic Review, 99(3), 750-768.
92) Motchenkova, Evgenia and Daniel Leliefeld (2010), “Adverse effects of corporate leniency programs in view of industry asymmetry”, Journal of Applied Economic Sciences, 5(2), 114–128.

93) Motchenkova, Evgenia and Tesfay Ghebrihiwet, (2010), “Leniency Programs in the presence of judicial errors”, TILEC Discussion Paper No. 2010-030.
94) Motchenkova, Evgenia, and Rob van der Laan, (2011), “Strictness of leniency programs and asymmetric punishment effect”, International Review of Economics, 58(4), 401-431.
95) Motta, Massimo, and Michele Polo, (2003), "Leniency Programs and Cartel Prosecution", International Journal of Industrial Organization, 21(3), 347-379.
96) Pavlova, Natalia and Andrey Shastitko, (2014), “Effects of hostility tradition in antitrust: leniency programs and cooperation agreements", Basic Research Program Working Paper Series BRP 58/EC/2014
97) Pinna, Andrea, (2010), “Optimal leniency programs in antitrust”, Universita di Cagliari and Universita di Sassari, CRENoS Working Paper 2010/18.
98) Posner, Richard, (1976), “Antitrust Law: An Economic Perspective”, University of Chicago Press, Chicago.
99) Reinganum, Jennifer, (1988), "Plea Bargaining and Prosecutorial Discretion", The American Economic Review, 78(4), 713-728.
100) Rey, Patrick, (2003), "Towards a Theory of Competition Policy", Ch. 3 of Advances in Economics and Econometrics: Theory and Applications, Eight World Congress, M. Dewatripont, L.P. Hansen S.J. Turnovsky (eds.), Cambridge University Press.
101) Sauvagnat, Julien, (2014), “Are leniency programs too generous?”, Economics Letters 123(3), 323-326.
102) Sauvagnat, Julien, (2015), “Prosecution and Leniency Programs: The Role of Bluffing in Opening Investigations”, The Journal of Industrial Economics, 63(2), 313-338.
103) Shastitko, Andrey and Sveltana Avdasheva, (2011), “Introduction of Leniency Programs for Cartel Participants: The Russian Case”, Antitrust Chronicle, 8, number 2.
104) Silbye, Frederik, (2010), “Asymmetric Evidence and Optimal Leniency Programs”, PhD Thesis, University of Copenhagen, Copenhagen, 41–61.
105) Spagnolo, Giancarlo, (2000a), "Optimal Leniency Programs", F.E.E.M. Nota di Lavoro No. 42.00, Fondazione ENI "Enrico Mattei", Milano.
106) Spagnolo, Giancarlo, (2000b), "How the law solves Bertrand’s Paradox and enforces collusion in auctions”. Revised version of F.E.E.M. Nota di Lavoro No. 52.00, Fondazione ENI "Enrico Mattei", Milano.
107) Spagnolo, Giancarlo, (2004), “Divide et Impera: Optimal Leniency Programs”, CEPR Discussion Paper No. 4840.
108) Spagnolo, Giancarlo, (2005), “Cartels Criminalization and their Internal Organization", in M. Schinkel et al. (Eds.), Remedies and Sanctions in Competition Policy: Economic and Legal Implications of the Tendency to Criminalize antitrust Enforcement in the EU Member States, London: Edwar Elgar.
109) Spagnolo, Giancarlo, (2008), “Leniency and whistleblowers in Antitrust”, in P.Buccirossi (ed.), Handbook of Antitrust Economics, MIT Press, Cambridge.
110) Stigler, George, (1964), “A theory of oligopoly”, The Journal of Political Economy, 72, 44-61.
111) Uytsel, Steven, (2015), “Anti-Cartel Enforcement in Japan: Does Leniency Make the Difference?” in C Beaton-Wells & C Tan (eds.) Anti-Cartel Enforcement in a Contemporary Age: Leniency Religion, Hart Publishing.
112) Veljanovski, Cento, (2010), “European Commission Cartel Prosecutions and Fines, 1998-2006: An Updated Statistical Analysis of Fines under the 1998 Penalty Guidelines”, Working Paper Case Associates.
113) Wandschneider, Frederik, (2014), “An Experimental Study of Ringleader Exclusion from Leniency Programmes”, Ph.D. thesis, University of East Anglia, Ch. 3.
114) Werden, Gregory, Scott Hammond and Belinda Barnett, (2011), “Recidivism Eliminated: Cartel Enforcement in the United States Since 1999”, presented at Georgetown Global Antitrust Enforcement Symposium, Washington DC, 22 September 2011.

115) Wils, Wouter, (2016), “The use of Leniency in EU Cartel enforcement: An assessment after twenty years”, World Competition, vol.39, issue 3.
116) Yeremin, Dmitry, Anton Subbot and Marat Mouradov, (2011), “Russia” in SJ Mobley and R Denton (eds.), Global Cartels Handbook: Leniency: Policy and Procedure, Oxford University Press, 2011.
117) Yusupova, Gyuzel, (2013), “Leniency Program and Cartel Deterrence in Russia: Effects Assessment”, Higher School of Economics Research Program No. WP BRP 06/PA/2012.
118) Zhou, Jun, (2013) “Evaluating Leniency with Missing Information on Undetected Cartels: Exploring Time-Varying Policy Impacts on Cartel Duration”, TILEC Discussion Paper 2011-042
119) Zhou, Jun, (2016), “The Dynamics of Leniency Application and Cartel Enforcement Spillovers”, TILEC Discussion Paper 2016-006.