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Heterogeneous Penalties and Private Information

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Heterogeneous Penalties and Private Information

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The theoretical framework of the adequacy of Leniency Programme reductions has been explored widely. However, the characteristics of the reporting cartel members remain unexplained. In this article, a model where cartel members receive heterogeneous fines and have private information on the probability of conviction, shows that higher fines increase the likelihood of reporting the cartel. To validate this result and analyze the sources of fine heterogeneity, data for EU and US cartels are used. Being the first reporter is shown to be correlated with recidivism, leadership and other fine reductions. Some characteristics of the cartels where reporting occurred are also unveiled.

JEL Classification: D43, K21, K42, L13, L4, L51

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1 Introduction

Cartels are explicitly prohibited by Article 101 of the Treaty on the Functioning of the European Union and by the US Sherman and Federal Trade Commission Acts. However, cartels are a perennial problem and are one of the main concerns of the European Commission and the US Department of Justice. Because cartels are secret, measuring the rate of success of cartel detection is challenging, as the increased number of detections in recent years may be the result of a higher desistance rate and/or a higher incidence of cartels. The US and EU Leniency Programmes (LPs) were thus designed to work as a device for the deterrence and dissolution of collusive agreements and have been in place since 1978 and 1996, respectively.[1]

The adequacy of leniency reductions has been analyzed extensively but the characteristics of the reporting cartel members remain unexplained. This article addresses this question by developing and testing a model where cartel members are heterogeneous in terms of the value of the cartel fine. The model extends Harrington (2013), in which the author models a duopoly of homogeneous firms who receive public or private signals on the probability of conviction by a Competition Authority. However, the underlying assumption of homogeneity of firms only allows for symmetric equilibria. In this article, the introduction of heterogeneity gives rise to different equilibrium thresholds for reporting, thus eliminating the restrictive assumption of symmetric equilibria and allowing for further policy recommendations.

The model shows that the firm with the highest fine has a lower reporting threshold and, in equilibrium, it will be the first reporter of the cartel, provided that it receives a sufficiently high signal on the probability of conviction and that this is not overly bi-

[1] See D.O.J. (1978) and European.Commission (1996). The US LP was amended in 1993, to account for transparency issues by means of making the guidelines easier to use as well as introducing higher compensation from cooperation. Revisions to the EU LP occurred in 2002 and 2006 ((European.Commission, 2002), (European.Commission, 2006)), making the programme more detailed and, in general, more "generous". The 2002 guidelines are much more detailed than those of 1996 and provide, in general, higher reductions for the reporting firms. The major changes in the LP of 2006 are in terms of clarification and additional flexibility to the previous LP Notice, regarding the immunity thresholds and the conditions for fine reductions, as well as the introduction of a discretionary marker system, so as to preserve an informant's position as being the first to come forward and disclose.

ased. The signals are private information and may be generated from public statements issued by EU or US officials, knowledge of the budget allocated to the detection and conviction of cartels, and the proportion of convictions in cartel investigations, among others. The factors impacting the reporting decision and their weight, as well as the sources of heterogeneity, are also analyzed.

The empirical analysis corroborates the theoretical results and adds to them by unveiling some of the characteristics of the initial reporting firms and of the cartels in which they take part.

The extensive literature on the topic of Leniency Programmes initiated with two pioneering articles. Motta and Polo (2003) examine the eligibility of firms under investigation to receive leniency and show that the positive effect of leniency on deterrence (faster, cheaper and more effective prosecution) tends to exceed its negative effect (lower overall sanctions). Spagnolo (2004) studies the ability of leniency to induce self-reporting and finds that the first best of complete and costless deterrence can be achieved, provided that positive rewards are available to self-reporting firms and imposed fines are maximal on all but the reporting cartel member.

The effect of leniency on deterrence is also investigated by Feess and Walzl (2004) who suggest that optimal enforcement policy should provide full amnesty, even after the investigation has initiated (Harrington (2008)). These results are also found by Chen and Harrington (2005), where it is argued that a partial LP may facilitate collusion and by Chen and Rey (2012). The latter article fails to find evidence that repeat offenders should be excluded from leniency and Herre and Rasch (2009) show that excluding the cartel ringleader decreases cartel stability.

Motchenkova (2004) highlights the importance of confidential leniency applications for achieving complete cartel deterrence, whereas Aubert et al. (2006) find that rewarding individuals, such as firm employees, is more efficient in terms of deterring collusion.

Gartner and Zhou (2012) analyze the delay in leniency applications, which is due to antitrust policies and macroeconomic fluctuations. Their article reinforces the need for further work analyzing post-cartel behavior, which is in line what what is done in

this article.

The empirical literature on leniency policies is recent and includes several articles which merely analyze descriptive statistics on the LP[2]. Two main methodologies have been developed by Chen and Harrington (2005) and Miller (2009), to infer the effects, on cartel formation and deterrence, of changing a law enforcement policy, and these have been applied by Miller and in Brenner (2011). Brenner studied EU cartel cases between 1990 and 2003. He found neither an increase in average duration after the introduction of the leniency policy nor an increase in the number of detected cartels immediately after the policy's introduction. These findings appear inconsistent with the theoretical conditions indicating that the 1996 LP had positive deterrence effects. Miller assessed the effect of the reformed US LP introduced in 1993 and found that the number of cartels detected by US authorities increased after the introduction of the new LP, consistent with an increase in the cartel detection rate. This increase was followed by a fall to a level below the pre-LP level, a pattern that according to his theory is consistent with increased cartel deterrence.

In Marvao (2012), it is shown that recidivism is one the factors which influence the granting and scale of EU leniency reductions and Brenner (2011) finds that large multinational are more likely to report and cooperate with an EU investigation.

The present article uses EU data, which was collected and compiled by the author from the publicly available reports and press releases on the European Commission's website, and US data which was made available by John Connor (Purdue University). The contribution to the current empirical literature lies in the use of a new EU dataset and in the examination of the characteristics of the initial reporting cartel members, and of the associated cartels.

The organization of the rest of the article is as follows. In the next section the theoretical model is introduced. In Section 3, the EU and US Leniency Programmes are discussed. The empirical methodology is described and discussed in Section 4. Section 5 offers concluding comments.

[2]Bloom (2006), Connor (2008), Connor (2013), Berinde (2008), Carree et al. (2010), Combe and Monnier (2011), Veljanovski (2010) and Dominte et al. (2013).

2 Theoretical model

The game has two stages. In the first stage, a two-firm cartel collapses for internal reasons.[3] Suppose that the cartel members (i and j) are risk-neutral and heterogeneous in terms of the value of their expected fines ($F_i \neq F_j$).

In the second stage, each firm receives a private signal on the expected probability of detection and conviction by the authorities (ρ), which is given by $s = E(\rho)$ and belongs in the interval $[\underline{s}, \overline{s}]$. The signals received can take the form of reports issued by the Competition Authority, private information on secret cartels, percentage of cartel investigations which resulted in convictions and share of the budget allocated to the investigation and/or prosecution of cartels, among others.[4] It is assumed that it is not costly to search for the signal. Given the signal received and the expectations on the other firm's behavior, firms decide to report (R) if the signal is above their threshold level (x_k) or not to report (NR).

Each cartel member can apply to the Leniency Programme and receive a fine reduction. θF_k denotes the share of the fine paid by each convicted firm ($\theta \epsilon [0, 1[$).

In addition to the fine, the cartel sanction includes a payment for overcharges and other costs inherent to being fined ($G \neq 0$)[5] These costs may include attorney fees, negative impact on consumer's perception (which may lead to lower sales), managers being fired, future punishment by other firms and possible future damage claims (from customers).

Firm i's CDF (cumulative distribution function) on firm j's signal conditional on its own signal, i.e., the probability that firm j does not report, is given by the $H(s_j|s_i)$ function. As in Harrington (2013), to capture the positive correlation between the signals,

[3] This assumption can easily be eliminated with no serious consequences for the results. If the cartel is ongoing, then current and future profits will be taken into account in the reporting decision. Assuming that the individual cartel profits grow at a lower rate than the growth of the expected fine is sufficient condition to guarantee that the results from the model hold.

[4] The share of investigations with no convictions can be used as an indicator of the signal's value, in the calibration of the model. However, this article refrains from doing so to keep the model general. The signals may also be correlated with the number of years in the industry and the firm's products and behavior.

[5] Assuming $G \neq 0$, ensure that there is no discontinuity issue in the threshold levels (the x's) with respect to the value of G.

it is assumed that:

A1: $H(s_j|s_i)(j \neq i)$ is continuously differentiable in s_i and s_j. If $s'' > s'$ then $H(s_j|s_i = s'')$ weakly first-order stochastically dominates $H(s_j|s_i = s')$.

Table 1 defines the variables present in the theoretical model.

[Table 1 here]

The value functions for firm i ($i \neq j$) are the following:[6]

$$-V_i^R = H(x_j|s_i)(\theta F_i + G_i) + [1 - H(x_j|s_i)](\frac{1+\theta}{2}F_i + G_i) \tag{1}$$

$$-V_i^{NR} = H(x_j|s_i)E[\rho|s_i, s_j \leq x_j](F_i + G_i) + [1 - H(x_j|s_i)](F_i + G_i) \tag{2}$$

Each firm reports if the additional value from reporting ($\Delta(s_j, x_i)(j \neq i)$) is positive:

$$\begin{aligned}\Delta(s_j, x_i)(j \neq i) \equiv V_i^R - V_i^{NR} \equiv E[\rho|s_i, s_j \leq x_j]\frac{F_i + G_i}{F_i} - \theta + \frac{1 - H(x_j|s_i)}{H(x_j|s_i)}\frac{1-\theta}{2} - \frac{G_i}{F_i} > 0 \\ \leftrightarrow F_i \geq G_i \frac{1 - E[\rho|s_i, s_j \leq x_j]}{E[\rho|s_i, s_j \leq x_j] + \frac{1-H(x_j|s_i)}{H(x_j|s_i)}\frac{1-\theta}{2} - \theta}\end{aligned} \tag{3}$$

The comparative statics below show that firms have a higher incentive to report when the signal is higher, because the perceived probability of conviction is then higher. The same occurs when the firm's expected fine level is larger.

$$\frac{\partial \Delta}{\partial s_i} = \frac{\partial E[\rho|s_i, s_j \leq x_j]}{\partial s_i}\frac{F_i + G_i}{F_i} - \frac{\partial H(x_j|s_i)}{\partial s_i}\frac{1-\theta}{2H(x_j|s_i)^2} \geq 0$$

$$\frac{\partial \Delta}{\partial F_i} = (1 - E[\rho|s_i, s_j \leq x_j])\frac{G_i}{F_i^2} \geq 0$$

Each firm chooses the strategy which minimizes the expected value of their penalties ($\Delta(x_j, x_i) = 0$). At the cut-off point ($s_j = x_j$), inequation (*3*) becomes:

$$\Delta(x_j, x_i) = 0 \leftrightarrow F_i = G_i \frac{1 - E[\rho|x_i, x_j \leq x_j]}{E[\rho|x_i, x_j \leq x_j] + \frac{1-H(x_j|x_i)}{H(x_j|x_i)}\frac{1-\theta}{2} - \theta} \tag{4}$$

[6]Reporting may also avoid further litigation costs but including these in the model will not change the conclusions nor add significant value to the model. These costs are thus excluded, which carries the same results as assuming that they are of the same amount for all the cartel members.

THEOREM 1: *An equilibrium exists in which firms simultaneously choose to report or not, given their own signal and the expectation on the other firm's signal. If* $(x_i, x_j)\epsilon(\underline{s}, \overline{s})$ *and* $\Delta(x_i, x_j) = 0$ *or* $\Delta(x_j, x_i) = 0$ *then* $\phi(s_i, s_j)$ *is the set of Bayesian-Nash Equilibria (BNE).*

Proposition 1: If $s_j\epsilon]x_j, \overline{s}]$, firm j's equilibrium strategy is to report, provided that $\Delta(x_i, x_j) \geq 0$, as then $\Delta(s_j, x_i) > 0$, $for\ all\ s_j > x_j$; and not to report if $s_j\epsilon[\underline{s}, x_j]$, provided that $\Delta(x_i, x_j) \leq 0$, as then $\Delta(s_i, x_i) < 0$, $for\ all\ s_j < x_j$.

Let $\Phi(.)$ denote the expected additional value from reporting, taking into account the decision of the other cartel member: $\Phi(x) = H(x|x)\Delta(x, x)$. $H(x|x)$ represents the probability that $s_j \leq x$ conditional on $s_i = x$ and $\Phi(.)$ is bounded as $x \to \underline{s}$. For equilibrium, it is assumed that:

1. if $\Phi(s') = 0$, then $x = s'$ is an equilibrium cut-off;
2. $x = \underline{s}$ is an equilibrium cut-off;
3. if $\Phi(\overline{s}) \leq 0$, then $x = \overline{s}$ is an equilibrium cut-off;
4. if $E[\rho|s_i = \overline{s}, s_j = \overline{s}]$, then there are at least three equilibria: $x\epsilon\{\underline{s}, s', \overline{s}\}$, where equilibria with lower x are preferred.

If $\Phi(s'_j) = 0$ and $\Phi(\overline{s_j}) < 0$, these equilibria are:

$$(\mathbf{1}) \qquad x_j = \underline{s_j} = \underline{s} \Rightarrow \qquad \Phi(\underline{s_j}) = H(\underline{s}|s_i)\Delta(\underline{s}, s_i) = \frac{1-\theta}{2} \geq 0$$

When $x_j = \underline{s_j} = \underline{s}$, reporting is strictly preferred for firm i, for all signal levels, given that the rival (firm j) will report.

$$(\mathbf{2}) \qquad x_j = \overline{s_j} = \overline{s} \Rightarrow \quad \Phi(\overline{s_j}) = H(\overline{s}|s_i)\Delta(\overline{s}, s_i) < 0\ iff\ E(\rho|\overline{s}, x_i)\frac{F_i + G_i}{F_i} < \theta + \frac{G_i}{F_i}$$

If $x_j = \overline{s_j} = \overline{s}$, firm j will not report and not reporting is also strictly preferred for firm i, for all signals, if the condition above holds. This is depicted in *Figure 1*, which shows that firm i is better off not reporting for low values of the the probability of prosecution and for low leniency reductions.

[Figure 1 here]

$$\textbf{(3)} \qquad x_j = s'_j \Rightarrow \qquad \Phi(s'_j) = H(s'_j|s_i)\Delta(s_i, s'_j) \geq 0 \; iff$$
$$H(s'_j|s_i)[\frac{E(\rho|s_i, x'_j)(F_i + G_i) - G_i}{F_i} - \frac{1-\theta}{2}] \geq \frac{\theta - 1}{2}$$

Firm j is indifferent between reporting or not if $\Phi(s'_j) = 0$; it will report if $\Phi(s'_j) > 0$ and it will not report if $\Phi(s'_j) < 0$. This relationship depends on the firm's own threshold level and it is graphed in *Figure 2*. As in (**2**), firm i is better off not reporting for low values of the the probability of prosecution and leniency reductions.

[Figure 2 here]

Finally, the equilibrium strategy pairs are the following:

(R, R) iff: $\begin{cases} (\overline{s_i}, \overline{s_j}) \\ (s'_i, \underline{s_j}) \textit{ and } \Delta(x_i, x_j) \geq 0 \textit{ or } (\underline{s_i}, s'_j) \textit{ and } \Delta(x_j, x_i) \geq 0 \\ (s'_i, s'_j) \textit{ and } \Delta(x_i, x_j) \geq 0,\ \Delta(x_j, x_i) \geq 0 \end{cases}$

(NR, NR) iff: $\begin{cases} (\underline{s_i}, \underline{s_j}) \\ (s'_i, \overline{s_j}) \textit{ and } \Delta(x_i, x_j) \leq 0 \textit{ or } (\overline{s_i}, s'_j) \textit{ and } \Delta(x_j, x_i) \leq 0 \\ (s'_i, s'_j) \textit{ and } \Delta(x_i, x_j) \leq 0, \Delta(x_j, x_i) \leq 0 \end{cases}$

(R, NR) or (NR, R) iff: $\begin{cases} (s'_i, \underline{s_j}) \textit{ and } \Delta(x_i, x_j) \leq 0 \textit{ or } (\underline{s_i}, s'_j) \textit{ and } \Delta(x_j, x_i) \leq 0 \\ (s'_i, \overline{s_j}) \textit{ and } \Delta(x_i, x_j) \geq 0 \textit{ or } (\overline{s_i}, s'_j) \textit{ and } \Delta(x_j, x_i) \geq 0 \\ (s'_i, s'_j) \textit{ and different signals for } \Delta(x_i, x_j) \textit{ and } \Delta(x_j, x_i) \end{cases}$

Relationship between the thresholds

A2: For simplification, assume both firms are charged the same level of overcharges: $G = G_i = G_j$.

If firm i receives a higher fine, then from equation (*4*) and at the threshold level, it follows that:

$$F_i > F_j \leftrightarrow \frac{1 - E[\rho|x_i*, x_j*]}{E[\rho|x_i*, x_j*] + \frac{1-H(x_j*|x_i*)}{H(x_j*|x_i*)}\frac{1-\theta}{2} - \theta} > \frac{1 - E[\rho|x_j*, x_i*]}{E[\rho|x_j*, x_i*] + \frac{1-H(x_i|x_j*)}{H(x_i|x_j*)}\frac{1-\theta}{2} - \theta} \quad (5)$$

(i) If both firms perceive the likelihood of conviction as being the same, such that $E[\rho|x_j*, x_i*] = E[\rho|x_i*, x_j*] = E[\rho]$ and given that $\frac{\partial H(x_j*|x_i*)}{\partial x_i*} < 0$ *and* $\frac{\partial H(x_i*|x_j*)}{\partial x_j*} < 0$, equation (*5*) becomes:

$$H(x_j * |x_i*) > H(x_i * |x_j*) \leftrightarrow x_j* > x_i*$$

Proposition 2a: If $E[\rho|x_j*, x_i*] = E[\rho|x_i*, x_j*]$, there exists a BNE in which the firm with the highest sales level has a lower reporting threshold: $F_i > F_j \leftrightarrow x_j* > x_i*$.

(ii) If firms' expectations on the likelihood of being caught, are different such that $E[\rho|x_j*, x_i*] - E[\rho|x_i*, x_j*] = \alpha$, where $\alpha\epsilon]-1, 1[$, equation (*5*) becomes:

$$H(x_i * |x_j*) < H(x_j * |x_i*)\frac{1 - E[\rho|x_i*, x_j*]}{H(x_j * |x_i*)\alpha + 1 - E[\rho|x_i*, x_j*] - \alpha}$$

When α is large, then $|F_i - F_j|$ becomes smaller and the expression above is equivalent to: $x_j* < x_i*$.

Proposition 2b: If $E[\rho|x_j*, x_i*] - E[\rho|x_i*, x_j*] = \alpha$, where $\alpha \neq 0$, and when $|F_i - F_j|$ is sufficiently small, then there exists a BNE in which the firm with the highest sales level has a lower reporting threshold: $F_i > F_j \leftrightarrow x_j* < x_i*$. This leads to an asymmetric equilibrium.

THEOREM 2: When $|F_i - F_j|$ is sufficiently small, there exists an asymmetric BNE in which $x_j* < x_i*$ and one in which $x_j* < x_i*$.

Each firm's beliefs on the likelihood of being caught are based on the same true value, thus being correlated and likely to be sufficiently similar. In this case, the cartel member with the highest level of expected fines has a lower equilibrium threshold for reporting and, in equilibrium, it will be the first reporting member, provided that the signal received is above its threshold level. When firm's expectations are biased and thus, very different, then an asymmetric BNE arises. The sources of fine variation are discussed in the following section.

This model can easily be extended to a larger number of firms, where the cartel member with the highest expected fine value will have the lowest reporting threshold and it will be the first reporter in the cartel. Similarly, it can easily be modeled from a pre-cartel environment where firms decide whether or not to enter the cartel, given their expectations on the potential fine level and the signals received, but this does not affect the results, provided that collusion occurs and that the profits from being in the cartel grow at a slower rate than the fine. Considering a game with ongoing collusion yields the same results.

3 Leniency Programs in the US and EU

US Leniency Programme

The DOJ's decision on the cartel fines is made in accordance with the *U.S. Sentencing Guidelines* and is, in the vast majority of cases, followed by a plea bargaining. According to *Chapter 8* of the Guidelines, the fine is set as:

$$F^{US} = TR^a b\theta\theta^a\theta^m\eta \Rightarrow \qquad F_i > F_j \leftrightarrow TR_i^a \frac{\theta_i\alpha_i\theta_i^a\theta_i^m\eta_i}{\theta_j\alpha_j\theta_j^a\theta_i^j\eta_j} > TR_j^a \tag{6}$$

TR^a denotes the basic fine[7], θ is the share of fine paid after the leniency reduction and α is the percentage of fine which is paid in case of inability to pay ($\alpha\epsilon[0, 1[$). $\theta^a\theta^m$ is the fine adjustment downwards (m≡ mitigating factors), in case of cooperation with the authorities, when the members are also victims or when remedial costs are larger than gains; or upwards (a≡ aggravating factors), in the cases of threat to individual's life, national security, environment or market, if it is a public entity or if it involved official corruption. η denotes the culpability score ($\eta\epsilon[0.05, 4]$).

The US Leniency Programme grants full immunity to the first firm coming forward ($\theta = 0$), whereas the other firms receive no leniency reduction. However, plea bargaining is present in over 90% of cartel offenses and the settlements often lead to a

[7]The basic fine is calculated as the maximum value between the amount in the fine Guidelines' table (*8C2.3*); the pecuniary gain to the firm from the offense; or the pecuniary loss from the offense caused by the organization, to the extent the loss was caused intentionally, knowingly, or recklessly.

reduced fine for the subsequent cartel members. Firms are also liable for the damages caused by the cartel's activity[8]. It is possible that the values of the prior probability of conviction (ρ) are higher in the US than in the EU, due to the *Amnesty Plus Program*, which benefits prosecuted cartel members who disclose previously undetected cartels.

Hypothesis 1a: *Firms which have previously colluded and/or which have a higher culpability score should receive larger US fines and are more likely to be the initial reporting firm.*

Hypothesis 1b: *The cartel leader should receive a larger US fine but will not receive immunity from fines, since the DOJ excludes leaders from receiving immunity*[9].

Hypothesis 1c: *US fines should be higher for longer and larger cartels, large markets and large market share, and when sales are higher.*

EU Leniency Programme

The EU fine is set in accordance with the *EU Guidelines on the method of setting fines*[10]. Bos and Schinkel (2006) interpret it as[11]:

$$F^{EU} = \theta^a \theta^m (0.3\eta CD + 0.25\kappa) TR^a \leq 10\% TR^W \Rightarrow F_i > F_j \leftrightarrow \frac{\theta_i^a \theta_i^m}{\theta_j^a \theta_j^m} TR_i^a > TR_j^a \quad (7)$$

The parameters $\theta^a \epsilon [1, 2]$ and $\theta^m \epsilon]0, 1]$ capture the value of aggravating and mitigating circumstances. The gravity of the infringement is given by $\eta \epsilon]0, 1]$ and CD measures the duration of the cartel, based on the available evidence. $k = 0$ or $k \epsilon [\frac{3}{5}, 1]$ captures the possibility of levying an entry fee. The value of affected sales is given by TR^a and the fine is capped at 10% of the total worldwide turnover of the firm in the previous year (TR^W).

[8] According to the *Antitrust Criminal Penalty Enhancement and Reform Act* of 2004, a firm awarded leniency is only liable for single, and not treble, damages. Therefore, a firm who reports the cartel would pay eg.: $0 + \frac{G}{3}$, given that $F = 0$ and $G_{reporter} < G_{others}$.

[9] See US Department of Justice (n 28) 2.

[10] The current fine guidelines were imposed pursuant to Article 23(2)(a) of Regulation No 1/2003, 2006/C, 210/02. For further information refer to the Guidelines, available at: http://ec.europa.eu/competition/antitrust/legislation/fines.html.

[11] The original formula is $F = \theta^a \theta^m (0.3\eta n + 0.25\kappa) TR^a$, where $CD \equiv n^{Bos,Schinkel}$

The leniency reductions for reporting and/or cooperating firms are set as stated in *Table 2*.[12] In a duopoly, the first reporter receives full immunity (θ =0) and the second receives a maximum fine reduction of 50% ($\theta \geq 0.5$).

[Table 2 here]

Hypothesis 2a: *In the EU, firms who have larger sales, act as the cartel leader, are repeat offenders or do not cooperate with the authorities, should receive larger fines.*
Hypothesis 2b: *EU fines should be higher for longer and larger cartels and for those which affect a larger market*.

The next section explores data on cartels convicted in the US and/or EU, to verify the above stated hypothesis. The signal, and its distribution, which are the core of the theoretical model, are of course not observed and are thus not included in the empirical analysis. A higher value of sales is often linked to a large market share and may be due to lower costs or higher productivity. The components of sales are not incorporated in the model ($TR_i^a = P_i Q_i^a$) because although the variation in sales is likely to be correlated with the timing of reporting, it is also likely to be constant over time.

4 Data

The US data employed in the empirical analysis is an excerpt from John Connor's *Private International Cartels* dataset.[13] This excerpt covers the years 1984 to 2009 and is limited to publicly reported information on 799 cartels, in a total of 2,310 firms.

Data on EU cartel cases was collected by the author through publicly available summary reports and associated press releases of the antitrust cases handled by the

[12]The current fine guidelines are "Guidelines on the method of setting fines" imposed pursuant to Article 23(2)(a) of Regulation No 1/2003, 2006/C, 210/02. For further information refer to the Guidelines, available at: http://ec.europa.eu/competition/antitrust/legislation/fines.html. For the setting of Leniency Reductions, please refer to "Commission Notice on immunity from fines and reduction of fines in cartel cases". Official Journal of the European Union C298, p.17.

[13]Private International Cartels spreadsheet by John M. Connor, Purdue University, Indiana, USA (January 2012).

European Commission and accessible via the Commission's website. Cartels are restricted to those with at least one successful LP application (81 cartels), as there is no publicly available information on the value of the individual fines in the other 17 cartels fined during this period and with final decisions in the period of 1998 to 15th July 2011.[14]

Some of the EU reports were triggered by a previous investigation and/or fine in another jurisdiction. At least 25% of the cartels reported to the EU Commission by a cartel member, were first convicted in the US, and at least another 20% were convicted by US and EU authorities in the same year[15]. A further 6% were fined by the EU Commission before a US conviction. The remaining cases were discovered due to other reasons, such as reporting by a third party (e.g. a customer or rival firm) or under the Commission's own initiative, perhaps by observing the evolution of prices. On average, 38 cartel members are fined per year and 18 leniency reductions and 7 reductions for mitigating circumstances are granted each year. *Table 3* describes the datasets which have been used by other authors in the analysis of cartel cases.

[Table 3 here]

Repeat offenders are a serious issue and the LP Notices are not explicit as to whether or not they should receive a lower fine reduction, if any. The 2006 EU Leniency Notice states that a repeat offender is any firm that was previously found to infringe Articles 101 or 102 of the EU Treaty, whereas the DOJ defines it as any firm that "after release from custody for having committed a crime, is not rehabilitated".[16] In the US, 351 firms are identified as repeat offenders[17] (11%), whereas in the EU only

[14]Cartels, other than cases, are analyzed in this article, because within the same case there may be several cartels, possibly with different members and different fines and fine reductions. The 81 cartels correspond to 63 cases. The first decision applying the LP to a cartel case was in 1998, on a cartel involving British Sugar. The complaint was made in 1994 and after the introduction of the LP, all four cartel members applied for leniency. Three reductions of 10% and one of 50% were granted.

[15]A further 4% of the cases were also convicted in the EU and US but there is no information on the year of conviction in the US.

[16]Michael D. Maltz, Recidivism 54 (1984), available at http://www.uic.edu/depts/lib/forr/pdf/

[17]The number of repeat offenders may be underestimated as some of the firms are anonymous, which makes it hard to identify their participation in other cartels.

6 firms (2%) fall under the above description (*RO*).

Nonetheless, if an investigation of a cartel member was initiated after all the cartels in which it participated had ended, the firm still has an incentive to report the other cartel(s) and apply for the LP if it believes that the probability of conviction is high. It does not seem to be the case that firms report cartels in different markets, as it happens with the US *Amnesty Plus Programme*, but arguably firms learn how to use the LP to their own benefit, either by learning how to report or how to collude and be the first reporter. Therefore, a broader definition of the term is also considered for the EU cases, defining a multiple offender as any firm that was convicted for collusion at least twice, which corresponds to 16% of the EU firms in the analysis (63/385) (*MO*). This issue is implicitly included in the theoretical model as the initial fine is increased in the case of recidivism. Both definitions are considered in the empirical analysis to distinguish between repeat and multiple offenders.

One other concern with the data is the possibility of sample selection bias. Given that cartels are illegal, they operate secretely so the available data only include cartels that were prosecuted and convicted. This issue can not be overcome, but its existence is acknowledged in the interpretation of the results. There may also be individual unobservable characteristics of repeat offending firms that determine their repeated participation in cartels, but this analysis is outside the scope of this article. The term "*single offender*" may also be misleading, either because the firm took part in an undiscovered cartel or because the cartel for which it is being prosecuted has not yet been convicted. Again, there is nothing that can be done with regards to this issue other than to acknowledge that the number of repeat offenders may be an underestimate.

Lastly, the variable which accounts for the duration of the cartel may be biased, because it measures the number of months for which the cartel was fined and not the true duration of the cartel. Some of the official EU reports mention suspicions of a longer duration, but the lack of evidence dictates that the fine is set for a shorter time period. In the US, the duration of the cartel is often used as an argument for plea bargaining and so the data available is the result of an agreement and not necessarily the true cartel duration.

Tables 4 and *5* define and summarize the variables for use in the model specifica-

tions.

[Table 4 here]

[Table 5 here]

5 Method

Building on the theoretical construct from *Sections 2* and *3*, the canonical specifications of the EU and US models are of the following form:

$$\begin{aligned} Immunity\_US_{ijts} &= \beta_0 + \beta_1 log(NF)_{jts} + \beta_2 RO_{ijts} + \beta_3 NRO_{jts} + \beta_4 leader_{ijts} \\ &+ \beta_5 many\_buyers_{jts} + \beta_6 mod\_buyers_{jts} + \beta_7 cartel.dur_{jts} \\ &+ \beta_8 cartel.dur2_{jts} + \beta_9 S\_US\_cartel_{jts} + \beta_{10} S\_EU\_cartel_{jts} \\ &+ +\beta_{11} Prison\_US_{ijts} + \beta_{12} Fine\_EU_{ijts} + \beta_{13} Fine\_US_{ijts} \\ &+ \varpi T_t + \delta S_s + \varepsilon_{ijts} \end{aligned}$$

$$\begin{aligned} Immunity\_EU_{ijts} &= \beta_0 + \beta_1 log(NF)_{jts} + \beta_2 RO_{ijts} + \beta_3 MO_{ijts} + \beta_4 NRO_{jts} + \beta_5 NMO_{jts} \\ &+ \beta_6 fine.increase_{ijts} + \beta_7 oth.red_{ijts} + \beta_8 eea_{jts} + \beta_9 Firm1post_{ijts} \\ &+ \beta_{10} Def.Turnover_{ijts} + \beta_{11} LP\_1996_{jts} + \beta_{12} LP\_2002_{jts} \\ &+ \beta_{13} log(inv.dur)_{jts} + \varpi T_t + \delta S_s + \varepsilon_{ijts} \end{aligned}$$

where i, j, t and s are the indices for firm, case, decision year and sector, respectively and for each case. ϖ and δ are the vectors of year (T) and sector (S) dummies, respectively, and ε is the error term, which is assumed to be *i.i.d.*.

The dependent variable is a dummy which takes the value of one if the firm reported the cartel and received immunity from fines, in the EU or the US. The components of the fine, as described in the theoretical model, are included in the above specifications: the number of cartel members ($log(NF)$), repeat and multiple offender dummies (RO and MO) and the number of repeat and multiple offenders per cartel (NRO and NMO). Proxies for the value of the individual sales level are also included, either using the deflated turnover of the firm ($Def.Turnover$) or the sales level of the cartel (S_EU_cartel

and S_US_cartel), as data on individual sales is not available for a large share of the sample. The fine adjustments are accounted for through aggravating circumstances, which include being the cartel leader and the type of market affected by the cartel ($fine.increase^{EU}$, $many\_buyers^{US}$, mod_buyers^{US}, $Prison\_US^{US}$ and $leader^{US}$), mitigating circumstances, including the geographic magnitude of the cartel's impact and cooperation with the investigation outside the LP ($oth.red^{EU}$, eea^{EU} and $inv.dur$), and leniency applications (LP^{EU} and $Firm1post^{EU}$). Additionally, information on cartel duration ($cartel.dur$), the fines paid by firms prosecuted in both EU and US ($Fine\_EU$ and $Fine\_US$) and controls for the different EU Leniency Programmes of 1996, 2002 and 2006 (LP_1996 and LP_2002) are also included.

Given that the dependent variable has a binary outcome, the appropriate regression method is a probit.[18] The restriction of homoscedasticity is tested and the likelihood-ratio shows that at the 5% level, there is no improvement from generalizing the homoscedastic model. Variable addition tests were also carried to support the inclusion of the variables in the probit model.

To further test the theoretical results, the sources of firm heterogeneity are also examined through the analysis of the level of fines and cartel sales or turnover for US ($FG\_total\_US_{ijts}$ and $Sales\_cartel\_US_{ijts}$) and EU prosecutions ($Def.Fine\_EU_{ijts}$ and $Def.Turnover\_EU_{ijts}$). To test these models, OLS estimations are used and several robustness checks are presented.

6 Results

US Cartels

The results of the model specifications which concern the US cartel decisions can be found in *Table 6*. Columns (4) and (5) introduce year and sector controls, respectively and the sample size drops given that some of the years and sectors have no variability to be explained by the dependent variable.

[18] The results show that the log-likelihood values from the probit specifications are larger than those from using the logit, so the probit model is chosen.

Data on the individual turnover are not available, but sales and overcharges are likely to be larger for the cartel leader. Although this creates a further incentive to report the cartel, the US DOJ guidelines state that leaders can not receive immunity from fines. It is thus surprising that the results show that the leader seems to be more likely (by 1 to 2 percentage points) to report and receive immunity from fines. The cartel leader is identified as the firm mentioned in the DOJ decision as a ringleader or mentioned in the history of the case as the cartel disciplinarian/bully. This result suggests that different definitions of ringleaders are used, or that the rule is not always enforced. Nevertheless, this result is in line with the findings from the theoretical model and with the empirical results on the determinants of cartel fines discussed below.

Repeat offenders are a highly debated issue. Connor (2010) has suggested that there is evidence of a large amount of recidivism and he identifies 389 recidivists worldwide in the period between 1990 and 2009. This number constitutes 18.4% of the total number of firms involved in 648 international hard-core cartel investigations and/or convictions. However, Werden et al. (2011) 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 how cartel members who merge and form a new firm are dealt with. Werden et al. (2011) follow the legal practice (DOJ and EC) and suggest that no repeat offenders have been fined in the US, since 1999. Surprisingly, the results from *Table 6*, which use Connor's data, show that repeat offenders are more likely to receive immunity from fines (6 to 8 percentage points). Even more serious is the fact that this likelihood is larger with each additional repeat offender in the cartel.

With regards to the geographical location, cartels which act in markets with a moderate and, to a lesser extent, large number of buyers (as opposed to small) are more likely to have one of their members applying for leniency and receiving immunity from fines. Firms in shorter and smaller cartels are also more likely to report and obtain immunity, perhaps because collecting evidence is easier and/or quicker. Finally, firms who receive lower fines in a EU conviction of the same cartel are also more likely to receive fine immunity in the US, which could be because they are quicker to report the cartel to the US DOJ. In the dataset, 52 of the 598 US cartels were also convicted

by EU authorities, with (at least) 6 and 23 of these cartels having been initially fined by EU and US authorities, respectively.

The predicted probability of receiving immunity is shown to be larger in the rubber and plastics (sector 16) and paper and printing (sector 11) sectors. These sectors only represent 6% and 4% of the cartel cases in the analysis, so the results are not driven by the number of cases but by specific characteristics of these sectors, such as being highly competitive, and which lead to a larger number of leniency applications.

[Table 6 here]

Table 8 shows the determinants of US fines and the sales levels of cartel members fined in the US, which are shown to be positively correlated. The analysis also reveals that repeat offending firms have higher sales and face lower monetary penalties (fine and overcharges), although these numbers decrease with the number of repeat offenders per cartel. As expected, the sales of the cartel leader are larger and sales are larger in both bid-rigging cartels and markets with many buyers. Bid-rigging cartels, as well as shorter ones, are also those in which the penalties are lower. Firms in cartels which are smaller in terms of the number of members, have lower sales and face lower penalties. Therefore, the sources of firm heterogeneity are recidivism, leadership of the cartel and the value of sales and overcharges.

[Table 8 here]

EU Cartels

The results of the model specifications for the EU cartel cases are shown in *Table 7*. Columns (2), (4) and (6) introduce year and sector controls, but the sample size drops as some of the years and sectors have no variability to be explained by the dependent variable.[19]

Although the Leniency Programme Notice excludes firms with a leading role from receiving immunity, it makes no statement regarding repeat offenders.[20] The results

[19]These variables are dropped so that Stata can converge on a solution to the regression problem.

[20]Recidivism is included in the aggravating circumstances in the setting of the original fine, as previously stated. However, the setting of fine and leniency reductions are independent and the fine guidelines are very

show that firms which have colluded more than once are around 15 percentage points more likely to report the cartel and receive immunity from fines. For sequential repeat offenders, this number is even larger at around 42 to 44 percentage points, at the mean values of the other explanatory variables (see *MO* and *RO* variables). It is somewhat reassuring that for each additional repeat offender in the cartel, the predicted probability of immunity is 6 to 7 percentage points lower.

To verify the results from the theoretical model, the sample is split into cartels which were reported after the end of the cartel (columns *10-12*) and those which were reported during the cartel activity (columns *7-9*). The results show that in the cases where the cartel had already ended at the time of the reporting, repeat offenders are 59 percentage points more likely to apply for and receive immunity from fines, whereas this variable is not significant in the remainder of the cases.

Repeat offending firms should receive higher initial fines, so these findings reinforce the theoretical result that firms who receive larger fines will be the initial reporter and show that post-cartel reports match the theory model, whereas the other cases do not necessarily match it. It may be that repeat offenders are also larger in terms of sales or have better knowledge of how to interpret the signals received, perhaps due to their previous collusive agreements, and thus, are better at choosing the timing of the report and what evidence to provide the European Commission with. Although it is in the authorities' interest to give incentives to the reporting of a cartel, legislation should ensure that the deterrence effect is not diminished by the existence of excessive leniency reductions.

The likelihood of being granted immunity decreases by 0.05 to 0.08 percentage points when the number of firms in the cartel increases by 1% (see *log(NF)*), which may be because extensive and accurate evidence regarding the participation of all the cartel members is harder to find. Although the revisions to the EU LP increased its generosity in terms of fine reductions, the requirements to obtain each category of leniency reductions may indeed be stricter. Nonetheless, it is shown that the predicted probability of immunity in cartels which were reported after its end, is lowest in the LP of 1996, whereas the opposite is true for cartels which were still active at the time of

strict and appear to allow very little if any "discretion".

the reporting (see *LP*_1996 and *LP*_2002).

Firms in longer cartels are also more likely to receive immunity from fines. For each additional 0.03 days of ongoing cartel activity, the likelihood of receiving immunity increases by 9 percentage points, although this occurs at a decreasing rate (see *cartel.dur* and *cartel.dur*2).

The results also show that, if the cartel is over at the time of reporting, then the granting of reductions outside the LP does indeed affect the likelihood of immunity. Firms who received other reductions are 47 to 58 percentage points less likely to apply for and receive immunity from fines (see *oth.red*). Although this could be due to firms claiming not to know that the agreement was illegal, it could also be that firms apply for other reductions if they do not expect to receive a (large) leniency reduction. Contrarily, fine increases don't seem to affect immunity from fines.

The absolute value of the individual turnover ($Def.Turnover$) is not significant in explaining immunity from fines. This is as expected, because it is not the absolute value of the turnover but its worldwide scale relative to the other cartel members which is the important factor influencing the decision to report. The lack of information on each firm's individual turnover and the difficulties in finding an appropriate measure of sales, make its empirical interpretation challenging. However, repeat offenders do receive additional fine increases and this result is thus in line with the theoretical findings from *Section 2*.

Cartels in the fine art auctions' sector (sector 9) are those in which most pre-investigation reports occurred, but only account for 1% of the total cartels fined by the EU. Conversely, cartels in the transport and videotapes, videos and LCDs sectors (sectors 6 and 8) are those where the predicted probability of immunity is lower, which may be because these are very competitive sectors with a large number of small firms and where future punishment from the other cartel members may be less feasible.

[Table 7 here]

To shed some light on the determinants of EU sales and fines, *Table 9* presents a similar analysis. As expected, the results show that the fine is larger for firms with higher levels of turnover, multiple offenders and firms in longer cartels. However, fines

are not larger for repeat offenders and in fact, they are smaller for a larger number of repeat offenders per cartel. In addition, it is shown that shorter investigations lead to larger fines, perhaps because when the initial reporting occurs, more and/or better evidence is revealed to the European Commission. It is, however, surprising that firms who receive reductions outside the LP seem to have a higher turnover, which could be due to a lower involvement in the cartel or cooperation outside the LP. The sources of firm heterogeneity in the EU are thus recidivism, aggravating and mitigating circumstances, such as being the cartel leader, and the value of the firm's turnover.

[Table 9 here]

7 Discussion

When the perceived probability of conviction is high, firms are more inclined to report the cartel. This prosecution effect is magnified by the existence of the EU and US Leniency Programmes, which are designed to dissolve existing cartels and deter new cartels from forming. In addition, a pre-emption effect exists as when firms believe that the other firm's signal is such that they will report, then the firm has an incentive to be the first reporter and apply for a fine reduction within the Leniency Programme.

Although the issue of the adequacy of fine reductions has been widely analyzed, identifying the characteristics of the reporting firms represents a gap in the current literature. This article extends Harrington's (2013) analysis and is the first to examine the case of firms which are heterogeneous in terms of the expected value of their fine and which receive private information on the probability of investigation and conviction by the authorities. This article is also the the first to empirically examine this issue.

The theoretical model shows that when the level of fines differs among firms, the threshold for reporting is also different. This is, if firms expect to receive a higher cartel fine, then their equilibrium threshold for reporting is lower, provided that the expectations on the likelihood of conviction are sufficiently unbiased. This finding has major policy implications, as identifying the most likely reporter in a cartel is key to designing a successful Leniency Programme.

Although the signal is a core part of the theoretical model, it is not present in the empirical analysis because it is not feasible to measure firms' expectations on the likelihood of being convicted. A higher signal lowers the firm's threshold level for reporting, so competition authorities should aim at increasing these signals. This could be done, for example, through unannounced inspections, screenings and requests for information or for a meeting with a firm's representative. These measures would supplement and enhance leniency. However, firms may be aware that competition authorities can "cheat" by sending higher signals, so it is essential that these are credible. The theoretical results are further tested with the division of EU data between cartels which were reported before and after their end.

The empirical results shed some light on the sources of fine heterogeneity, i.e., the characteristics of the reporting cartel members, as well as those of the cartels to which they belong. It is shown that EU firms who reported the cartel and received immunity from fines through the LP are typically repeat or multiple offenders and are less likely to have received other fine reductions, although in the US the reporting firms are more likely to be the cartel leader. The main sources of fine heterogeneity are thus recidivism and leadership of the cartel, which are in line with the findings from the theoretical model and illustrate the need for more proactive competition authorities, as mentioned above.

When the EU data are divided, the results show that repeat offenders are much more likely to receive immunity if they report once the collusive agreement ended. In contrast, firms who received other reductions are much less likely to apply for and be granted immunity if the cartel is over. These results support the findings from the theory model which relate to post-cartel behavior.

Some of the characteristics of the cartels in which pre-investigation reporting occurred are also unveiled. In the EU, these cartels tend to be smaller in terms of the number of members (and also number of repeat and multiple offenders) and tend to impact a geographical area wider than just the EEA. Reporting is 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 who also took part in the cartel. In the US, the predicted probability of immunity is significantly larger in the rubber and

plastic sector and the paper and printing sector, as well as in markets with a moderate number of buyers. These sectors are characterized by a large number of firms and it may well be the case that long-term punishment from the other cartel members is not credible.

Knowing the characteristics of the reporting firms and of the cartels in which they take part is vital to provide the correct incentives for firms so as to dissolve and dissuade cartels. The Leniency Programme should therefore be in line with these incentives.[21]

[21]The results also draw important implications for the tax revenue literature. The main issues in dealing with tax offenders are the size of the penalties and deciding who to audit. The results of this article allow to infer that when the correct incentives are in place, firms with the largest levels of sales or market share (the industry leaders) will more likely report tax infractions, so auditing should focus on smaller firms.

8 Tables and Figures

Table 1: Description of the variables from the theoretical model

Variable	Definition
$k = i, j$	cartel members, N=2
$s_k \epsilon [\underline{s}, \overline{s}]$	private signal on the probability of conviction
$x_k \epsilon [\underline{s}, \overline{s}]$	reporting threshold level of the signal
$\phi(s_i, s_j)$	firm's strategy pair
R, NR	firm's decision to report or not report
F_k	individual fine paid by each cartel member
	$F_k = f[recidivism(RO)]$
$\theta = 1 - LRed$	share of the fine paid after the leniency reduction (LRed)
G_k	overcharges paid by each cartel member
Y_k	sales level of the individual firm
ρ	probability that a cartel is investigated and convicted
$H(s_j \vert s_i)$	firm i's CDF on firm j's signal conditional on its own signal
$\Delta(s_j, x_i) = V_i^R - V_i^{NR}$	additional value from reporting for firm i

Table 2: Leniency reductions

	LP 1996	LP 2002 and 2006
1st reporter, before investigation	≥75%	100%
1st reporter, after investigation	50-75%	30-50%
1st firm cooperating	10-50%	30-50%
2nd firm cooperating	10-50%	20-30%
subsequent firms cooperating	10-50%	≤20%

Source: Author's interpretation of European Commission's Notices on the LPs.

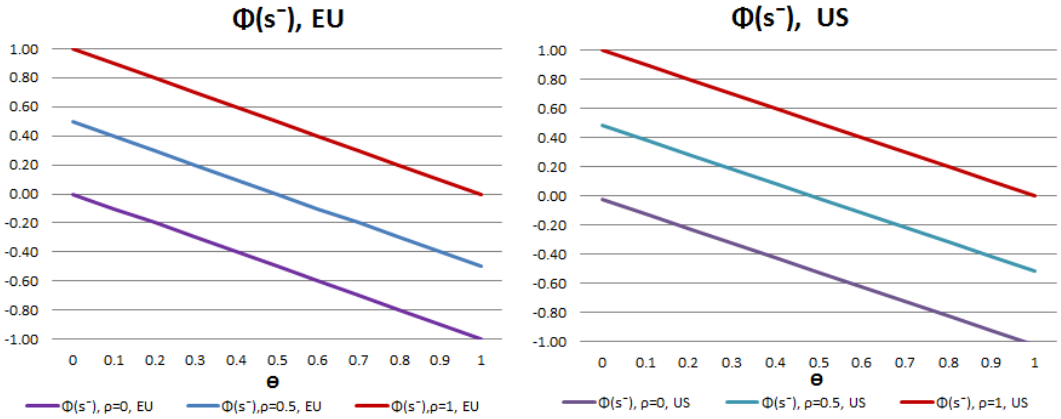

Figure 1: Probability that one firm reports, conditional on its signal being lower than its reporting threshold and when the other firm does not report: $\Phi(\bar{s})$, when $\widehat{F(US)} = 24600$, $\widehat{G(US)} = 565.43$, $\widehat{F(EU)} = 10190$ and $\widehat{G(EU)} = 0$, for several values of θ.

Table 3: Dataset and analysis of cartels

Author	Data	Number Cartels	Number Firms	Analysis	Time Period
?	Asia	377		*Descriptive Statistics*	1990-2007
Berinde (2008)	EU	78		*Descriptive Statistics*	1990-2008
Veljanovski (2010)	EU	63		*Descriptive Statistics*	1999-2007
Asker (2010)	US	1		*Descriptive Statistics*	2001-2002
Connor (2010)	US	799	2310	*Descriptive Statistics*	1984-2009
Borrell and Jimènez-Gonzalez (2008)	world	47		Antitrust effectiveness	2003-2004
Levenstein and Suslow (2011)	EU,US	81		Cartel duration	1990-2007
Sjoerd (2005)	EU	67	399	Fine, Gravity, Inv.Duration	1990-2005
Brenner (2009)	EU	61	232	Fine, Investigation Duration	1990-2003
Marvao (2012)	EU	81	385	Leniency Reduction	1998-2011
Miller (2009)	US	342		Cartel discoveries	1985-2005

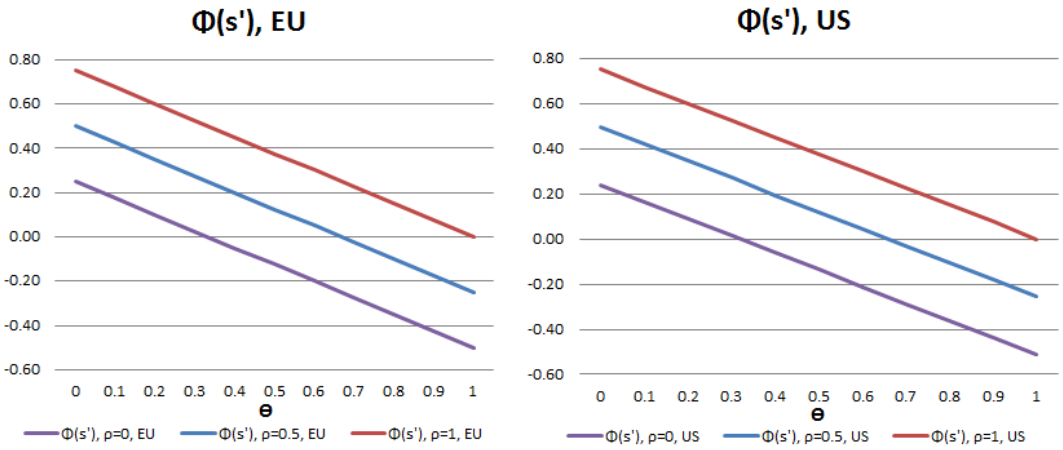

Figure 2: Probability that one firm reports, conditional on its signal being lower than its reporting threshold and when the other firm is indifferent between reporting or not: $\Phi(s')$, when $\widehat{F(US)} = 24600$, $\widehat{G(US)} = 565.43$, $\widehat{F(EU)} = 10190$, $\widehat{G(EU)} = 0$ and $H(s_j|s_i) = 0.5$, for several values of θ.

Table 4: Summary statistics - US data

Variable		Obs	Mean	Std. Dev.	Min	Max
firm(id)		2200	1273.52	743.79	1	2535
cartel		2310	332.32	191.67	1	799
sector		2310	16.26	7.74	1	28
t(fine)	year in which the cartel was fined	2310	2004.76	5.17	1984	2011
immunity_US	dummy (=1) if the firm received immunity of fines	2310	.02	.14	0	1
FG_total	total fine and overcharges paid by each firm in US and EU	1001	4698.90	17505.16	0.13	245704
Sales_cartel	sales of the cartel in the US and EU	2275	9010.56	42710.72	0	800000
NF (firms)	number of firms in the cartel	2310	15.18	21.86	2	112
log(NF)	logarithm of NF	2310	2.25	0.87	0.69	4.72
leader	dummy (=1) if the firm is the cartel leader	2310	.17	.37	0	1
many_buyers	dummy (=1) if the cartel's market has many buyers	2310	.67	.47	0	1
mod_buyers	dummy (=1) if the cartel's market has a moderate number of buyers	2310	.08	.27	0	1
RO	dummy (=1) if the firm is a repeat offender	2310	2.93	5.64	0	27
NRO	number of repeat offenders per cartel	2310	3.36	3.78	0	20
bid_rigging	dummy (=1) if it is a bid-rigging cartel	2310	.45	.50	0	1
cartel.dur	cartel duration, in months	2308	472.43	3016.61	0	24120
cartel.dur2	squared cartel duration	2308	9319192	7.29e+07	0	5.82e+08
cartel_share	cartel share, in %	921	1.61	8.36	.09	97
S_US_cartel	sales of the cartel in the US	2286	5257.90	38387.78	0	800000
S_EU_cartel	sales of the cartel in the EU	2297	3691.56	10760.25	0	116460
Fine_US	fine paid by the firm to the US	2265	3.75	25.69	0	579
Fine_EU	fine paid by the firm to the EU	2255	10.19	49.48	0	1137.7
Prison_US	months of prison in the US	2303	.69	6.27	0	126

Table 5: Summary statistics - EU data

Variable		Obs	Mean	Std. Dev.	Min	Max
firm(id)		553	179.24	110.55	1	373
cartel		553	47.43	26.93	1	93
sector		553	2.77	2.02	1	9
t(fine)	year in which the cartel was fined	553	2006.47	4.07	1998	2013
immunity_EU	dummy (=1) if firm received immunity of fines	553	0.12	0.33	0	1
Def.Turnover	deflated turnover of the firm, in t-1	553	14.37	172.25	0	3767.17
Def.Fine	deflated fine paid by the firm	553	33.14	72.01	0	981.03
NF(firms)	number of firms per cartel	553	8.05	4.12	2	17
log(NF)	logarithm of NF	553	1.94	0.56	0.69	2.83
Firm1pre	dummy (=1) if first pre-investigation reporter	553	0.10	0.30	0	1
Firm1post	dummy (=1) if first post-investigation reporter	553	0.20	0.40	0	1
r_aft_end	dummy (=1) if firm reported after the end of the cartel	553	0.35	0.48	0	1
RO	dummy (=1) if firm participated in at least 2 sequential cartels (repeat offender)	553	0.04	0.19	0	1
NRO	number of repeat offenders per cartel	553	0.20	0.39	0	2
MO	dummy (=1) if firm participated in at least 2 cartels (multiple offender)	553	0.38	0.49	0	1
NMO	number of multiple offenders per cartel	553	2.25	2.00	0	9
fine.increase	fine increases received by a firm (%)	553	0.23	0.52	0	2.9
eea	dummy (=1) if cartel only affects the EEA market	553	0.69	0.46	0	1
LP	dummy (=1) if the cartel was found due to a leniency application	553	0.76	0.43	0	1
oth.red	reductions received by a firm, outside the LP (%)	553	0.03	0.10	0	1
cartel.dur	duration of the cartel, in months	553	90.44	72.52	2	419
carteldur2	squared cartel duration	553	13429.67	24623.8	4	175561
inv.dur	investigation duration, in months	553	46.65	21.24	3	96
log(inv.dur)	logarithm of inv.dur	553	3.71	0.58	1.10	4.56
invdur2	squared investigation duration	553	2626.401	2241.239	9	9216
LP_1996	dummy (=1) if the LP of 1996 was in place	553	0.20	0.40	0	1
LP_2002	dummy (=1) if the LP of 2002 was in place	553	0.43	0.50	0	1

Table 6: Regression results - Probit - US data

(immunity_US)	(1)	(2)	(3)	(4)	(5)
cartel.dur(x10k)	-0.01**	-0.02***	-0.02***	-0.02**	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
many_buyers	0.02***	0.02***	0.02***	0.02***	0.01
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)
mod_buyers	0.06*	0.08*	0.07*	0.05	0.13
	(0.03)	(0.04)	(0.04)	(0.04)	(0.14)
leader	0.01*	0.02*	0.01	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
RO(x100)	0.07**	0.08**	0.06*	0.05	0.02
	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)
NRO(x100)	0.07	0.11	0.15*	0.18*	0.07
	(0.07)	(0.09)	(0.09)	(0.10)	(0.08)
Prison_US	-0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
S_US_cartel	-0.00	0.00	0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
S_EU_cartel	0.00	-0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fine_EU(x100)	-0.06***	-0.05**	-0.05**	-0.09***	-0.12***
	(0.02)	(0.02)	(0.02)	(0.03)	(0.04)
log(NF)			-0.01**	-0.01**	0.00
			(0.00)	(0.00)	(0.00)
$\widehat{immunity\_US}$	0.96%	1.19%	1.10%	1.15%	0.68%
t=1992				0.62***	0.57**
				(0.14)	(0.23)
t=1996				0.83***	0.70**
				(0.15)	(0.29)
t=1997				0.93***	0.93***
				(0.09)	(0.09)
t=1998				0.84***	0.71***
				(0.10)	(0.21)
t=1999				0.90***	0.79***
				(0.05)	(0.14)
t=2000				0.67***	0.68***
				(0.22)	(0.25)
t=2001				0.73***	0.37
				(0.13)	(0.24)
t=2002				0.75***	0.61***
				(0.09)	(0.20)
t=2003				0.73***	0.68***
				(0.11)	(0.18)
t=2004				0.77***	0.64***

				(0.12)	(0.25)
t=2005				0.56***	0.40**
				(0.12)	(0.18)
t=2006				0.51***	0.37**
				(0.13)	(0.17)
t=2009				0.49***	0.30**
				(0.14)	(0.15)
t=2010				0.70***	0.55***
				(0.10)	(0.19)
t=2011				0.68***	0.82***
				(0.13)	(0.15)
sector 4, construction					0.51** (0.20)
sector5, Food and beverage					0.69*** (0.19)
sector11, paper and printing					0.98*** (0.04)
sector12, organic chemicals for agriculture					0.99*** (0.01)
sector13, other organic chemicals					0.90*** (0.08)
sector14, inorganic chemicals					0.97*** (0.03)
sector16, rubber and plastic					0.99*** (0.02)
sector17, stone, clay and graphite products					0.64*** (0.17)
sector21, electronic devices					0.89*** (0.15)
sector23, transport services					0.60*** (0.22)
sector25, wholesale and retail					0.66*** (0.14)
sector26, finance, insurance and banking					0.87*** (0.09)
sector28, other services					0.93*** (0.07)
N	2228	2042	2042	1494	1161
Pseudo R^2	9.54%	10.00%	11.24%	17.25%	32.96%
Chi^2	56.29	52.23	58.00	449.90	.
Log-likelihood	-209.58	-204.73	-201.88	-175.63	-134.02
no. iterations	6	6	6	8	9

***, **, * correspond to 1, 5 and 10% significance level, respectively. Standard errors are clustered at the cartel level and reported in parenthesis. *x100* and *x10k* denote variables which were multiplied by 100 or 10000 respectively. The variables *cartel.dur2* and *Fine_US* were dropped from the Stata calculations. Only statistically significant year and sector dummies reported.

Table 7: Regression results - Probit - EU data

(immunity_EU)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	(all)	(all)	(all)	(all)	(all)	(all)	(over)	(over)	(over)	(ongoing)	(ongoing)	(ongoing)
log(NF)	-0.05***	-0.03	-0.08***	-0.07***	-0.07***	-0.06**	-0.04	-0.09	-0.05	-0.01	-0.04	-0.06**
	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.09)	(0.07)	(0.07)	(0.03)	(0.03)	(0.03)
Firm1post	-0.10***	-0.10***	-0.09***	-0.09***	-0.08***	-0.08***				-0.03	-0.03	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)				(0.03)	(0.04)	(0.03)
MO	0.15***	0.14***					0.19**			0.14***		
	(0.04)	(0.04)					(0.08)			(0.05)		
NMO	-0.01**	-0.01					-0.01			-0.00		
	(0.01)	(0.01)					(0.03)			(0.00)		
RO					0.44***	0.42**			0.59***			0.18
					(0.16)	(0.17)			(0.19)			(0.27)
NRO			-0.00	-0.01	-0.06**	-0.07**		-0.02	-0.11**		-0.01	-0.05
			(0.01)	(0.01)	(0.03)	(0.03)		(0.03)	(0.06)		(0.02)	(0.03)
fine.increase	0.02	0.02	0.03	0.03			0.05	0.04		0.02	0.03	
	(0.02)	(0.02)	(0.02)	(0.02)			(0.05)	(0.06)		(0.03)	(0.04)	
cartel.dur(x100)					-0.03	-0.02			0.17			0.09**
					(0.03)	(0.03)			(0.12)			(0.04)
cartel.dur2(x100)					0.01*	0.01						-0.02**
					(0.01)	(0.01)						(0.01)
eea	0.00	0.01	0.01	0.00	-0.00	-0.01	-0.08	-0.07	-0.16	-0.04	-0.05	-0.01
	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.10)	(0.10)	(0.13)	(0.04)	(0.04)	(0.04)
oth.red	-0.04	-0.03	-0.08	-0.07	-0.07	-0.02	-0.47*	-0.52**	-0.58***	0.05	0.04	0.09
	(0.13)	(0.14)	(0.13)	(0.15)	(0.13)	(0.15)	(0.27)	(0.21)	(0.19)	(0.17)	(0.18)	(0.16)
log(inv.dur)	-0.00	0.00	-0.01	-0.00	-0.01	-0.00	0.04	0.04	0.03	0.01	0.00	-0.03
	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.08)	(0.07)	(0.08)	(0.02)	(0.02)	(0.02)

Def.Turnover	-0.00	-0.00	-0.00	0.00	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
LP_1996	-0.10***	0.19	-0.11***	0.18	-0.09***	0.19	-0.50***	-0.53***	-0.54***	1.00***	1.00***	1.00***
	(0.02)	(0.19)	(0.02)	(0.18)	(0.02)	(0.18)	(0.13)	(0.08)	(0.09)	(0.00)	(0.00)	(0.00)
LP_2002	-0.03*	0.00	-0.03*	0.03	-0.02	0.03	-0.16*	-0.13	-0.07	0.79***	0.80***	0.83***
	(0.02)	(0.06)	(0.02)	(0.07)	(0.02)	(0.07)	(0.09)	(0.10)	(0.10)	(0.09)	(0.08)	(0.10)
$\widehat{immunity}\_EU$	9.31%	8.42%	10.28%	9.19%	9.94%	8.98%	13.34%	15.14%	13.59%	5.21%	6.13%	5.80%
t=2001		0.88***		0.90***		0.91***	0.96***	0.95***	0.96***	0.60**	0.79***	0.93***
		(0.05)		(0.04)		(0.04)	(0.01)	(0.02)	(0.01)	(0.26)	(0.16)	(0.07)
t=2002		0.96***		0.95***		0.95***	-0.05	-0.10	-0.11	0.98***	0.98***	0.98***
		(0.01)		(0.01)		(0.01)	(0.17)	(0.11)	(0.08)	(0.00)	(0.00)	(0.00)
t=2003		0.94***		0.93***		0.93***	-0.04	-0.10	-0.10	0.97***	0.96***	0.97***
		(0.01)		(0.01)		(0.01)	(0.14)	(0.09)	(0.10)	(0.01)	(0.00)	(0.00)
t=2004		0.93***		0.93***		0.93***	-0.14*	-0.16***	-0.16***			
		(0.01)		(0.01)		(0.01)	(0.07)	(0.05)	(0.04)			
t=2005		0.95***		0.94***		0.94***	0.13	-0.05	0.02	0.99***	0.98***	0.99***
		(0.01)		(0.01)		(0.01)	(0.47)	(0.12)	(0.16)	(0.00)	(0.00)	(0.00)
t=2006		0.96***		0.95***		0.96***	-0.08	-0.11	-0.08	0.99***	0.99***	0.99***
		(0.01)		(0.01)		(0.01)	(0.10)	(0.08)	(0.11)	(0.00)	(0.00)	(0.00)
t=2007		0.96***		0.96***		0.96***				1.00***	1.00***	1.00***
		(0.01)		(0.01)		(0.01)				(0.00)	(0.00)	(0.00)
t=2008		0.95***		0.94***		0.94***	-0.03	-0.09	-0.08	0.98***	0.98***	0.98***
		(0.01)		(0.01)		(0.01)	(0.17)	(0.11)	(0.10)	(0.00)	(0.00)	(0.00)
t=2009		0.97***		0.97***		0.97***	-0.22***	-0.24***	-0.24***	1.00***	1.00***	1.00***
		(0.01)		(0.01)		(0.01)	(0.09)	(0.06)	(0.06)	(0.00)	(0.00)	(0.00)
t=2010		0.98***		0.97***		0.97***	-0.12	-0.16***	-0.12**	1.00***	1.00***	1.00***
		(0.01)		(0.01)		(0.01)	(0.08)	(0.04)	(0.05)	(0.00)	(0.00)	(0.00)
t=2011		0.94***		0.93***		0.93***	-0.14**	-0.16***	-0.15***			

		(0.01)		(0.01)		(0.01)	(0.06)	(0.04)	(0.04)			
t=2012		0.98***		0.97***		0.97***	-0.19***	-0.20***	-0.20***	1.00***	1.00***	1.00***
		(0.01)		(0.01)		(0.01)	(0.06)	(0.04)	(0.04)	(0.00)	(0.00)	(0.00)
t=2013		0.93***		0.93***		0.93***						
		(0.01)		(0.01)		(0.01)						
sector2,industrial inputs		-0.05*		-0.06**		-0.06**	0.20	0.14	0.25*	-0.07***	-0.08***	-0.10***
		(0.03)		(0.02)		(0.03)	(0.14)	(0.14)	(0.14)	(0.02)	(0.03)	(0.03)
sector3, food and		-0.00		-0.04		-0.04	0.49**	0.32	0.58***	-0.06***	-0.08***	-0.07***
detergents		(0.05)		(0.04)		(0.03)	(0.24)	(0.23)	(0.22)	(0.01)	(0.01)	(0.01)
sector4, elevators and		0.05		0.16		0.13				0.00	0.06	0.01
escalators		(0.07)		(0.10)		(0.09)				(0.04)	(0.08)	(0.05)
o.sector==5												
sector6, transport		-0.02		-0.04		-0.05				-0.05**	-0.05*	-0.01
		(0.04)		(0.03)		(0.03)				(0.02)	(0.03)	(0.06)
sector7, needles and		-0.06*		-0.07**		-0.08***				-0.08***	-0.09***	-0.09***
haberdashery		(0.03)		(0.03)		(0.03)				(0.01)	(0.01)	(0.01)
sector8, videotapes, videos		-0.05		-0.06*		-0.05				-0.03	-0.05**	-0.06***
and LCD		(0.03)		(0.03)		(0.03)				(0.03)	(0.02)	(0.01)
sector9, fine art		0.43***		0.21**		0.19*				0.30	0.10	0.09
auctions		(0.13)		(0.11)		(0.10)				(0.19)	(0.14)	(0.11)
N	553	524	553	524	553	524	143	143	143	337	337	337
Pseudo R^2	11.76%	14.27%	7.71%	10.58%	10.94%	13.47%	18.70%	14.20%	21.87%	15.67%	10.98%	11.96%
Chi^2	51.78	.	38.75	.	75.26	166924.01	.	.	3.55e+09	.	.	.
Log-likelihood	-180.17	-171.74	-188.45	-179.13	-181.85	-173.34	-58.63	-61.87	-56.34	-100.10	-105.67	-104.51
no. iterations	5	8	4	8	4	8	8	8	8	9	9	9

***, **, * correspond to 1, 5 and 10% significance level, respectively. Standard errors are clustered at the cartel level and reported in parenthesis.

9 Appendix

Table 8: Regression results - Fixed effects - US data

	FG_total	FG_total	FG_total	Sales_Firm	Sales_Firm	Sales_Firm
	(1)	(2)	(3)	(4)	(5)	(6)
cartel.dur	-46.16**	9.31	-4.67	0.72	3.67	4.22
	(22.42)	(12.37)	(3.00)	(0.59)	(2.97)	(10.38)
cartel.dur2	d.	d.	d.	-0.00	-0.00	0.02
				(0.00)	(0.00)	(0.06)
many_Buyers	-1325.17	-3256.65	892.44	337.51	9423.60***	1288.92
	(2348.54)	(1981.76)	(959.63)	(207.23)	(1498.91)	(762.46)
mod_Buyers	-2834.11	-5466.28*	-2107.26*	-66.95	18.09	d.
	(3502.15)	(3013.48)	(1072.06)	(113.24)	(23.39)	
leader	518.02	1036.43	59.69	-12.85	115.83	347.54**
	(1165.81)	(1397.61)	(429.04)	(99.73)	(87.55)	(125.18)
RO	-217.98***	-80.36**	-1.98	15.46**	14.64*	15.86
	(71.57)	(34.32)	(9.42)	(7.06)	(8.12)	(10.67)
NRO	1436.41***	1162.97***	292.19**	-13.37	-81.16*	-29.38
	(431.24)	(285.80)	(117.42)	(13.51)	(46.71)	(43.26)
S_US_cartel	0.08	0.04	0.33***	0.06***	0.45***	0.23**
	(0.05)	(0.03)	(0.04)	(0.01)	(0.08)	(0.11)
S_EU_cartel	0.67*	1.00***	0.15***			
	(0.37)	(0.29)	(0.03)			
Prison_US	46.08	55.84**	3.84			
	(41.59)	(26.28)	(4.63)			
log(NF)	30.77	-1996.83	-1052.89*	-101.54*	82.74	-55.28
	(1230.68)	(1773.54)	(537.07)	(59.26)	(121.28)	(231.83)
bid_rigging	-3028.65	-4434.98*	-882.58	285.41	8962.29***	d.
	(2633.44)	(2561.54)	(981.07)	(200.69)	(1598.65)	
Cartel_Share			-118.75***			-411.06
			(21.08)			(302.33)
constant	947.22	-262.11	246.61	-108.57	-15095.32***	-282.00
	(3089.33)	(4516.56)	(1368.37)	(198.19)	(3017.86)	(456.88)
Year FE		yes	yes		yes	yes
Sector FE		yes	yes		yes	yes
N	993	993	463	186	186	73
R^2	63%	84%	98%	55%	68%	61%

***, **, * correspond to 1, 5 and 10% significance level, respectively. Standard errors are clustered at the cartel level and reported in parenthesis. Adjusted R^2 not available.

Table 9: Regression results - Fixed effects - EU data

	Def.Fine	Def.Fine	Def.Fine	Def.Fine	Def.Fine	Def.Fine	Def.Turnover	Def.Turnover	Def.Turnover	Def.Turnover	Def.Turnover	Def.Turnover
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(12)	(13)
log(NF)	-1.76	-4.96	-7.02	-14.40	-18.77	-23.99	20.24	19.40	17.31	21.16	20.72	20.32
	(7.95)	(8.77)	(8.76)	(14.73)	(16.08)	(16.19)	(15.21)	(14.71)	(15.64)	(23.63)	(23.14)	(24.66)
Firm1pre	-45.99***	-41.83***	-42.46***	-42.80***	-39.06***	-40.50***	5.27	5.98	5.97	4.68	5.74	7.68
	(7.01)	(6.08)	(6.00)	(6.11)	(5.25)	(5.32)	(25.95)	(25.68)	(26.71)	(25.45)	(25.17)	(26.14)
Firm1post	-12.34	-10.04	-8.22	-4.57	-1.49	1.14	26.82	27.04	30.42	15.10	16.03	20.74
	(9.43)	(9.15)	(8.41)	(7.81)	(7.52)	(7.07)	(20.03)	(19.79)	(19.65)	(20.05)	(19.84)	(19.82)
MO	18.39**			20.71**			2.21			5.52		
	(8.93)			(8.25)			(19.58)			(20.13)		
NMO	3.59			3.01			0.09			0.55		
	(2.30)			(2.48)			(4.79)			(5.62)		
RO			2.39			9.25			2.27			-1.76
			(7.93)			(8.87)			(44.78)			(43.97)
NRO		-9.88*	-8.67		-5.20	-4.52		-5.40	-3.58		-5.43	-1.77
		(5.58)	(6.32)		(8.59)	(8.33)		(15.53)	(17.31)		(20.78)	(22.10)
cartel.dur			0.11			0.23*			0.11			0.03
			(0.11)			(0.12)			(0.27)			(0.32)
cartel.dur2			-0.00			-0.00**			-0.00			-0.00
			(0.00)			(0.00)			(0.00)			(0.00)
eea	8.99	9.51	7.53	12.10	7.30	5.78	12.83	13.97	10.89	11.72	11.50	3.20
	(7.60)	(9.73)	(9.04)	(11.32)	(13.83)	(12.87)	(17.05)	(17.31)	(17.17)	(24.78)	(24.48)	(24.63)
oth.red	-39.98*	-53.44***	-49.56***	-43.48**	-43.97**	-32.16*	225.22***	223.41***	228.78***	127.67	127.24	146.01*
	(20.33)	(18.93)	(17.86)	(20.19)	(20.65)	(17.72)	(76.56)	(76.14)	(76.52)	(81.08)	(80.64)	(80.54)
fine.increase	8.02	12.71		14.52**	16.79**		18.45	19.57		30.81*	31.74*	
	(6.15)	(8.35)		(7.22)	(8.02)		(16.25)	(16.23)		(17.36)	(17.26)	

LP	-11.58	-7.19	-4.15	-31.64*	-24.87	-22.53	-1.51	-1.28	3.52	-11.32	-10.39	-2.13
	(14.98)	(16.19)	(14.28)	(16.10)	(15.91)	(15.33)	(21.04)	(20.16)	(19.80)	(29.58)	(28.73)	(28.69)
log(inv.dur)	-10.93	-14.22**	-16.14**	-24.93***	-26.32***	-29.85***	9.58	8.95	6.19	5.32	5.01	3.58
	(8.02)	(7.10)	(7.03)	(7.62)	(7.63)	(7.78)	(13.52)	(13.49)	(13.99)	(17.54)	(17.48)	(18.42)
Def.Turnover	0.03***	0.03***	0.03***	0.02***	0.03***	0.03***						
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)						
LP_1996	-19.85	-21.33	-15.44	129.08*	117.13*	125.23*	39.91	38.88	49.42**	-0.50	-5.54	16.54
	(13.77)	(14.71)	(12.18)	(71.85)	(69.13)	(73.89)	(26.04)	(25.94)	(24.43)	(114.84)	(114.88)	(115.20)
LP_2002	-4.66	2.17	3.85	74.62	82.53	85.92	4.05	3.84	7.47	-12.13	-11.98	-1.52
	(8.19)	(7.48)	(7.95)	(60.23)	(60.42)	(63.32)	(19.66)	(18.55)	(18.96)	(51.23)	(51.28)	(51.34)
constant	74.91**	102.44***	107.07***	2.27	42.14	49.59	-95.80	-90.71	-84.76	-103.74	-92.71	-87.79
	(35.62)	(36.42)	(36.50)	(63.38)	(58.01)	(59.28)	(61.99)	(60.48)	(61.95)	(138.93)	(136.02)	(136.85)
N	553	553	553	553	553	553	553	553	553	553	553	553
R^2	10.38%	7.12%	6.62%	21.01%	18.73%	18.31%	3.63%	3.65%	3.42%	13.96%	13.95%	13.39
Adjusted R^2							1.49%	1.69%	1.09%	8.13%	8.30%	7.35%
Year FE				yes	yes	yes				yes	yes	yes
Sector FE				yes	yes	yes				yes	yes	yes

***, **, * correspond to 1, 5 and 10% significance level, respectively. Standard errors are clustered at the cartel level and reported in parenthesis.

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