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The impact of the 2002 reform of the EU leniency program on cartel outcomes*

Annabelle Jochem[†] Pierpaolo Parrotta[‡] Giacomo Valletta[§]

Abstract

The objective of this study is to empirically assess whether the 2002 reform of the EU leniency program, which brought the EU leniency policy much closer to the US policy, has increased the European Commission's capability to destabilize cartels while making prosecution more efficient. More specifically, relying on a difference-in-difference approach, we estimate the impact of the 2002 reform on cartel duration, fines before and after applying leniency reductions and duration of investigation. We find that the 2002 reform decreased cartel duration by about 87 percent, but did not significantly affect the other outcome variables. Thus, our findings seem to suggest that the 2002 reform has improved the cartel-destabilizing effect of the EU leniency program, without enhancing however its effectiveness in prosecuting cartels.

JEL Classification: C21, D43, K21, L41.

Keywords: Leniency policy, cartels, detection, deterrence, prosecution.

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1 Introduction

Cartels are among the most welfare-reducing practices that firms may engage in (Motta, [36]). Antitrust authorities (AA hereafter) actively fight such practices by implementing policies aimed at deterring their formation while detecting and prosecuting their activities. Historically, horizontal infringements have been a conspicuous part of the focus of the antitrust activity at EU level¹ and Leniency Programs (LP hereafter), which provide immunity and/or fine reductions to cartel members who decide to collaborate with the AA, have been widely adopted to fight cartels by many OECD countries (OECD, [39]).

Even if in law enforcement LPs share some similarities with plea bargain (lenient treatment in exchange of information), as stressed by Spagnolo [43], they have some specific features that are essential for their effectiveness. First, LPs may act before a wrongdoing has been detected and prosecution has started. Moreover, LPs are general, they apply to anyone who is in a specific situation, and public, they should take the form of codified and predictable policies. The last two aspects are essential to reduce uncertainty and discretionality in fine reductions as they may both inhibit self-reporting.

In this respect, transparency, and not only generosity, is essential for a LP to meet its ultimate objective, that is to help law enforcement in three ways. First, in an *ex-ante* perspective, the introduction of a LP should increase cartel deterrence by increasing the probability that a potential conspirator could self-report the cartel to the AA: the LP should erode the possibility of trusting other potential cartels members. Moreover, a successful LP should enhance *ex-post* the capacity of AAs to uncover existing cartels by making them less stable, by encouraging their members to blow the whistle. Finally, and still in an *ex-post* perspective, a LP should ease prosecution by inducing conspirators to provide information to the AA.

The European Commission (EC hereafter) introduced its first LP in 1996 (EC [20]).

¹Up to 2004 already, more than 75 per cent of all horizontal infringement cases had been cartel cases (Caree et. al. [12])

This first attempt was considered rather ineffective at eliciting self-reports from cartel members (see Brenner [8] and Spagnolo [43]). This was mostly due to the fact that the amount of fine reduction, for self-reporting firms, was uncertain and discretionary. In 2002, the EC introduced a substantial reform of the LP (EC [22]) aiming mainly at making the program more transparent and generous, by decreasing the level of discretion in granting leniency, and increasing the amount of fine reductions for leniency applicants. The reform was welcomed as a clear improvement and many considered it as very successful “in persuading companies to come clean” (Van Barlingen [6]).

Since the introduction of the reform, the share of decisions in which immunity was granted to the first undertaking cooperating with the EC has reached about 90% (Wils [44]). It seems rather clear that, after 18 years, leniency has been playing a prominent role in the EU antitrust enforcement.

Most of the existing empirical literature has focused, in an *ex-ante* perspective, on the LP’s objective of reducing the number of cartels by deterring their formation. Obvious observability issues make this task rather difficult: Miller [38] and Harrington and Chang [29] propose two different methodologies meant to provide observable conditions that, if met, would provide indirect evidence of increased deterrence. Several studies have then tried to assess the impact of the EU (and the American) LP, in this context, with mixed results.

This paper diverts from the beaten path by relying on a more *direct* approach that specifically focuses on the 2002 reform and on its effect on existing cartels. We start from the observation that, as suggested by Spagnolo [43], the 2002 reform could be considered as a kind of “natural experiment” as it “took place in discrete steps” and was “not likely to have been fully anticipated by firms and lawyers”. Because of the timing and structure of the reform, we could rely on a quasi-experimental design that has allowed us to assess the effect of the reform on the ex-post objectives of the program. More precisely, we have evaluated whether the reform managed to increase the detection capability of the program, by making existing cartels less stable, while also facilitating prosecution, by making more information available to the AA.

To do so, we rely on difference-in-difference (DID hereafter) approach that allows

us to identify the effect of the 2002 LP reform by comparing, before and after its introduction, our treatment group, self-reported cartels, with our control group, cartels detected (i.e. not self-reported) by the EC.

We have focused on three outcome variables: cartel duration, fines before and after applying for leniency reductions, and duration of investigation. We use cartel duration as a proxy of the stability of a cartel while the two other variables provide an assessment of the prosecution capacity of the AA. Indeed, as in Brenner [8], we use fines (before and after leniency) as a proxy of the amount of information gathered by the AA, and duration of investigation as a proxy of the cost of investigation.

Our results are highly policy relevant as we find that, with the introduction of the reform, the duration of self-reported cartels decreased on average by about 87 percent, compared to cartels detected directly by the EC. Hence the reform seems to have boosted competition and possibly consumer surplus to some extent: the longer a cartel lasts, the higher is the harm to consumers in terms of high prices and to markets in terms of lack of allocative and dynamic efficiency. However, we find that the 2002 reform had no significant effects on both levied fines and duration of investigation. Thus, it emerges that the cartel-destabilizing effect attributable to the 2002 reform is not coupled with evidence supporting an enhancement in the effectiveness of cartel prosecution. In this sense, our findings suggest that the effects of 2002 leniency reform may have not been as extensive as predicted or thought by the EC itself.

In order to carry our investigation, we have built our own data-set by looking at all decisions issued by the EC between 1990 and 2017, in which a fine was imposed. However, the bulk of our empirical analysis focuses specifically on cartels detected over the period 1998-2006. This is due to the fact that in 2006 the EC introduced a further reform of the LP (EC [25]) and this naturally limits the time horizon of our analysis. More specifically, for cases detected or self-reported after 2006, it would not be possible to disentangle the effect of the 2002 reform on our outcome variables, from the effect of the 2006 reform. Nonetheless, we also perform robustness checks by considering a longer time span: from the first introduction of the EU LP in 1996 until 2012. We find that results arising from such a sensitivity analysis are very much in line with our

main findings. In any case, our main objective is to evaluate the 2002 reform (given its specificity), so our analysis should not be interpreted as an overall assessment of the EU LP since its beginnings.

The paper is organized as follows. Sections 2 and 3 describe the theoretical and empirical background, respectively. Section 4 presents the data, describes the empirical model and provides descriptive evidence of the relationship under analysis. Section 5 discusses the empirical findings. Section 6 concludes the paper. The Appendix reports further descriptive and empirical evidence.

2 The main features of the 2002 reform

The revision of the EU LP introduced in 2002 had the explicit objectives to make the program more transparent and more generous. With the reform, potential applicants could expect automatic *full* amnesty if they were the first to provide enough useful information to the AA, before the opening of an investigation. Finally, also ringleaders were included in the program (provided that they had not coerced other firms into participating to the cartel). Table 1 summarizes the main novelty elements brought by the 2002 reform.

[Table 1 about here]

One of the main drawbacks of the 1996 LP was that the level of fine reduction was essentially discretionary. In fact, full fine-reductions had been rarely granted and the level of protection for prospective applicants was not considered to be predictable and reliable (Arp and Swaak [5]). With the reform introduced in 2002, the EC started to grant automatic immunity from fines to the first member of a cartel providing enough information to open an investigation, or to enable the EC to find an infringement of the Art. 101 of the Treaty on the Functioning of the European Union (TFEU hereafter, secs. 8a, 8b, 9 of EC [22]).² Consequently, the revised LP was not only more lenient

²Previously Art. 81 (ex Art. 85) of the Treaty establishing the European Community (TEC).

than its predecessor, but also more transparent, exposing firms to less uncertainty concerning the possibility and the amount of a fine reduction when applying.

A stream of the theoretical literature has specifically focused on the capability of LPs to destabilize existing cartels and deter the formation of new ones (see Motta and Polo [37], Spagnolo [42], Rey [41] and Aubert et al. [2], Harrington [30] among others). Some contributions explicitly point out the necessity of granting (full) leniency (or even a positive reward) only to the first informant. However, they also signal possible negative effects on deterrence related to the reduction in expected terms of fines and to the fact that self-reporting could be used as a credible threat to enforce collusion. Several papers also look at LPs in lab experiments (Hamaguchi et al., [28], Bigoni et al., [7]; Apesteguia et al., [7]; Hinloopen and Soetevent [32]). Some of them seem to agree about the fact that even moderate LPs may have a positive deterrence effect while only more generous LPs seem to have a positive effect on detection. However, the latter ones could also enhance cartel formation.

Under the 1996 LP, if a firm applied for leniency after the AA had already launched an investigation, fine reductions could only amount at most to 75% of the fine. With the reform introduced in 2002, a firm applying after the investigation had started, could still obtain immunity provided that the amount of reported information would allow the EC to find an infringement (secs. 8b, 10 of EC [22]). Granting immunity to firms applying only after the AA has already launched an investigation is consistent with the idea that, under certain conditions, relying on leniency the prosecutor could manage to elicit more effective information, at a lower cost, increasing the probability of conviction (Motta and Polo [37], Chen and Rey [13]).

Consistently with the 1996 LP, the EC stuck to the provision that fine reductions may not only be granted to the first self-reporting firm. Nonetheless, the EC amended this provision by making more transparent the procedure for the partial reductions of fines to subsequent applicants: firms would enjoy a reduction of 30-50%, 20-30% or up to 20% dependent on the order in which they had managed to provide evidence representing significant “added value” to the prosecutor. The idea is that, by incrementally lowering fine reductions for later-reporting companies, the AA might instigate a

“race to the courthouse” among subsequent applicants that could bring evidence more quickly and of a higher value. Extending fine reductions to self-reporting firms beyond the first one, might have ambiguous effects. As noticed by Ellis and Wilson [18], self-reporting firms benefit from the conviction of other cartel members. In this perspective, the advantage of the first self-reporting firm could be eroded by the possibility of other firms to apply for leniency.³

Finally, in contrast with the 1996 LP, the 2002 LP made ringleaders eligible to full immunity, as long as they “did not take steps to coerce other undertakings to participate in the infringement” (sec. 11c, EC [22]). The effects of such a provision are, at least in theory, rather ambiguous. At a first sight, not excluding ringleaders from immunity, could loosen cartel stability, since even the ringleader might have an incentive to rush to apply for leniency (Spagnolo [43]). On the other hand, not excluding the ringleader from immunity also increases its expected payoff from colluding, making the cartel more stable (Bos and Wandschneider [9]).⁴

After the introduction of the 2002 reform there have been further regulatory changes that could also have had an impact on the incentives of cartel members to self-report and on the overall prosecution capacity of the EC.⁵ Our empirical strategy does not allow us (in practice) to include other policy changes occurring between 2002 and 2006,

³This intuition is corroborated by later studies, see for example Motchenkova [35], Spagnolo [42] and Harrington [30]. However, this intuition relies on the assumption that all the cartels members are convicted with certainty after a single firm reports the cartel to the AA. In a framework where extending leniency beyond the first self-reporter does significantly increase the probability of a successful prosecution, Feess and Walzl [27] come to the conclusion that a LP under which fine reductions are only granted to the first firm reporting is suboptimal. For experimental evidence explicitly addressing this see Hamaguchi et al. [28].

⁴Clemens and Rau [15] also provide experimental evidence supporting the idea that that ringleader exclusion from immunity may facilitate collusion.

⁵First, Council Regulation 1/2003 (EC [23], which came into force in May 2004) introduced major changes in the enforcement powers of the Commission, simplified the administrative procedures, and paved the way for a greater role of national competition authorities in antitrust enforcement, possibly impacting the length and the cost of EC’s prosecutions in general. Moreover, the length and the cost of cartel investigation may also have been affected by the creation, in June 2005, of the Cartels directorate within Directorate-General for Competition. Third, still in 2005, a two-stage procedure for antitrust cases was introduced with the objective of giving the Commission the possibility to discriminate cases deserving an in-depth investigation and cases that should be quickly dismissed. Finally, the introduction of the Green paper in December 2005 (EC [24]), meant to encourage damages actions for infringement of antitrust law, may also have altered the benefit from self reporting due to the possibility of future private litigations.

and to disentangle their effects from the impact of the 2002 reform. Nonetheless, we deem these reforms in the framework of cartel regulation to be of a minor importance compared to the 2002 reform.

Finally, the 2002 reform was amended by a further reform of the LP in 2006 (EC [25]). The latter reform introduced minor changes, mostly in line with the previous reform, mainly meant to further clarify (a) the amount of information to provide in order to obtain immunity and, (b) the duty of cooperation of all leniency applicants. Moreover a marker system was introduced, allowing subsequent applicants to secure their place in the queue for fine reduction. Finally, the Commission restricted access to statements made by firms under the LP to ensure that the incentives to self-report would not be offset by higher payments in damage proceedings.

3 Empirical background

A relevant share of the existing empirical literature on LPs has focused their ex-ante capacity of deterring cartels. An important limitation of tackling such an issue is that only detected cartels are observable, which may create a problem of selection bias. In order to overcome this difficulty, Miller [38] has proposed a simple dynamic model that provides observable conditions under which the deterrence capability of a LP can be inferred. In particular, if a LP increases the possibility of uncovering cartels then one should observe a short-term increase in the overall number of detected cartels. Moreover, in the long term, the overall number of detected cartels should decrease, provided that the LP is effective in reducing the rate of cartel formation. Miller tests these conditions to evaluate the effects of the 1993 reform of the US leniency policy. Relying on data from the US DOJ, he found that the overall number of detected cartels increased right after the reform, and then it decreased below the pre-reform level. Both findings are consistent with his theory.

An alternative methodology has been developed by Harrington and Chang [29]. They pointed out that, if a leniency policy has been effective at enhancing deterrence, one should observe an increase in cartel duration right after the introduction of the

policy, followed by a decrease in the long term. The more unstable cartels (i.e. those with a lower expected duration) are those that will more likely collapse after the introduction of an effective LP. In the long term, cartel duration however is likely to decrease in light of enhanced deterrence.

It is worth highlighting that the empirical predictions of these papers are meaningful in a framework where the LP is introduced from scratch and involves the comparison between a situation where antitrust enforcement does not rely on a LP, with a situation where the LP is put in place. In such a perspective, several papers have tried to test Miller's and/or Harrington and Chang's predictions, often with mixed results.

The first attempt is probably due to Brenner [8], who focuses on the effect of the introduction of the 1996 LP in Europe. He considers cartels uncovered between 1990 and 2003, relying on a data-set consisting of 61 cases. He finds that the introduction of the LP was not followed by a significant variation in either average cartel duration or number of detected cartels. The introduction of the LP was however accompanied by a significant increase in the amount of fines and a reduction in investigation duration. Overall, his findings seem to point out that the newly introduced policy did not have a significant impact on antitrust policy in Europe.

De [16] looks at the determination of the life-span of european cartels detected between 1990 and 2008. Relying on a competing risk Cox proportional hazard model, she shows that cartels detected before the introduction of the 1996 LP had a higher survival probability than cartels detected afterward. Levenstein and Suslow [34] also rely on a competitive hazard model and look at a wider set of determinants of cartel duration. They also find some descriptive evidence supporting the fact that an increased level of enforcement is followed by a raise in cartel duration. Finally, Zhou [45] finds evidence supporting the enhanced deterrence of the 2002 European LP that, differently from De [16], is consistent with Harrington and Chang's theory.

To the best of our knowledge, the only contribution relying on a DID approach, as we do in our analysis, to assess the consequences of the introduction of LPs is due to Dong, Massa and Žaldokas [17]. However, they take a very different perspective from ours. Rather than looking at the direct destabilizing effects of LPs, they evaluate their

consequences on the financial performance and the strategic behavior of firms.

4 Data

Our database consists of cases falling under Art. 101 of the TFEU. We have looked initially at all decisions issued by the EC between 01 January 1990 and 31 December 2017, in which a fine was imposed. To construct the database we have only relied on publicly available information: in most of the cases we extracted the relevant information from the non-confidential version of the ‘Commission Decision’ published on the EC’s website. For a number of cases, the relevant information was either complemented or completely extracted from the ‘Summary of the Commission Decision’ and/or press releases (also available from the EC’s website).

Thus, we collected information on 182 cartels fined in 136 EC’s decisions, addressed to 1,314 different legal entities. Based on this database, we constructed a cartel-level data set. Given the lag between the date on which (a) the legal entity applied for immunity/leniency or (b) the EC itself received the first information on the cartel case, and the release of the final decision about the case, our entire data set essentially involves cartels uncovered up to 2012.⁶

Since our main objective is to evaluate the impact of the 2002 reform, the introduction of the 2006 LP reform limits the time span of our main empirical analysis. Indeed, in order to improve the comparability between pre- and post-treatment period, we balance the time windows in the sample period (1998-2006). More precisely, the first information on a cartel may not occur either before 01 January 1998 or later than 08 December 2006, the latter date refers to the official introduction of the 2006 LP reform. Furthermore, we remove observations associated with cartel durations above the 99th percentile and below the 1st percentile, to reduce the potential bias arising from such extreme percentiles. We also disregard settlement decisions from the sample because they do not represent typical cartel decisions, i.e. EC and firms involved in cartels

⁶Table A1 shows the overall number of detected cartels by year over this period, the number of self-reported cartels as well as the number of cartels detected directly by the Commission (i.e., non self-reported), over the period 1983-2012.

agree upon shorter procedures and reduced fines.⁷ Thus, our final data set comprises 60 cartel cases, 26 (17 self-reported and 9 detected by the EC) of them occur under the 1996 LP and 34 (19 self-reported and 15 detected by the EC) under the 2002 LP reform.

We rely on a longer sample period both to build some of our descriptive statistics and to run our robustness checks.

4.1 Description of outcome variables

We consider *cartel duration* as an outcome of cartel behavior that provides indirect evidence about cartel stability: more stable and successful cartels exist longer. Cartels that are better able to overcome changes in the economic environment surrounding them are more likely to survive longer (see Harrington and Chang [29], Levenstein and Suslow [34], Hellwig and Huschelrath [31] among others). A more transparent and generous LP may destabilize cartels by making reporting to the agency more profitable. Indeed, reporting does not only reduce the expected fines (in case of conviction) while also increasing rivals' costs (Ellis and Wilson [18]), but it also increases distrust among cartels members and hence the perceived riskiness of being part of a collusive agreement (Spagnolo[42]).

Cartel duration is determined as the difference between the start date and the end date of a legal entity's involvement in the cartel, according to the EC. In case a legal entity's participation in the cartel was interrupted, a second start and end date is specified. In this case, the cartel duration is determined as the sum of both periods of involvement (i.e., not counting the interruption period).⁸ Cartel duration, at the case level, is determined as a simple mean of the firm-specific duration of cartel participation.

⁷Figure A1 shows the number of detected and settled cartels over the 1996-2012 time period.

⁸Some decisions do not contain exact dates regarding the start and/or end of the cartel involvement or the date the EC first obtained information regarding the cartel. If no day of month is specified, the first of each month is used, unless the case description comprises more precise information (e.g. if it says mid-March, 15 March is used instead of 1 March). If no day and month of the year is given, 1 January is used, unless the case description allows for a more precise assessment of the date (e.g. if it says summer 2003, 1 June is used instead of 1 January).

As in Brenner [8] we use the amount of levied *fin*es, at cartel level, as a proxy of the amount of information revealed to the agency: once one has controlled for other factors determining the level of a fine, a case that can rely on a higher amount of revealed information, and that is better documented, should lead to a higher fine. Clearly, the very existence of a LP does provide a rationale to conspirators to keep incriminating evidence (that may be later used to apply for leniency). Moreover, a more transparent and generous LP may provide incentives to reporting firms to reveal more information, as the evidence needed to obtain leniency is more precisely codified, while also making it more likely for them to reveal “high-cost information” (i.e., information that would be too costly to obtain for the AA, absent a LP) to the AA (Brenner [8]).

Before describing how we compute our fine-related outcome variables, it may be useful first to provide an overview of the methodology for setting fines applied by the EC. The legal basis for fining firms that infringe competition law is Article 103 TFEU (ex. Art. 87 TEC), which is, in turn, the basis for Regulation 17/1962 (EC [19]), replaced by Regulation 1/2003 with identical provisions on fines. Article 15 (2) of Regulation 17/1962 specifies that the EC may impose fines from 1,000 – 1,000,000 units of account, or a sum in excess thereof but not exceeding 10% of the turnover in the preceding business year of each of the firms participating in the infringement, whereby the gravity and the duration of the infringement need to be regarded when fixing the fine.

In 1998 and 2006, the EC issued its guidelines (EC [21] and [26]) on its fining policy to ensure the transparency and impartiality of its decisions. Under both guidelines, a so-called basic amount is determined, which is based on the gravity and the duration of the infringement. Under the 2006 guidelines, the basic amount is directly linked to the relevant value of sales. The basic amount is adjusted if the EC finds aggravating and/or mitigating circumstances or considers it necessary to increase the fine to ensure that the deterrence effect of the fines is sufficiently high. If the adjusted basic amount exceeds the legal maximum of 10% of the worldwide turnover, it is capped at this amount. Any fine reduction granted under the leniency notice (specified as percentages) is applied to the fine after having applied the 10% turnover limit. If the case is settled pursuant to

the settlement notice, the fines are reduced by 10% (applied to the amount of the fine, after deducting fine reductions relating to the leniency notice). Finally, fines may be reduced if they are very likely to undermine the economic viability of the firms involved (so-called inability-to-pay reduction). In some rare cases, extraordinary reductions or increases of fines are applied (at various stages of the process described above).

When choosing the most appropriate fine-related outcome variable, we are constrained by data availability: for confidentiality reasons, not all of the fine components described above are published in the non-confidential versions of the EC's decision. However, in all cases, the final fine (e.g. the fine after applying the 10% turnover limit, including aggravating, mitigating and deterrence factors), the leniency and/or settlement reductions, the inability-to-pay-reductions and the extra increase or decrease are specified and therefore used as outcome variable. Alongside the final fine, also the percentage of leniency reduction is typically specified. Depending on the information available in each case, the leniency reduction in EUR is derived either based on the final fine or based on the fine after applying the 10% turnover limit,⁹ taking into account any relevant fine reductions or fine increases.¹⁰ The fine before leniency is determined by adding the leniency reduction in EUR to the final fine.

Also regarding the final fine and the fine before leniency two alternative measures are used: (a) the fine each legal entity is jointly and severally liable for, *final fine liability*, and (b) the amount hypothetically payable attributable to each legal entity assuming that all firms equally share the amount they are jointly and severally liable for, *final fine cash*. The difference can best be illustrated with a simple example. Consider two legal entities (A and B) are jointly and severally liable for 10 million EUR, of which the legal entity (C) is jointly and severally liable for 3 million EUR. Measure a) contains 10 million EUR for both A and B, whilst it contains 3 million EUR for C. Measure b) contains 4.5 million EUR for both A and B (each is attributed one third of the 3 million EUR A, B and C are jointly and severally liable for and one

⁹In some old cases, fines are specified in ECU, where one ECU = 1 EUR.

¹⁰For 15 cases, relevant information is missing, so that the leniency reduction in EUR cannot be determined. However, only 3 of these cases are part of our period of investigation (1998-2006). We treat these missing values as zeros.

half of the remaining 7 million EUR, A and B are jointly and severally liable for) and 1 million EUR for C (C is attributed one third of the 3 million EUR A, B and C are jointly and severally liable). The final fine and the fine before leniency at case level are determined by summing up the final fines and the fines before leniency levied to each cartel participant. Obviously, we use both measures to hypothetically compare what would had been the amounts of fines in absence of leniency policy schemes. All fines are deflated using the OECD Consumer prices index for Europe (all items), using 2010 as base year.¹¹

Finally, we still follow Brenner [8] in using *duration of investigation* as a proxy of the cost of prosecution. A shorter prosecution does not only impact positively the firms involved and other stakeholders. It is also a signal of the administrative efficiency of the AA (for a given technology and staff). Of course, the length and cost of investigation are also related to the quality and the quantity of information revealed to the AA by self-reporting firms. So, if on the one hand, more and better information may facilitate the task of the AA in establishing the presence of a wrongdoing, on the other hand, more information, specially if of low-quality, may make the processing work of the AA heavier and hence more costly.¹² Moreover, a more efficient LP may increase the number of detected cartels and hence potentially increase the workload of the AA making prosecution more costly because of congestion.

We have considered two alternative measures for the duration of investigation: the difference between the date of the EC's prohibition or settlement decision and (a) the date of the EC's decision to initiate proceedings in the case, *investigation duration DIP*,¹³ or (b) the date the EC obtained the first information regarding the potential cartel, *investigation duration FI*, (e.g. the date of an immunity application or the date of a complaint by customers or competitors that led to the investigation).¹⁴ For

¹¹Available at: <https://data.oecd.org/price/inflation-cpi.htm>.

¹²In a study on the determinants of the duration of investigation of European cartels, Hoang et. al. [33] find that the presence of a chief witness does reduce the duration of investigation while the presence of further collaborators does not have a significant impact on the duration of investigation suggesting that they just brought additional workload to the EC.

¹³If this date is not specified, the date the EC issued its Statement of Objections is used instead (12 cases), as it usually coincides with date of the EC's decision to initiate proceedings in the case.

¹⁴If the date the EC first heard about the infringement is not available, the date the EC initiated

some cases the decision date may vary by addressee or there may be several decision dates. The reason for the former is that some of the investigated firms settled with the EC, whilst others did not, causing the EC to adopt separate decisions for the two groups of firms. The latter arises if the original decision was amended, e.g. if the addressees successfully appealed the original decision. In this case, the data set contains the most recent information regarding cartel duration and fines, but the duration of investigations is still based on the date of the original decision. The duration of investigation at the case level is determined as a simple mean of the firm-specific durations of investigation.¹⁵

4.2 Description of the policy variables

We rely on three policy variables. The first one, *self_reported*, is a dummy variable, taking the value 1 if the cartel was disclosed to the EC by a cartel member under the 1996 or 2002 leniency program and 0 otherwise. The second one, *2002 LP*, is a dummy variable, taking the value 1 if the revised 2002 leniency program was in place when the cartel was detected or self-reported (and 0 otherwise). The third and most relevant variable is the interaction of the dummy variables, $self_reported \times 2002\ LP$, i.e. a dummy variable taking the value 1 if the cartel was reported under the revised 2002 leniency program and 0 otherwise.

4.3 Description of the control variables

We include as controls the following variables. The number of different firms jointly and severally liable for the infringement involved in the cartel, *companies involved* as a measure of cartel scope. The number of countries affected by the cartel were considered as a measure for the geographic scope of the infringement, *national markets*. Often, the EC decisions contain only rather vague information on the geographic scope of the infringement, e.g. “EEA-wide”, “Most of the EEA”, “Northern Europe”. There-

proceedings is used instead (3 cases).

¹⁵See Figure A2 to compare the two measures of investigation duration.

fore, determining the number of countries affected by the infringement involved some discretion. However, when determining the number of countries based on such information such as EEA-wide or EU-wide, it was taken into account that the composition of the EU and the EEA has changed over time. Based on the information provided on the cartel, each cartel is classified to one of the four categories (i) *Export, import or trade restriction*, (ii) *Market sharing agreement*, (iii) *Price agreement* or (iv) *Multiple infringement*. For each category, we defined a separate dummy variable. The industry affected by the cartel according to the “NACE REV2” classification is not available from the EC’s decision, summary of press release but was retrieved from the EC’s webpage relating to each case.¹⁶ For the early cases, the industry is not available from the EC’s website and is derived based on the industry description in the decision instead. Based on the “NACE REV2” industry code, a total of 8 industry dummies are defined.¹⁷ We also include further dummy indicators related to fines. These variables indicate whether *mitigating factors* or *aggregating factors* were considered in the case by the EC, and the *limit of 10% firm’s turnover* was applied for at least one addressee of the cartel.

4.4 Estimation strategy

Our estimation strategy is based on a DID setting, in which each outcome variable Y is regressed linearly (and estimated by OLS) as follows:

$$Y_i = \alpha + \beta self_reported_i + \gamma 2002LP_i + \delta self_reported_i \times 2002LP_i + \omega X_i + \varepsilon_i. \quad (1)$$

All outcome variables are log-transformed in order to both (i) smooth their distribution (i.e. reducing the weight of extreme values) and (ii) facilitate the interpretation of the main estimates, which can be interpreted as semi-elasticities.

The treatment effect is identified by the parameter δ , which is carried by the interac-

¹⁶For example, for case 33708 see: http://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=1_33708.

¹⁷See Table 2.

tion variable *self_reported*×2002LP. The matrix X includes further controls, namely the four types of cartels (i) *Export, import or trade restriction*, (ii) *Market sharing agreement*, (iii) *Price agreement*, or (iv) *Multiple infringement*; the number of cartel partners, *companies involved*, and geographical scope, *national markets*; the industry dummies; different circumstances that may have affected the cartel, *mitigating factors* and *aggregating factors*; and whether the *limit of 10% firm’s turnover* applied to the case. ε is assumed to be an idiosyncratic term, unrelated with the other independent variables.

In our DID specification, we make use of cartels detected directly by the Commission (i.e., non self-reported) as controls for self-reported cartels. The underlying assumption here is that, in absence the policy change (i.e. the 2002 reform of the LP), the unobserved difference between treated (self-reported cartels) and controls (non self-reported ones) is on average constant over time. This is known as parallel trend assumption (Angrist and Pischke [3]; Cameron and Trivedi [11]). Although there is no formal and unique test for this important identifying assumption, a visual inspection of whether treatment and control groups show similar trends prior to the treatment may be useful to provide descriptive evidence supporting such a critical assumption. In the next section, we provide some evidence concerning this assumption.

Treatment and control units may differ in both observed and unobserved characteristics. We do control for a number of observable characteristics that may affect the composition of treated and controls. However, we cannot rule out potential sources of unobserved heterogeneity between our treatment and control group, that may undermine the conditional mean independence assumption of our DID estimator. Specifically, self-selection into treatment of a specific group of cartels may lead to biased estimates because of changes in the composition of treatment and control groups after the 2002 leniency reform. Therefore, unobserved factors, which are not ‘accounted for’ by our covariates, that could for instance be associated with weaker cartels (Bos et al. [10]) or collusive firms with higher likelihood to file leniency applications directly after their deviation (Chowdhury and Wandschneider [14]) could bias our main estimates. Nonetheless, to the best of our knowledge, we are not aware of any counter-

factual analysis that may better evaluate the effect of 2002 leniency reform on cartel outcomes.

4.5 Descriptive evidence

Figure 1 reports the overall number of cartels that were uncovered, on a yearly basis, from 1996 to 2012 at the EU level. This figure also shows the share of self-reported cartels together with the share of cartels that were detected (non self-reported) by the EC. The former share seems to follow an increasing path since the introduction of the 1996 LP. The increase in the share of self-reported cartels becomes even more pronounced from 2002 onwards. In particular, in 2007-2009 and 2011 the only cartels that were uncovered were self-reported cartels. In addition, consistently with Miller [38], we observe that, whereas the overall number of detected cartels peaks in 2002 (in Miller's theory, this is consistent with an enhanced detection capability), it decreases to the pre-reform level in 2003 and then decreases at a lower level in the subsequent years (in Miller's theory, this pattern would be consistent with an enhanced deterrence capability associated with a lower cartel formation rate).

Figure 2 shows the survival probability of cartels as a function of their duration. The cartels considered are those uncovered during the pre-lenieny period, under the 1996 LP, and after the 2002 policy change, respectively. The survival rate of pre-lenieny cartels is almost everywhere above the other two, which are relatively close to each other, even though cartels uncovered after the 2002 leniency reform are typically characterized by a shorter average duration compared to those uncovered under the 1996 LP. In principle, the introduction (and the subsequent modification) of the LP have decreased, in the long term, cartel duration consistently with the findings of Harrington and Chang [29].

Figure 3 and Figure 4 show the survival probability of the duration of investigation. In the first of the two figures, the duration of investigation is computed from the beginning of the proceeding (DIP), in the second one is computed from the moment the first information regarding the potential cartel is obtained (FI). Figure 3 does not

seem to suggest a substantial difference in the duration of investigation between cartels detected under the 1996 LP and those detected after the 2002 reform. Figure 4 shows that the 2002 reform may be associated with longer average duration of investigation; however such a difference turns out to be not significant.

Figure 5 reports the average fine per case (in million of Euros) by year, distinguishing between the payable fine and the leniency reduction. It turns out that, in the post-reform period (2002-2006), both the payable fine and leniency reduction increase substantially compared to the pre-reform period (1996-2001). A considerably different and less clear pattern is observed for the 2007-2012 period, which is however not covered in our main empirical analysis.

[Figures 1-5 about here]

Figures 6-12 report checks on parallel trends, for each of the dependent variables. Each of these figures shows values (dots) and linear fits (lines) of the dependent variable, respectively for self-reported cartels (red) and detected (non self-reported) cartels (blue), before and after the introduction of the 2002 reform (dashed vertical line). For the dependent variable ‘log of cartel duration’, $ln_cartel_duration$ (Figure 6), we clearly observe parallelism. For the other two dependent variables, ‘log of investigation duration’, $ln_investigation_DIP$ and $ln_investigation_FI$ (Figures 7-8), we observe divergent linear trends in the pre-treatment period. Finally, for the ‘log of final fines’, with and without leniency reduction, respectively ln_final_cash and $ln_final_cash_BL$ (Figures 9 and 10), and for the ‘log of final liability’, with and without leniency reduction, respectively $ln_final_liability$ and $ln_final_liability_BL$ (Figures 11-12), we also find non-parallel trends. Nonetheless, for such outcome variables, which are expressed in monetary terms, we may still assume that there is not an anticipation effect of the reform. Indeed, Figures 9-12 show that while in the pre-treatment period fines for cartels detected directly by the Commission decrease slightly more than fines for the self-reported ones, in the post-treatment period fines for cartels detected directly by the Commission start increasing steadily while those related to self-reported ones follow a rather decreasing pattern. This descriptive evidence seems to point out that fines for

cartels detected by the Commission have not been decreasing before 2002 because of the opportunities associated with the leniency reform, which is also consistent with the negative slope of the red line.

[Figures 6-12 about here]

As Figures 6-12 show the behavior of the outcome variables before and after 2002, they can also be used as a prima facie evidence of the impact of the reform. One can simply compare vertical differences between treated observations (self-reported cartels) and controls (non self-reported cartels) in the pre- and post-treatment period. As far as cartel duration is concerned, it emerges very clearly that the steady difference, observed during the pre-treatment period, between treated and controls, disappears almost entirely after the 2002 reform. Finally, when looking at the fines that the conspirators are charged for, we generally find an increase in their monetary values after 2002, independently of whether the cartel was self-reported or not. In addition, differences in levied fines between treated and controls appear to decrease over time in the post-treatment period.

4.6 Descriptive statistics

Table 2 summarizes some descriptive statistics concerning outcomes (both in levels and log-levels), policy and control variables. For each variable, the table shows number of observations, mean and standard deviation values for the full sample, before- and after-reform. In addition, the last column reports, for each variable, the difference between the average post- and pre-reform value, and whether such a difference is statistically significant (and at what level). Interestingly, all outcome variables significantly increase in the after-reform period, with the exception of cartel duration. It is worth stressing that this is an overall comparison, which does not distinguish between self-reported and detected cartels. We find that (i) the investigation duration DIP (FI) increases by about 22 (73) weeks; the final cash (liability) raises by more than 150 (500) million EUR, and the related before leniency amount by approximately 188 (695) million EUR.

However, when examining outcome variables in log-levels, we find significant differences only for final fine liability (with and without leniency reduction) and investigation duration DIP and FI. In addition, significant differences are observed for the number of cartels falling into the category “price agreements” and “multiple infringements”. After 2002, the latter decreased by 33 percentage points, whereas the former increased by 23 percentage points. No relevant differences emerge in the industry composition, which seems to cover just a larger proportion of cases in the construction sector in the post-reform period.

[Table 2 about here]

5 Results

5.1 Main results

Our main results are reported in Tables 3-5. Table 3 shows the main results for cartel duration. We sequentially augment the basic specification by including dummies for the “kind of cartel”, the number of companies involved and the geographical scope of the cartel (i.e number of national markets affected by the cartel), and finally the industry dummies (as codified in Table 2). Such a structure is common to all the following tables presenting on our empirical findings.

In line with the descriptive evidence, we find that cartel duration of self-reported cartels decreases substantially in the after-reform period. In particular, the fully specified and likely most reliable model reports a treatment effect of -0.87 (i.e. the coefficient on the treatment variable), which implies that the difference in cartel duration between self-reported cartels and cartels detected by the Commission decreased by about 87 percent, compared to the pre-reform scenario: the life of cartels belonging to our treatment group has been significantly shortened by the reform, as compared the life of cartels belonging to our control group. This is consistent with the idea that, thanks to the reform, conspirators had stronger incentives to blow the whistle, destabilizing existing cartels. This finding is sizeable and policy relevant: making cartels less stable, and

shortening their life to such extent, is very likely to enhance market competition with obvious positive effects on consumer welfare and market efficiency.

[Table 3 about here]

Results on investigation duration DIP and investigation duration FI are reported respectively on the above and the below part of Table 4. Treatment effects are not generally significant except for the fully specified model involving investigation duration DIP. The value showed there may imply that the difference in the duration of investigation between self-reported cartels and cartels detected by the EC almost halved in the after-reform period. Even if this finding may indicate, in principle, a substantial enhancement of the EC capability to prosecute cartels efficiently, we have doubts about its interpretation. First, it is somehow puzzling that a similar significant effect is not found also for investigation duration FI. Second, and even more substantial, the assumption of parallel trends in the pre-treatment period is not supported by our descriptive evidence, as shown in the previous section and this may bias the estimation of the causal effect of the reform on this outcome variable.

[Table 4 about here]

Finally, no significant treatment effects are associated with the final fine cash or liability, with and without taking into account leniency reductions. So, the difference in total amount of fines (before the application of leniency reduction) between cartels belonging to our treated group and our control group, did not change significantly with the introduction of the 2002 reform. If, like Brenner [8], one considers the total amount of fines as a proxy for the information revealed to the agency, then our result entails that the 2002 reform did not significantly alter the incentives to reveal information concerning the cartel for self-reporting firms as compared to firms belonging to cartels detected by the EC.

[Table 5 about here]

5.2 Robustness checks

We test our main findings by performing the robustness checks that are reported in Table 6. More specifically, in the two top panels we add information on mitigating and aggravating factors to the covariates of the baseline model. The inclusion of these further control variables does not significantly change the treatment effect coefficients. Indeed, the treatment effect on the cartel duration is now -0.84 and the one on the investigation duration DIP is -0.53 (for both results the same interpretations provided for the main findings hold). Moreover, the bottom panel checks inform on whether estimates on ‘final cash before leniency’ and ‘final liability before leniency’ are sensitive to the exclusion of cartels with missing information on leniency reductions. Actually, the treatment effects appear to be more negative than the ones shown in the main analysis. However, given the lack of precision (i.e. statistical significance), we are reluctant to compare such estimates.

[Table 6 about here]

Moreover, in Table A2 we report further evidence of the effects of the 2002 reform on a longer time period: from the first introduction of the LP in 1996 until 2012. As for the previous sensitivity tests, DID estimates are quite similar to the main findings in terms of size and significance levels. Although we do not aim at assessing the impact of the 2006 LP reform, the latter robustness checks indicate that the inclusion of cartel cases observed from 2006 onwards does not alter the interpretation of the key results arising from our empirical analysis on the 1996-2006 time horizon.

[Table A2 about here]

Overall, we find that the performed robustness checks corroborate our main findings.¹⁸

¹⁸We also implemented finite-sample corrections to robust standard errors by using the ‘jackknife’ and ‘bootstrap’ approach, respectively. Standard errors are extremely close to the ones estimated in absence of any correction approach. These results are available upon request to the authors.

6 Discussion and conclusions

Leniency policies have played a central role in antitrust enforcement over the last 20 years. This is true also for the EU where the first introduction of a LP dates back to 1996. This first attempt is commonly considered as rather unsatisfactory because of its lack of clarity and transparency. The 2002 reform, that is the main focus of this study, was meant to boost the incentives of cartel members to self-report by making clearer the conditions under which the first firm to blow the whistle would have received full immunity. Very importantly, the 2002 reform also made immunity available after an investigation was open and granted fine reductions to firm self-reporting after the first one. The EC considered these innovations as an addition to what was already an “indisputable success” (Arbault and Peiro [1]) and that they would have improved even further its capability to efficiently fight against cartels.

It is indeed commonly acknowledged that the main features of the 2002 reform have been rather beneficial, our paper is the first to provide specific empirical evidence about their actual impact on cartel stability and cost of prosecution.

We have built a data set based on all the decisions issued by the EC over the period 1990-2017. Then, thanks to the timing and the structure of the different reforms of the European LP, we have been able to rely on a quasi-experimental design (focusing on the period 1998-2006) that has allowed us to estimate the effect of the 2002 reform on the following outcome variables: cartel duration, duration of investigation, and fines levied by the EC (both before and after the applications leniency reductions).

On the one hand, we find that the introduction of the reform has substantially decreased cartel duration of self-reported cartels, as compared to the duration of cartels that have been detected directly by the Commission. This result seems to suggest that the reform did have an impact on the stability of cartels.

On the other hand, we do not find empirical evidence of a significant impact on the size of fines and on the duration of investigation. Hence, our findings suggest that making the program more transparent and generous neither significantly reduced prosecution costs nor allowed the EC to gather richer and more effective evidence from

cartel members.

To some extent, our findings are at odds with some of the EC claims as they seem to suggest that the 2002 reform cannot be considered an unambiguous success, especially on the prosecution side. However, in a broader perspective, our findings do confirm the view that the 2002 reform did represent a turning point for the fight against cartels at EU level. As shown in Figure 1 (and Table A1) the ratio between the number of self-reported cartels and cartels directly detected by the EC has kept increasing since the introduction of the reform. Moreover, even in cases in which the chief witness received full immunity from fines, further fine reductions have been more often granted to further undertakings. In addition, in cases in which no cartel member had received full immunity, reductions of the fine because of the LP have been granted to one or more conspirators (Wils [44]). Essentially, the reform has greatly increased the number of cartels detected “from the inside” through whistle-blowers and/or leniency applications, confirming the fact that the EU LP has probably become the most effective tool for detecting cartels in Europe (and elsewhere OECD [40]).

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Figure 1: Uncovered cartels (detected by EC and self-reported)

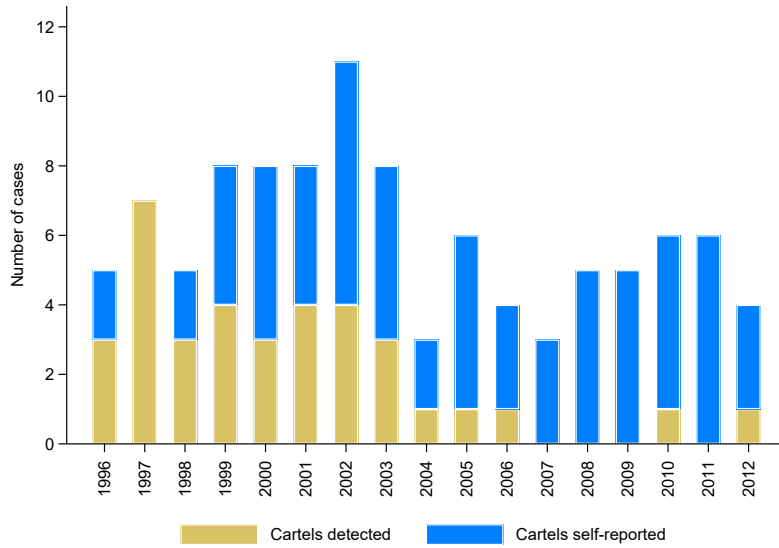


Figure 2: Cartel duration

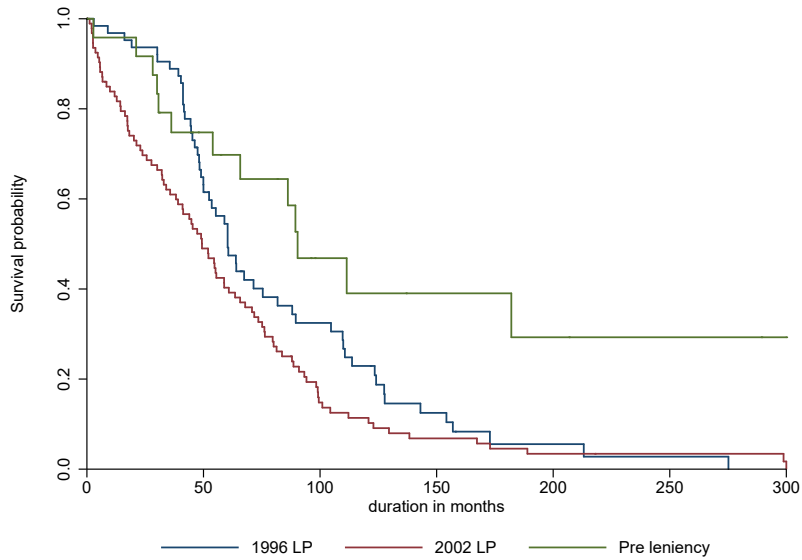


Figure 3: Investigation duration (DIP)

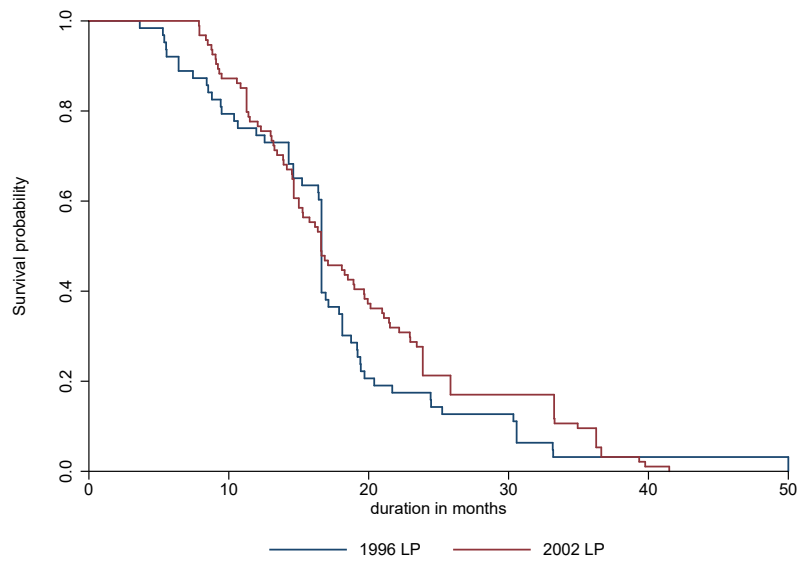


Figure 4: Investigation duration (FI)

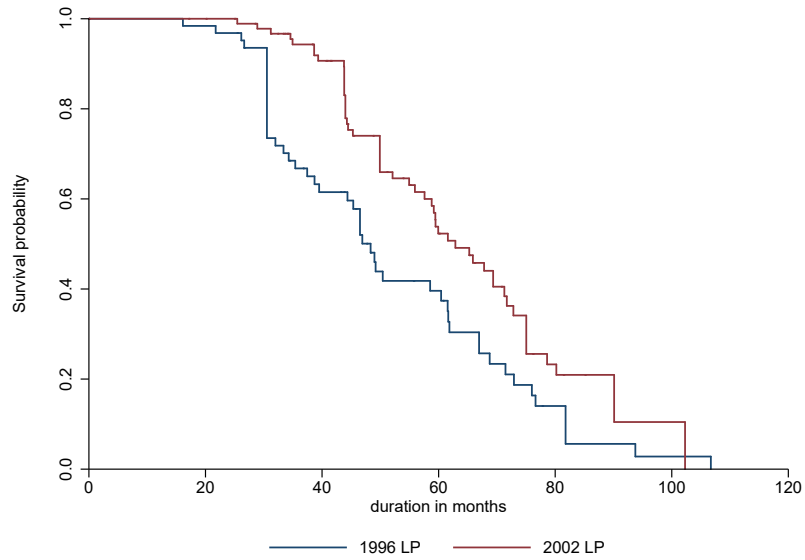


Figure 5: Average fine per case

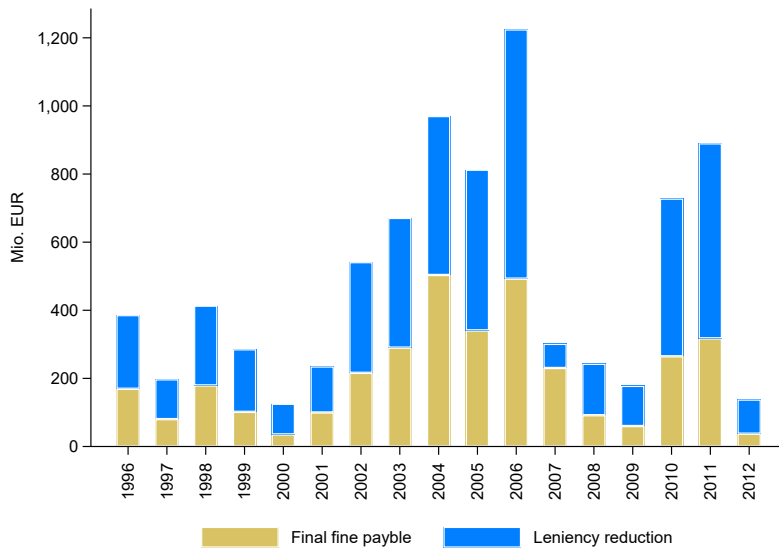
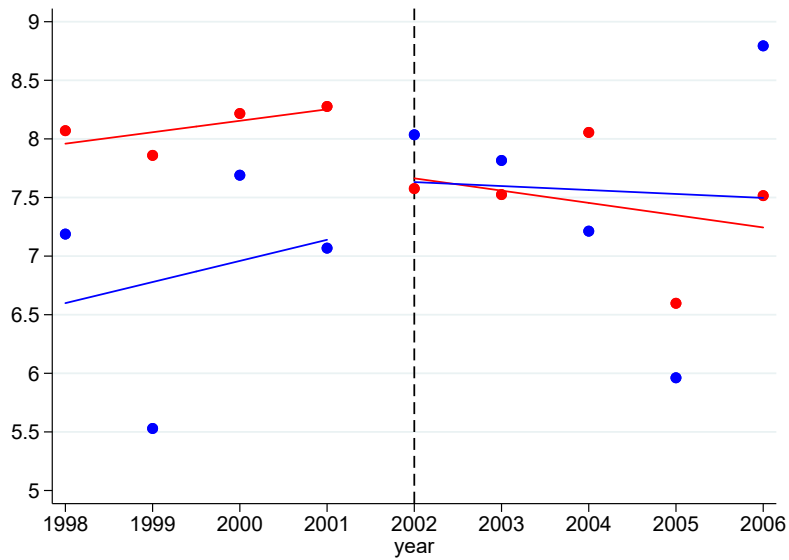
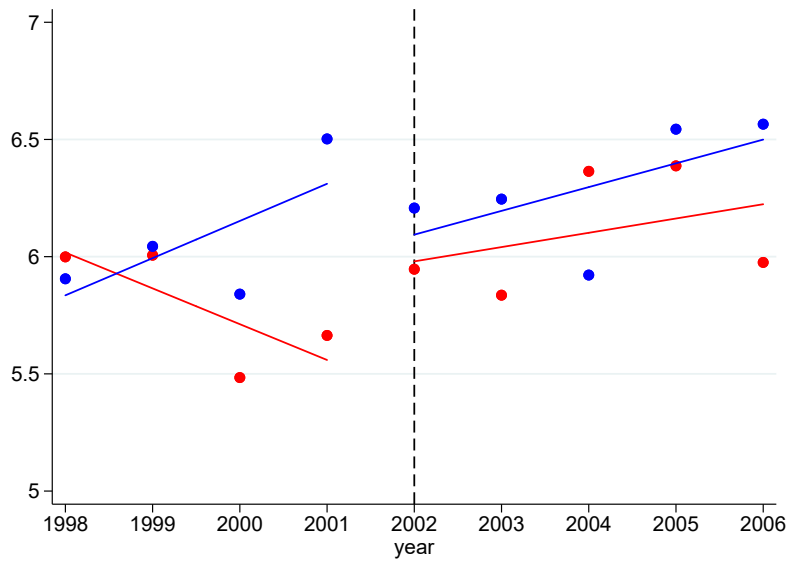


Figure 6: Parallel trends – log of cartel duration



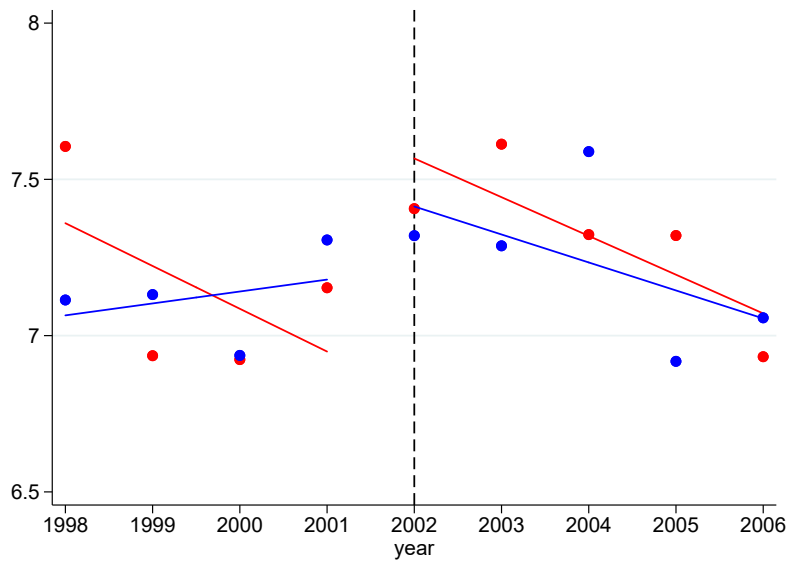
Note: Self-reported (red) vs detected (blue).

Figure 7: Parallel trends – log of investigation duration (DIP)



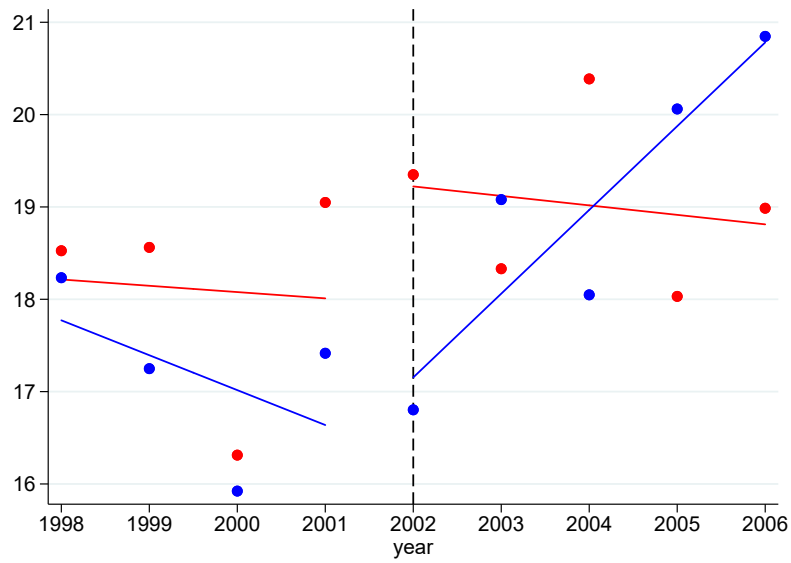
Note: Self-reported (red) vs detected (blue).

Figure 8: Parallel trends – log of investigation duration (FI)



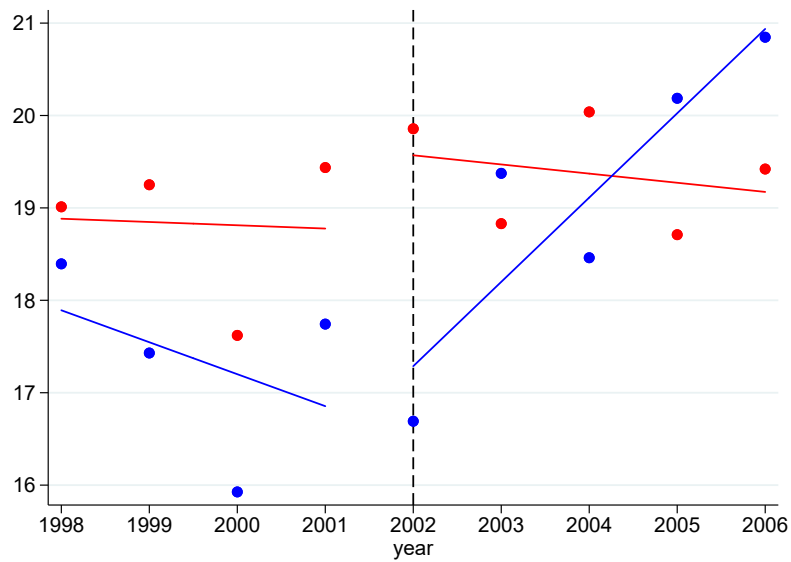
Note: Self-reported (red) vs detected (blue).

Figure 9: Parallel trends – log of final fine cash



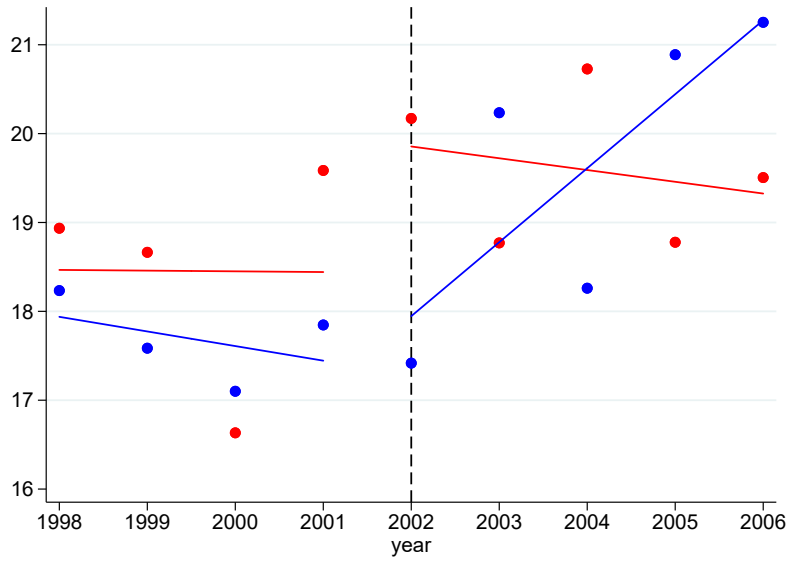
Note: Self-reported (red) vs detected (blue).

Figure 10: Parallel trends – log of final fine cash (before leniency)



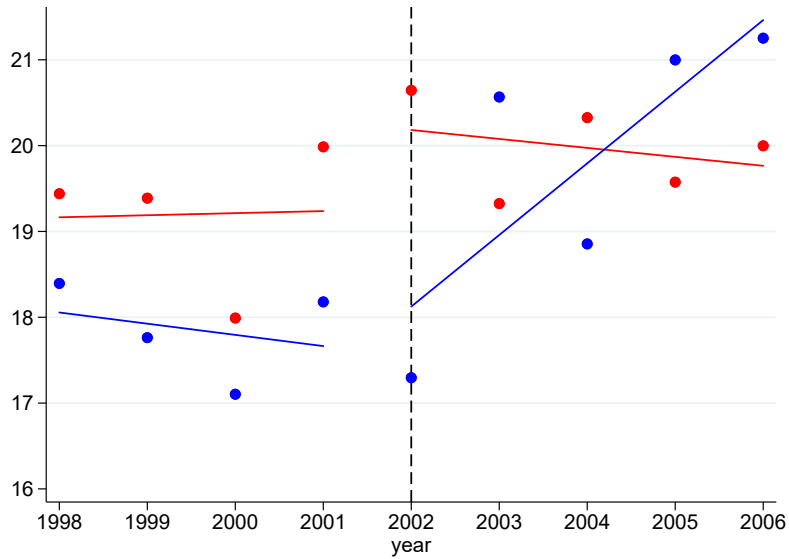
Note: Self-reported (red) vs detected (blue).

Figure 11: Parallel trends – log of final fine liability



Note: Self-reported (red) vs detected (blue).

Figure 12: Parallel trends – log of final fine liability (before leniency)



Note: Self-reported (red) vs detected (blue).

Table 1: Comparison of the EU leniency program before and after the 2002 reform

<i>Design element</i>	<i>1996-2001</i>	<i>2002-2006</i>
Total immunity for the first self-reporting firm	No	Yes
Immunity if the EC has already started investigations	No	Yes
Fine reductions for the first self-reporting firm only	No	No
Degree of leniency depends on added-value of evidence provided	Yes	Yes
Ringleader exclusion from immunity	Yes	No

Table 2: Descriptive statistics

Variable	Full sample			1996 LP			2002 LP			difference
	N	mean	SD	N	mean	SD	N	mean	SD	
<i>Outcome variables (in levels)</i>										
cartel duration (days)	60	2399.83	1556.33	34	2181.74	1686.10	26	2685.03	1346.97	-503.28
investigation duration DIP (days)	60	472.75	242.22	34	538.38	276.57	26	386.91	154.87	151.46**
investigation duration FI (days)	60	1462.42	554.85	34	1682.68	505.44	26	1174.39	486.89	508.29***
final fine cash (milio EUR)	60	222.02	269.72	34	287.59	325.54	26	136.28	135.31	151.31**
final fine cash BL (milio EUR)	60	317.23	361.79	34	396.99	440.65	26	210.90	182.43	187.64**
final fine liability (milio EUR)	60	489.46	929.87	34	710.51	1178.47	26	200.39	232.52	510.12**
final fine liability BL (milio EUR)	60	698.48	1171.74	34	996.77	1474.07	26	304.83	307.20	694.68**
<i>Outcome variables (in log-levels)</i>										
ln (1 + cartel duration)	60	7.55	0.75	34	7.42	0.78	26	7.72	0.69	-0.30
ln (1 + investigation duration DIP)	60	6.04	0.50	34	6.18	0.48	26	5.86	0.47	0.31**
ln (1 + investigation duration FI)	60	7.22	0.37	34	7.39	0.30	26	7.00	0.35	0.38***
ln (1 + final fine cash)	60	18.35	1.65	34	18.64	1.59	26	17.96	1.68	0.67
ln (1 + final fine cash BL)	60	18.80	1.53	34	18.99	1.58	26	18.52	1.48	0.60
ln (1 + final fine liability)	60	18.90	1.73	34	19.42	1.52	26	18.22	1.77	1.21***
ln (1 + final fine liability BL)	60	19.37	1.60	34	19.80	1.52	26	18.77	1.58	1.07**
<i>Policy variables</i>										
self_reported (1/0)	60	0.60	0.49	34	0.56	0.50	26	0.65	0.49	-0.09
2002 LP (1/0)	60	0.57	0.50	34	1.00	0.00	26	0.00	0.00	-
self_reported × 2002 LP (1/0)	60	0.32	0.47	34	0.56	0.50	26	0.00	0.00	-
<i>Control variables</i>										
Export, import or trade restriction (1/0)	60	0.03	0.18	34	0.06	0.24	26	0.00	0.00	0.06
Market sharing agreement (1/0)	60	0.13	0.34	34	0.15	0.36	26	0.12	0.33	0.03
Price agreement (1/0)	60	0.25	0.44	34	0.35	0.49	26	0.12	0.33	0.23**
Multiple infringement (1/0)	60	0.58	0.50	34	0.44	0.50	26	0.77	0.43	-0.33***
companies involved	60	5.18	3.56	34	5.82	4.08	26	4.35	2.67	1.47
national markets	60	12.94	7.85	34	12.67	7.87	26	12.94	7.43	-0.27
manufacturing C1 (1/0)	60	0.20	0.40	34	0.15	0.36	26	0.27	0.45	-0.12
manufacturing C2 (1/0)	60	0.63	0.49	34	0.67	0.47	26	0.58	0.50	0.09
manufacturing C3 (1/0)	60	0.05	0.22	34	0.06	0.24	26	0.04	0.20	0.02
construction (1/0)	60	0.07	0.25	34	0.12	0.33	26	0.00	0.00	0.12*
wholesale and retail trade (1/0)	60	0.02	0.13	34	0.03	0.17	26	0.00	0.00	0.03
transportation and storage (1/0)	60	0.05	0.22	34	0.06	0.23	26	0.04	0.20	0.02
financial and insurance activities (1/0)	60	0.02	0.13	34	0.00	0.00	26	0.04	0.20	-0.04
arts, entertainment and recreation (1/0)	60	0.02	0.13	34	0.00	0.00	26	0.04	0.20	-0.04
mitigating factors (1/0)	60	0.32	0.47	34	0.35	0.49	26	0.26	0.45	0.09
aggravating factors (1/0)	60	0.60	0.49	34	0.65	0.49	26	0.54	0.51	0.11
limit 10% firm's turnover (1/0)	60	0.28	0.45	34	0.29	0.46	26	0.27	0.45	0.02

Note: Monetary values are reported in millions EUR and deflated by using the OECD Consumer Price Index for the year 2010. Manufacturing C1 includes manufacture of food products, beverages, textiles, wearing apparel, paper and paper products, coke and refined petroleum products. Manufacturing C2 includes manufacture of chemicals and chemical products, basic pharmaceutical products and pharmaceutical preparations, rubber and plastic products, other non-metallic mineral products, basic metals, fabricated metal products, except machinery and equipment, computer, electronic and optical products, electrical equipment, machinery and equipment n.e.c., motor vehicles, trailers and semi-trailer. Manufacturing C3 includes manufacture of other transport equipment, furniture, repair and installation of machinery and equipment.

Table 3: Main results – Cartel duration

	$\ln(1 + \text{cartel duration})$			
	(i)	(ii)	(iii)	(iv)
<i>self-reported</i>	0.96*** (0.26)	0.96*** (0.28)	1.08*** (0.25)	1.18*** (0.28)
<i>2002 LP</i>	0.37 (0.35)	0.36 (0.34)	0.36 (0.31)	0.38 (0.40)
<i>self-reported</i> \times <i>2002 LP</i>	-1.03** (0.39)	-0.85** (0.40)	-1.00*** (0.35)	-0.87** (0.43)
<i>Kind of cartel</i>	No	Yes	Yes	Yes
<i>Firms and markets</i>	No	No	Yes	Yes
<i>Industry dummies</i>	No	No	No	Yes
R-squared	0.20	0.25	0.34	0.41
Observations	60	60	60	60

Note: Standard errors are heteroskedasticity-robust. *, **, and *** denote significance at the 10, 5, and 1 percentage level, respectively. *Kind of cartel* is a set of dummy variables informing on whether the cartel was a *price agreement*, *market sharing agreement*, *export*, *import or trade restriction*, or associated with *multiple infringements*. *Firms and markets* is a set of variables informing on the number of *companies involved* and *national markets* affected by the cartel.

Table 4: Main results – Investigation duration

	<i>ln (1 + investigation duration DIP)</i>			
	<i>(i)</i>	<i>(ii)</i>	<i>(iii)</i>	<i>(iv)</i>
<i>self_reported</i>	-0.27 (0.18)	-0.26 (0.17)	-0.15 (0.19)	-0.01 (0.21)
<i>2002 LP</i>	0.29 (0.18)	0.44** (0.19)	0.46** (0.21)	0.36* (0.21)
<i>self_reported</i> × <i>2002 LP</i>	-0.01 (0.24)	-0.21 (0.27)	-0.33 (0.27)	-0.49* (0.27)
<i>Kind of cartel</i>	No	Yes	Yes	Yes
<i>Firms and markets</i>	No	No	Yes	Yes
<i>Industry dummies</i>	No	No	No	Yes
R-squared	0.17	0.24	0.34	0.53
Observations	60	60	60	60
	<i>ln (1 + investigation duration FI)</i>			
	<i>(i)</i>	<i>(ii)</i>	<i>(iii)</i>	<i>(iv)</i>
<i>self_reported</i>	-0.07 (0.16)	-0.07 (0.16)	-0.08 (0.14)	-0.12 (0.17)
<i>2002 LP</i>	0.35** (0.16)	0.46*** (0.16)	0.43*** (0.14)	0.48*** (0.17)
<i>self_reported</i> × <i>2002 LP</i>	0.05 (0.19)	-0.06 (0.20)	-0.08 (0.19)	-0.10 (0.21)
<i>Kind of cartel</i>	No	Yes	Yes	Yes
<i>Firms and markets</i>	No	No	Yes	Yes
<i>Industry dummies</i>	No	No	No	Yes
R-squared	0.27	0.34	0.38	0.44
Observations	60	60	60	60

Note: Standard errors are heteroskedasticity-robust. *, **, and *** denote significance at the 10, 5, and 1 percentage level, respectively. *Kind of cartel* is a set of dummy variables informing on whether the cartel was a *price agreement*, *market sharing agreement*, *export*, *import* or *trade restriction*, or associated with *multiple infringements*. *Firms and markets* is a set of variables informing on the number of *companies involved* and *national markets* affected by the cartel.

Table 5: Main results – Fines

	<i>ln (1 + final fine cash)</i>				<i>ln (1 + final fine cash) BL</i>			
	(i)	(ii)	(iii)	(iv)	(i)	(ii)	(iii)	(iv)
<i>self_reported</i>	0.21 (0.71)	0.21 (0.71)	-0.13 (0.82)	-0.21 (1.01)	0.77 (0.64)	0.78 (0.64)	0.52 (0.72)	0.43 (0.89)
<i>2002 LP</i>	0.39 (0.74)	1.13 (0.73)	0.77 (0.76)	0.04 (0.92)	0.42 (0.73)	1.12* (0.67)	0.91 (0.69)	0.16 (0.85)
<i>self_reported</i> × <i>2002 LP</i>	0.55 (0.90)	-0.32 (0.85)	-0.26 (0.87)	0.45 (1.01)	0.27 (0.84)	-0.56 (0.77)	-0.46 (0.81)	0.20 (0.93)
<i>Kind of cartel</i>	No	Yes	Yes	Yes	No	Yes	Yes	Yes
<i>Firms and markets</i>	No	No	Yes	Yes	No	No	Yes	Yes
<i>Industry dummies</i>	No	No	No	Yes	No	No	No	Yes
R-squared	0.07	0.27	0.37	0.50	0.12	0.37	0.39	0.52
Observations	60	60	60	60	60	60	60	60
	<i>ln (1 + final fine liability)</i>				<i>ln (1 + final fine liability) BL</i>			
	(i)	(ii)	(iii)	(iv)	(i)	(ii)	(iii)	(iv)
<i>self_reported</i>	0.28 (0.73)	0.28 (0.74)	0.05 (0.82)	-0.05 (1.03)	0.85 (0.67)	0.85 (0.68)	0.70 (0.73)	0.56 (0.92)
<i>2002 LP</i>	1.17 (0.74)	1.83** (0.76)	1.53* (0.77)	0.61 (0.89)	1.23* (0.72)	1.84** (0.71)	1.68** (0.71)	0.72 (0.83)
<i>self_reported</i> × <i>2002 LP</i>	0.11 (0.92)	-0.67 (0.88)	-0.69 (0.89)	0.16 (1.01)	-0.15 (0.85)	-0.91 (0.81)	-0.89 (0.83)	-0.08 (0.93)
<i>Kind of cartel</i>	No	Yes	Yes	Yes	No	Yes	Yes	Yes
<i>Firms and markets</i>	No	No	Yes	Yes	No	No	Yes	Yes
<i>Industry dummies</i>	No	No	No	Yes	No	No	No	Yes
R-squared	0.13	0.26	0.35	0.51	0.17	0.33	0.35	0.50
Observations	60	60	60	60	60	60	60	60

Note: Standard errors are heteroskedasticity-robust. *, **, and *** denote significance at the 10, 5, and 1 percentage level, respectively. *Kind of cartel* is a set of dummy variables informing on whether the cartel was a *price agreement*, *market sharing agreement*, *export*, *import or trade restriction*, or associated with *multiple infringements*. *Firms and markets* is a set of variables informing on the number of *companies involved* and *national markets* affected by the cartel.

Table 6: Robustness checks

	$\ln(1 + \text{cartel duration})$	$\ln(1 + \text{investigation duration DIP})$	$\ln(1 + \text{investigation duration FI})$
<i>self_reported</i>	1.19***	0.01	-0.12
	(0.28)	(0.21)	(0.17)
<i>2002 LP</i>	0.37	0.36	0.48***
	(0.41)	(0.22)	(0.17)
<i>self_reported</i> × <i>2002 LP</i>	-0.84**	-0.53*	-0.08
	(0.42)	(0.30)	(0.21)
R-squared	0.42	0.54	0.45
Observations	60	60	60
	$\ln(1 + \text{final fine cash})$	$\ln(1 + \text{final fine cash BL})$	$\ln(1 + \text{final fine liability})$
<i>self_reported</i>	-0.17	0.48	-0.03
	(0.97)	(0.85)	(0.98)
<i>2002 LP</i>	0.07	0.20	0.63
	(0.88)	(0.82)	(0.85)
<i>self_reported</i> × <i>2002 LP</i>	0.09	-0.16	-0.19
	(1.00)	(0.94)	(0.97)
R-squared	0.54	0.56	0.54
Observations	60	60	60
	$\ln(1 + \text{final fine liability BL})$	$\ln(1 + \text{final fine liability BL})$	$\ln(1 + \text{final fine liability BL})$
<i>self_reported</i>	0.49	0.62	0.62
	(0.87)	(0.89)	(0.89)
<i>2002 LP</i>	0.13	0.62	0.62
	(0.85)	(0.84)	(0.84)
<i>self_reported</i> × <i>2002 LP</i>	-0.32	-0.60	-0.60
	(1.00)	(0.99)	(0.99)
R-squared	0.56	0.56	0.56
Observations	57	57	57

Note: Standard errors are heteroskedasticity-robust. *, **, and *** denote significance at the 10, 5, and 1 percentage level, respectively. Controls include: *kind of cartel, firms and markets, industry dummies, mitigating and aggravating factors, and limit of 10% firm's turnover*. Bottom panel columns report estimates on *final fine cash before leniency and final fine liability before leniency* after the exclusion of cartels with missing information on leniency reductions.

Appendix

Figure A1: Cartels detected and settled

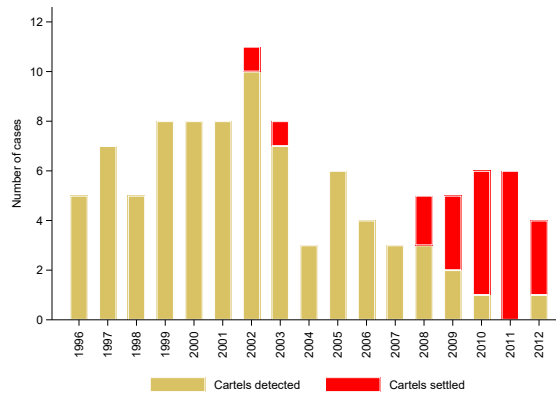


Figure A2: Comparison of investigation duration measures

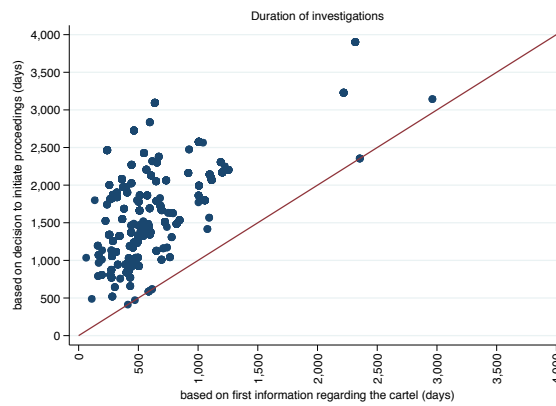


Table A1: Cartels detected and self-reported by FI year

<i>FI year</i>	<i>Detected</i>	<i>Self-reported</i>	<i>Total</i>
1983	1	0	1
1986	1	0	1
1987	3	0	3
1988	3	0	3
1989	5	0	5
1990	0	1	1
1991	5	0	5
1992	2	1	3
1993	2	0	2
1994	4	0	4
1995	8	0	8
1996	3	2	5
1997	8	0	8
1998	3	2	5
1999	5	15	20
2000	3	5	8
2001	9	4	13
2002	4	7	11
2003	6	6	12
2004	1	2	3
2005	1	5	6
2006	1	3	4
2007	0	7	7
2008	0	9	9
2009	0	9	9
2010	1	13	14
2011	0	7	7
2012	1	3	4
	80	101	181

Table A2: Robustness checks: longer time period (1996 – 2012)

	$\ln(1 + \text{cartel duration})$	$\ln(1 + \text{investigation duration DIP})$	$\ln(1 + \text{investigation duration FI})$
<i>self_reported</i>	0.73***	-0.16	-0.27*
	(0.26)	(0.19)	(0.14)
<i>2002 LP</i>	0.11	0.15	0.20
	(0.39)	(0.18)	(0.15)
<i>self_reported</i> × <i>2002 LP</i>	-0.85**	-0.22	0.27
	(0.42)	(0.28)	(0.19)
R-squared	0.56	0.42	0.39
Observations	93	93	93
	$\ln(1 + \text{final fine cash})$	$\ln(1 + \text{final fine cash BL})$	$\ln(1 + \text{final fine liability})$
<i>self_reported</i>	-0.29	-0.56	0.18
	(0.74)	(0.72)	(0.64)
<i>2002 LP</i>	0.45	-0.35	0.42
	(0.58)	(0.61)	(0.56)
<i>self_reported</i> × <i>2002 LP</i>	-0.31	0.08	-0.55
	(0.78)	(0.78)	(0.73)
R-squared	0.58	0.57	0.61
Observations	93	93	93
	$\ln(1 + \text{final fine liability BL})$	$\ln(1 + \text{final fine liability BL})$	$\ln(1 + \text{final fine liability BL})$
<i>self_reported</i>	0.27	-0.01	
	(0.63)	(0.62)	
<i>2002 LP</i>	0.36	-0.41	
	(0.56)	(0.60)	
<i>self_reported</i> × <i>2002 LP</i>	-0.53	-0.23	
	(0.75)	(0.77)	
R-squared	0.67	0.65	
Observations	82	82	

Note: Standard errors are heteroskedasticity-robust. *, **, and *** denote significance at the 10, 5, and 1 percentage level, respectively. Controls include: *kind of cartel, firms and markets, industry dummies, mitigating and aggravating factors, and limit of 10% firm's turnover*. Bottom panel columns report estimates on *final fine cash before leniency and final fine liability before leniency* after the exclusion of cartels with missing information on leniency reductions.