Heterogeneity of Penalties and Private Information

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ABSTRACT

The theoretical framework of the adequacy of fine reductions under the EU and US Leniency Programmes has been widely explored. However, the characteristics of the reporting cartel members remain unexplained. This is the first paper to develop a model where cartel members are heterogeneous in terms of sales and have private information on the probability of conviction. It is shown that firms with a higher sales level have a lower equilibrium threshold for reporting. To validate this result, data for EU and US cartels is used and the theoretical model is supported. Being the first reporter is also shown to be correlated with recidivism, leadership and some characteristics of the cartels where spontaneous reports occur are identified. Knowing the characteristics of the reporting firms is vital to dissolve and dissuade cartels and the wide policy implications of these findings are discussed in the paper.

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

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1. Introduction

The US and EU Leniency Programmes (LPs) were designed to work as a device of deterrence and dissolution of collusive agreements and have been in place since 1978 and 1996[2], respectively. While the US LP provides the first reporter with immunity of fines in exchange for the reporting of a previously unknown cartel, the EU LP offers immunity or substantial fine reductions, in exchange for the reporting of the cartel or cooperation with an ongoing investigation.

The adequacy of the fine reductions has been extensively analyzed but the characteristics of the reporting cartel members remain unexplained. This paper addresses this question by being the first to develop a model where cartel members are heterogeneous in terms of the sales level. Not only this assumption is more realistic as it gives rise to different equilibrium thresholds for reporting, thus eliminating the restrictive assumption of symmetric equilibria and allowing for more conclusive policy recommendations. It is shown that the firm with the highest sales level has a lower threshold level for reporting and, in equilibrium, it will be the first reporter of the cartel, provided that the signal received is above its threshold. These 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, proportion of convictions in cartel investigations, among others[3]. The empirical analysis corroborates these results and adds to it by revealing some of the characteristics of the first reporting firms and of the cartels in which they take part.

There is an extensive literature on the Leniency Programmes. Bloom (2006) suggests ways of improving transparency and certainty while other authors use game the-

[2]The US LP was amended in 1993, to account for transparency issues by means of guidelines easier to use as well as higher compensation from cooperation. Revisions to the EU LP occurred in 2002 and 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, for 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.

[3]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 paper refrains from doing so to keep the model general.

ory models to explain cartel behavior and the LP effects, often on pricing.[4] Many authors look at the setting of the rewards (i.e. fine reductions): Houba et al. (2009) find that it is optimal to restrict the granting of reductions to first-time offenders. Harrington (2008) supports the view that the first reporter should be granted total immunity and Motta and Polo (2003) conclude that significant reductions should be given for cooperation even after the investigation has started. Aubert et al. (2005) find that rewarding individuals, such as firm employees, is more efficient in terms of deterring collusion, whereas Herre and Rasch (2009) find that if the cartel ringleader is excluded from the LP, cartels are less stable, especially if this is in an industry with a high probability of forming a cartel. This is an important policy issue, and Buccirossi and Spagnolo (2006) note that a badly designed LP may even allow for cartel activity that would not be feasible otherwise, via the imposition of lower net penalties. The deterrence effect is also studied by Spagnolo (2004), who finds that a "moderate" LP can destabilize and deter cartels, while in contrast, Chen and Harrington (2007) conclude that a partial LP may actually facilitate collusion. The trade-off between this destabilizing effect and lower expected net fines is studied by Chen and Rey (2007). Indeed, Chang and Harrington (2009) argue that the LP may increase the rate of cartel formation because the additional caseload makes the authorities less aggressive. The paper which is more closely related to this research is by Harrington (2011), where the author models a duopoly of homogeneous firms who receive signals on the probability of conviction by the EU. However, this assumption can only lead to symmetric equilibria. The theoretical contribution of this paper is thus, the introduction of heterogeneity, in terms of the sales level, among cartel members.

The empirical literature in this general area is recent and includes several papers that merely analyze descriptive statistics on the LP (e.g. Connor 2007, Mihai 2008, Veljanovski 2009, Asker 2009). One of the first empirical papers using econometric methods is by Borrell and Jimènez (2007), who look at the drivers of antitrust effectiveness and find it to be increased by the LP. Levenstein and Suslow (2009) estimate the impact of organizational mechanisms, such as moral hazard problems. Miller (2009)

[4] See Houba et al.(2009) for an extensive survey of the literature.

finds that the number of cartels discovered increases in the periods around the introduction of the LP and decreases to pre-LP levels afterwards. Finally, Arlman (2005) and Brenner (2009) use EU cases to estimate the effects of the LP and Marvao (2012) estimates the factors that influence the granting and scale of fine regulations. This paper uses EU data which was self-collected and compiled from the publicly available reports and press releases in the Commission's website and US data which was made available by John Connor. The empirical contribution of this paper to the current empirical literature is in the use of an innovative EU dataset and in examining the characteristics of the firms who "spontaneously" report the cartel and receive immunity of fines, and of the cartels in which they take part.

The organization of the rest of the paper 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. Theoretical Model

2.1. Setting of the model and Strategies

The game here identified has two stages. In the first stage, a two-firm cartel collapses for internal reasons. Suppose that the firms (i and j) are risk-neutral and heterogeneous in terms of sales (Y_k, where $k = (i, j)$). In the second stage, each firm receives a private signal on the expected probability of detection and conviction, which is given by $s_k = E(\rho)$ and where the values of each signal belong 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, share of the budget allocated to investigation and/ or prosecution of cartels, among others. Given the signal received and the expectations on the other firms's behavior, firms decide to report if the signal is above their threshold level.

The firms' strategy pair is the following:

$$\phi(s_i, s_j) = \begin{cases} (R,R) & iff\ s_i \epsilon (x_i, \overline{s}]\ and\ s_j \epsilon (x_j, \overline{s}] \\ (R,NR) & iff\ s_i \epsilon (x_i, \overline{s}]\ and\ s_j \epsilon [\underline{s}, x_j] \\ (NR,R) & iff\ s_i \epsilon [\underline{s}, x_i]\ and\ s_j \epsilon (x_j, \overline{s}] \\ (NR,NR) & iff\ s_i \epsilon [\underline{s}, x_i]\ and\ s_j \epsilon [\underline{s}, x_j] \end{cases}$$

Each cartel member can apply for the Leniency Programme and receive a fine reduction, thus paying a smaller or no share of its fine. In this model, θF_i denotes the share of the fine paid by the cartel member. Beside the penalty set for each cartel member, there are also overcharges for damage caused to consumers and other costs inherent to being fined (G_i). It is assumed that the values of F_i and G_i are exogenous and common knowledge and that the Fine is set at its maximum, which is 10% of the firm's turnover in the previous year: $F_{i,t} = 0.1 Y_{i,t-1}$[5].

The probability that a cartel is investigated and prosecuted by the authorities is given by ρ. The behavior of firm j is included in the Incentive Compatibility Constraint (ICC) of firm i (and vice-versa), through the use of the $H(s_j|s_i)$ function, which corresponds to firm i's CDF on firm j's signal conditional on its own signal, i.e., it is the probability that firm j does not report.

The value functions for firm i are the following:

$$\begin{aligned} -V_i^R = &\quad H(x_j|s_i)(\theta F_i + G_i) &&+[1 - H(x_j|s_i)](\tfrac{1+\theta}{2} F_i + G_i) \\ -V_i^{NR} = &\quad H(x_j|s_i) E[\rho | s_i, s_j \leq x_i](F_i + G_i) &&+[1 - H(x_j|s_i)](F_i + G_i) \end{aligned}$$

Each firm decides to report if the additional value from reporting is positive. This is given by $\Delta(s_j, x_i) = V_i^R - V_i^{NR}$. Therefore, the following ICCs, or equilibrium conditions, must hold:

Firm *i* reports if: $\Delta(s_j, x_i) \equiv E[\rho | s_i, s_j \leq x_j] \frac{F_{t,i} + G_i}{F_{t,i}} - \theta + \frac{1 - H(x_j|s_i)}{H(x_j|s_i)} \frac{1-\theta}{2} - \frac{G_i}{F_{t,i}} > 0$

[5] Columns (1) to (3), in Tables 6 and 7 in *Appendix B* show the determinants of fines and sales level which, in accordance with the current legislation on cartel fines, are shown to be positively correlated.
$Fine^{EU} = f^+(recidivism, turnover), f^-(number\ of\ cartel\ members, other\ reductions, first\ reporter\ pre-investigation)$
$Fine^{US} = f^+(leader, number\ of\ repeat\ offenders\ per\ cartel, sales, prison\ sentence), f^-(moderate\ sized\ market, bid-rigging\ cartel, numberofcartelmembers, recidivism, firm's\ market\ share)$
$Turnover^{EU} = f^+(other\ reductions, fine\ increases, first\ reporter\ post-investigation)$
$Sales^{US} = f^+(moderate\ sized\ markets, bid-rigging\ cartel, number\ of\ cartel\ members, firm's\ market\ share), f^-(leader, cartel\ duration)$

Firm *j* reports if: $\Delta(s_i, x_j) \equiv E[\rho|s_j, s_i \leq x_i]\frac{F_{t,j}+G_j}{F_{t,j}} - \theta + \frac{1-H(x_i|s_j)}{H(x_i|s_j)}\frac{1-\theta}{2} - \frac{G_j}{F_{t,j}} > 0$

The comparative statics below show that firms have a higher incentive to reporting when the signal is higher, since the perceived probability of conviction is then higher. The same occurs when the firm's sales level is higher, as the fine paid depends on the sales level in the previous period[6].

$\frac{\partial\Delta}{\partial s_i} = \frac{\partial E(\rho)}{\partial s_i}\frac{F_{t,i}+G_i}{F_{t,i}} - \frac{\partial H}{\partial s_i}\frac{1-\theta}{2H^2} \geq 0$

$\frac{\partial\Delta}{\partial Y_i} = \frac{\partial\Delta}{\partial F_i}\frac{\partial F_i}{\partial Y_i} = [1 - E(\rho)]\frac{G_i}{0.1^2 Y_{t-1,i}^2} \geq 0$

Since each firm chooses the strategy which minimizes the expected value of their penalties, the ICCs become:

Firm *i*: $\Delta(s_j, x_i) = 0 \leftrightarrow E[\rho|s_i, s_j \leq x_j]\frac{F_{t,j}+G_i}{F_{t,i}} + \frac{1-H(x_j|s_i)}{H(x_j|s_i)}\frac{1-\theta}{2} - \frac{G_i}{F_{t,i}} = \theta$

Firm *j*: $\Delta(s_i, x_j) = 0 \leftrightarrow E[\rho|s_j, s_i \leq x_i]\frac{F_{t,j}+G_j}{F_{t,j}} + \frac{1-H(x_i|s_j)}{H(x_i|s_j)}\frac{1-\theta}{2} - \frac{G_j}{F_{t,i}} = \theta$

2.2. Equilibrium

Firms take as given the existence of the LP and decide to report or not contemporaneously. Using ICC_i when firm j is at its cut-off point ($s_j = x_j$), the following condition is true:

$\Delta(x_j, x_i) = 0 \leftrightarrow E[\rho|x_i, x_j]\frac{F_{t,i}+G_i}{F_{t,i}} + \frac{1-H(x_j|x_i)}{H(x_j|x_i)}\frac{1-\theta}{2} - \frac{G_i}{F_{t,i}} = \theta$

The same condition can be written for firm j. Therefore, firm i's equilibrium strategy is to report when $s_i > x_i$ iff $\Delta(x_j, x_i) \geq 0$, as then $\Delta(s_i, x_j) > 0,\ \forall s_i > x_i$; and not to report when $s_i < x_i$ iff $\Delta(x_j, x_i) \leq 0$, as then $\Delta(s_i, x_j) < 0,\ \forall s_i < x_i$

THEOREM: An equilibrium exists in which firms 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.

Below, the equilibrium cut-off points for firm i are examined. If $C = 0 > B$ (as defined below), then there are 3 equilibria: $x\epsilon\{\underline{s}, s', \overline{s}\}$, where equilibria with lower x

[6] In fact, the fine is set according to the following formula: $F = F_0 + A - M = [k(g_t)Y_{t-1}][a\%cartel\ duration + b\% + (A - M)]$ and it is capped at 10% of the total turnover of the firm in the previous year. In the formula, t represents the time period, $k(g_t)$ is a multiplier of proportional penalty that depends on the gravity of the offense (g_t), $a \leq 30\%$ depends on the degree of gravity of the infringement and $b\epsilon[15\%, 25\%]$ aims at deterring undertakings from entering horizontal price-fixing, market-sharing and output limitation agreements.

are preferred.

(**1**) $x_j = \underline{s_j} = \underline{s}$

$\Phi(\underline{s_j}) = H(\underline{s}|s_i)\Delta(\underline{s}, s_i) =$

$= H(\underline{s}|s_i)[E(\rho|\underline{s}, x_i)\frac{F_{t,i}+G_i}{F_{t,i}} - \theta - \frac{G_i}{F_{t,i}}] + [1 - H(\underline{s}|s_i)]\frac{1-\theta}{2} = 0 + [1-0]\frac{1-\theta}{2} = \frac{1-\theta}{2} \geq 0$

Reporting is strictly preferred for firm i, for all signals, since the rival reports.

(**2**) $x_j = \overline{s_j} = \overline{s}$

$\Phi(\overline{s_j}) = H(\overline{s}|s_i)\Delta(\overline{s}, s_i) =$

$= H(\overline{s}|s_i)[E(\rho|\overline{s}, x_i)\frac{F_{t,i}+G_i}{F_{t,i}} - \theta - \frac{G_i}{F_{t,i}}] + [1 - H(\overline{s}|s_i)]\frac{1-\theta}{2} = 1[E(\rho|\overline{s}, x_i)\frac{F_{t,i}+G_i}{F_{t,i}} - \theta - \frac{G_i}{F_{t,i}}] +$

$[1-1]\frac{1-\theta}{2} = E(\rho|\overline{s}, x_i)\frac{F_{t,i}+G_i}{F_{t,i}} - \theta - \frac{G_i}{F_{t,i}} \equiv B < 0$ iff "B"<0

Then, not reporting is strictly preferred for firm i, for all signals, since the rival does not report and provided $B < 0$.

(**3**) $x_j = s'_j$

$\Phi(s'_j) = H(s'_j|s_i)\Delta(s_i, s'_j) =$

$= H(s'_j|s_i)[E(\rho|s_i, x'_j)\frac{F_{t,i}+G_i}{F_{t,i}} - \theta - \frac{G_i}{F_{t,i}}] + [1 - H(s'_j|s_i)]\frac{1-\theta}{2} \equiv C = 0$ iff "C" $= 0$

Then, firms are indifferent between reporting or not.

Finally, the equilibrium strategy pairs are the following:

(1) (R,R): Both firms report if:

- $(\overline{s_i}, \overline{s_j})$
- $(s'_i, \underline{s_j})$ *and* $\Delta(x_i, x_j) \geq 0$ OR $(\underline{s_i}, s'_j)$ *and* $\Delta(x_j, x_i) \geq 0$
- (s'_i, s'_j) *and* $\Delta(x_i, x_j) \geq 0, \Delta(x_j, x_i) \geq 0$

(2) (NR,NR): Neither report if:

- $(\underline{s_i}, \underline{s_j})$
- $(s'_i, \overline{s_j})$ *and* $\Delta(x_i, x_j) \leq 0$ OR $(\overline{s_i}, s'_j)$ *and* $\Delta(x_j, x_i) \leq 0$
- (s'_i, s'_j) *and* $\Delta(x_i, x_j) \leq 0, \Delta(x_j, x_i) \leq 0$

(3) (R,NR) or (NR,R): Only one firm reports in all the other cases:

- $(s'_i, \underline{s_j})$ *and* $\Delta(x_i, x_j) \leq 0$ OR $(\underline{s_i}, s'_j)$ *and* $\Delta(x_j, x_i) \leq 0$

- $(s_i', \overline{s_j})$ *and* $\Delta(x_i, x_j) \geq 0$ OR $(\overline{s_i}, s_j')$ *and* $\Delta(x_j, x_i) \geq 0$
- (s_i', s_j') *and different signals for* $\Delta(x_i, x_j)$ *and* $\Delta(x_j, x_i)$

2.3. Relationship between the thresholds

To show the relationship between the thresholds of the two cartel members, both ICCs are rewritten in terms of the fine:

Firm *i*: $\Delta(s_j, x_i) = 0 \leftrightarrow E[\rho|s_i, s_j \leq x_j]\frac{F_{t,i}+G_i}{F_{t,i}} + \frac{1-H(x_j|s_i)}{H(x_j|s_i)}\frac{1-\theta}{2} - \frac{G_i}{F_{t,i}} = \theta \leftrightarrow F_{t,i} = G_i\frac{1-E[\rho|s_i,s_j\leq x_j]}{E[\rho|s_i,s_j\leq x_j]+\frac{1-H(x_j|s_i)}{H(x_j|s_i)}\frac{1-\theta}{2}-\theta}$

Firm *j*: $\Delta(s_i, x_j) = 0 \leftrightarrow E[\rho|s_j, s_i \leq x_i]\frac{F_{t,j}+G_j}{F_{t,j}} + \frac{1-H(x_i|s_j)}{H(x_i|s_j)}\frac{1-\theta}{2} - \frac{G_j}{F_{t,j}} = \theta \leftrightarrow F_{t,j} = G_j\frac{1-E[\rho|s_j,s_i\leq x_i]}{E[\rho|s_j,s_i\leq x_i]+\frac{1-H(x_i|s_j)}{H(x_i|s_j)}\frac{1-\theta}{2}-\theta}$

Assume that firm i has a higher sales level in any time period ($Y_{t,i} > Y_{t,j}$)[7] and, for simplification, that both firms will be charged the same level of overcharges ($G = G_i = G_j$). Equating the two ICCs, it follows that:

$Y_{t-1,i} > Y_{t-1,j} \leftrightarrow F_{t,i} > F_{t,j}$

$\leftrightarrow G_i\frac{1-E[\rho|s_i,s_j\leq x_j]}{E[\rho|s_i,s_j\leq x_j]+\frac{1-H(x_j|s_i)}{H(x_j|s_i)}\frac{1-\theta}{2}-\theta} > G_j\frac{1-E[\rho|s_j,s_i\leq x_i]}{E[\rho|s_j,s_i\leq x_i]+\frac{1-H(x_i|s_j)}{H(x_i|s_j)}\frac{1-\theta}{2}-\theta}$

$\leftrightarrow \frac{1-E[\rho|s_i,s_j\leq x_j]}{E[\rho|s_i,s_j\leq x_j]+\frac{1-H(x_j|s_i)}{H(x_j|s_i)}\frac{1-\theta}{2}-\theta} > \frac{1-E[\rho|s_j,s_i\leq x_i]}{E[\rho|s_j,s_i\leq x_i]+\frac{1-H(x_i|s_j)}{H(x_i|s_j)}\frac{1-\theta}{2}-\theta}$

At the equilibrium cut-off points: $s_i = x_i*, s_j = x_j*$

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

Assume that the expected value of being caught is the same, for a given value of the signal received, such that: $E[\rho|x_j*, x_i*] = E[\rho|x_i*, x_j*] = E[\rho]$ Then, the previous expression becomes:

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

$\leftrightarrow \frac{1-H(x_i*|x_j*)}{H(x_i*|x_j*)} > \frac{1-H(x_j*|x_i*)}{H(x_j*|x_i*)}$

[7] In fact, to ensure that higher sales lead to higher fines, the following assumption is made: $[k(g_{t,i})Y_{t-1,i}][a\%CD + b\% + (A_i - M_i)] > [k(g_{t,j})Y_{t-1,j}][a\%CD + b\% + (A_j - M_j)] \leftrightarrow \frac{k(g_{t,i})}{k(g_{t,j})}\frac{a\%CD+b\%+(A_i-M_i)}{a\%CD+b\%+(A_j-M_j)}Y_{t-1,i} > Y_{t-1,j}$

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

$\leftrightarrow x_j * > x_i *$, since $\frac{\partial H(x_j * | x_i *)}{\partial x_i *} < 0$ *and* $\frac{\partial H(x_i * | x_j *)}{\partial x_j *} < 0$,

In sum, the class of perfect equilibria has the following properties:

1. if $s_j \epsilon] x_j, \overline{s}]$, a firm reports, provided that $\Delta(x_i, x_j) \geq 0$, as then $\Delta(s_j, x_i) > 0$, $for\ all\ s_j > x_j$. Inversely, if $s_j \epsilon [\underline{s}, x_j]$, the firm does not report if $\Delta(x_i, x_j) \leq 0$, as then $\Delta(s_i, x_i) < 0$, $for\ all\ s_j < x_j$;
2. If $Y_{i,t-1} > Y_{j,t-1}$, then $x_{i,t} * < x_{j,t} *$
3. If $F_i > F_j$, then $x_i * < x_j *$

Note that there is an issue of discontinuity in the x's with respect to the value of the overcharges (G). However, this is not problematic as there is no defined value for what the overcharges should amount to and so there is a lot of uncertainty in this value. The fact that firms know that they will pay overcharges creates an additional incentive for firms to report. Furthermore, although firms fined in the EU pay no overcharges, penalties for being caught in a cartel do not come strictly from the Government. Other effects such as attorney fees, negative impact on consumer's perception, which may lead to lower sales, managers being fired and future punishment by other firms show that there is never real full immunity.

This model can easily be extended to a larger number of firms, where the cartel member with the highest sales level will have the lowest threshold and so 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 sales level and the signals they receive, but this does not affect the results, provided that collusion occurs. Future research will focus on allowing firms to report in different periods, since it is likely that a time lapse exists between the reporting and the initiation of the investigation, or the investigation may still be secret at the time of a second reporting. It would also be interesting to change the risk preferences of the cartel members, as this may lead to more precise results allowing for the elimination of the risk-neutrality assumption.

3. Two specific cases: LPs in US vs EU

While the results from the general model hold for any positive values of the leniency reduction $(1-\theta)$ and the overcharges (G), it is discussed in this section how the ICCs change when applied to the EU and US Leniency Programmes. The equilibria and its properties are the same as before, as well as the relationship between the thresholds.

3.1. US Leniency Programme

The US Leniency Programme grants full immunity to the first reporting firm, while the other firms receive no fine reduction. Therefore, in the model, θ is set equal to zero. However, even in the case of immunity of fines, firms still have to pay overcharges for the damages caused by the cartel's activity.

It is possible that the values of the prior probability of conviction (ρ) are higher for the US than for the EU, keeping all else constant, due to the existence of the *Amnesty Plus Program*. This program refers to benefits for prosecuted cartel members who disclose previously undetected cartels, therefore raising the probability of conviction. Nonetheless, this is not relevant, except in the comparison of cartels prosecuted in the US and the EU, in terms of magnitude of the effects in both cases.

In equilibrium, the following ICCs must hold:

Firm *i* reports if: $\Delta(s_j, x_i) \equiv E[\rho|s_i, s_j \leq x_j]\frac{F_{t,i}+G_i}{F_{t,i}} + \frac{1-H(x_j|s_i)}{H(x_j|s_i)}\frac{1}{2} - \frac{G_i}{F_{t,i}} > 0$

Firm *j* reports if: $\Delta(s_i, x_j) \equiv E[\rho|s_j, s_i \leq x_i]\frac{F_{t,j}+G_j}{F_{t,j}} + \frac{1-H(x_i|s_j)}{H(x_i|s_j)}\frac{1}{2} - \frac{G_j}{F_{t,j}} > 0$

3.2. EU Leniency Programme

After the fines for each cartel member are set, the leniency reductions for reporting and /or cooperating firms are set as stated in *Table 1* below[8].

[8]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".Offcial Journal of the European Union C298, p.17.

Table 1: 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.

With only two firms, and according to the LP, the first reporter receives full immunity (θ =0) and the second receives a maximum of 50% fine reduction (θ =0.5). Although firms pay no overcharges, penalties for being caught in a cartel do not come strictly from the Government, as previously discussed. For this reason, G^{EU} is extended to include all the monetarily measurable negative effects from being caught. The same reasoning can be made for the case of the US LP. In equilibrium, the following ICCs must hold:

Firm *i* reports if: $\Delta(s_j, x_i) \equiv E[\rho|s_i, s_j \leq x_j]\frac{F_{t,i}+G_i^{EU}}{F_{t,i}} + \frac{1-H(x_j|s_i)}{H(x_j|s_i)}\frac{1}{2} - \frac{G_i^{EU}}{F_{t,i}} > 0$

Firm *j* reports if: $\Delta(s_i, x_j) \equiv E[\rho|s_j, s_i \leq x_i]\frac{F_{t,j}+G_j^{EU}}{F_{t,j}} + \frac{1-H(x_i|s_j)}{H(x_i|s_j)}\frac{1}{2} - \frac{G_j^{EU}}{F_{t,j}} > 0$

The next section explores data for both the US and the EU, to verify the theoretical results and analyze the characteristics of the firms who reported the cartel and received immunity of fines, as well as the cartels in which they took part.

4. Empirical Model

4.1. Data

The US data employed in the empirical analysis is an excerpt from John Connor's "Private International Cartels" dataset[9]. This excerpt covers the years of 1984 to 2009 and is limited to publicly reported information on 799 cartels, in a total of 2310 firms.

Data on EU cartel cases was self-collected using publicly available summary reports and associated press releases of the antitrust cases handled by the European Commission and accessible via the Commission's website. Cartels are restricted to those

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

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[10] and with final decisions in the period of 1998 to 2011[11], concerning a total of 385 cartel members.

Repeat offenders are a serious issue and the LP Notices are not explicit as to whether or not they should receive a lower reduction, if any. The 2006 EU Leniency Notice states that a repeat offender is any firm that was previously found to infringe Articles 81 or 82 of the EU Treaty, whereas the DOJ defines it as any firm whom "after release from custody for having committed a crime, is not rehabilitated"[12]. In the US, 11% of the firms are identified as repeat offenders[13] (351/2310), whereas in the EU, only 2% of the firms (6/385) correspond to the above description. Nonetheless, if an investigation on a cartel member initiated after all the cartels in which it participated ended, the firm still has an incentive to report the other cartel(s) and apply for the LP if it believes that there is a high probability of conviction in those cartels. 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 instead that firms learn how to use the LP in 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 used for the EU cases and it is considered that a Repeat Offender is any firm who was convicted for collusion at least twice, which corresponds to 16% of the EU firms in the analysis (63/385). This issue is not directly included in the theoretical model, but it is incorporated in the value of the fine, as the initial fine is increased in the case of recidivism.

One other concern with the data is the possibility of sample selection bias. Since cartels are illegal, they operate secretely so the available data only include cartels that

[10]Cartels, other than cases, are analyzed in this paper, since within the same case there may be several cartels, possibly with different members and different fine and fine reductions. The 81 cartels correspond to 63 cases.

[11]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. The dataset is updated until July 15th 2011.

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

[13]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.

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 out of the scope of this paper. 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, but to acknowledge that the number of repeat offenders may be underestimate.

Table 2 and *Table 3* define and summarize the variables for use in the model specifications.

[Table 2 here]

[Table 3 here]

4.2. Method

Building on the theoretical construct shown in the previous Section, the canonical specification of the EU and US models are of the following form:

$$\begin{aligned} Immunity\_EU_{ijts} &= \beta_0 + \beta_1 N_{jts} + \beta_2 RO_{ijts} + \beta_3 NRO_{jts} + \beta_4 cartel.dur_{jts} + \beta_5 carteldur2_{jts} \\ &+ \beta_6 Def.Turnover_{ijts} + \beta_7 oth.red_{ijts} + \beta_8 fine.increase_{ijts} \\ &+ \beta_9 Firm1pre_{ijts} + \beta_{10} Firm1post_{ijts} \\ &+ \beta_{11} eea_{jts} + \beta_{12} LP_{jts} + \beta_{13} LP\_1996_{jts} + \beta_{14} LP\_2002_{jts} \\ &+ \beta_{15} inv.dur_{jts} + \beta_{16} invdur2_{jts} \\ &+ \gamma T_t + \delta S_s + \varepsilon_{ijts} \end{aligned}$$

$$\begin{aligned} Immunity\_US_{ijts} &= \beta_0 + \beta_1 N_{jts} + \beta_2 RO_{ijts} + \beta_3 NRO_{jts} + \beta_4 cartel.dur_{jts} + \beta_5 carteldur2_{jts} \\ &+ \beta_6 S\_US\_cartel_{jts} + \beta_7 S\_EU\_cartel_{jts} + \beta_8 Prison\_US_{ijts} \\ &+ \beta_9 leader_{ijts} + \beta_{10} Many\_buyers_{jts} + \beta_{11} Mod\_buyers_{jts} \\ &+ \gamma T_t + \delta S_s + \varepsilon_{ijts} \end{aligned}$$

where i, j, t and s are the indices for firm, case, decision year and sector, respectively and for each case. γ 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 of fines. The variables from the theoretical model are included in the above specifications: the number of cartel members (N), a repeat offender dummy (RO), the number of repeat offender per cartels (NRO) and the duration of the cartel ($cartel.dur$).

The value of the fine is also incorporated and it is a function of the firm's turnover in the previous year. This value is included, either using the deflated turnover ($Def.Turnover$) or the sales level of the cartel (S_EU and S_US), 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 leader and the impact of the cartel in its specific market ($fine.increase^{EU}$, $Many\_buyers^{US}$, Mod_buyers^{US}, $Prison\_US^{US}$ and $leader^{US}$), mitigating circumstances including the geographic magnitude of the cartel's impact ($oth.red^{EU}$ and eea^{EU}) and leniency applications (LP^{EU}, $Firm1pre^{EU}$, $Firm1post^{EU}$). Additionally, I also control for the three different EU Leniency Programmes of 1996, 2002 and 2006.

Since the dependent variable has a binary outcome, the appropriate regression method is a probit[14]. The restriction of homoskedasticity is tested and the likelihood-ratio shows that at the 5% level, there is no improvement from generalizing the homoskedastic model. Variable addition tests were also carried to support the inclusion of the variables in the probit model.

4.3. Results

4.3.1. EU Cartels

The results of the model specifications for the EU are shown on *Table 4*. Columns (2) and (3) introduce year and sector controls, respectively but the sample size drops

[14]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.

as some of the years and sectors have no variability to be explained by the dependent variable[15].

While the Leniency Programme Notice excludes firms with a leading role from receiving immunity, it makes no statement regarding repeat offenders[16]. The results show that firms who have colluded more than once are around 10% more likely to report the cartel and receive immunity of fines (see *RO*). Repeat offending firms are typically larger in terms of sales and they may know better how or when to report and what evidence to provide to the European Commission, due to their previous collusive agreements. While 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 Leniency reductions.

As it is assumed in the theoretical model and according to the Leniency Notice, it is also shown that immunity is more likely in cases where the reporting of the cartel occurs before an investigation is initiated by the Authorities (see *LP*). 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 be stricter, as the results show that full immunity from fines is more likely in the earlier LPs (see LP_1996 and LP_2002). Cartels in the sectors of elevators and escalators (Sector 4) and needles and haberdashery (Sector 7) are those in which more spontaneous reports occurred but only account for 5% and 7% of the total of cartels, respectively. This may be because these are very competitive sectors, where future punishment from the other cartel members is less feasible.

The absolute value of the individual turnover ($Def.turnover(M)$) is not significant in explaining immunity from fines. This is as expected, since it is not the absolute value of the turnover but its value relatively to the other cartel members which influences the decision of reporting. The lack of information on each firm's individual turnover and

[15]These variables are dropped so that Stata can converge on a solution to the regression problem. Specification (2) drops 8 observations for the year of 1999 and 12 for the year 2000. Specification (3) drops further 8 observations regarding sector 5, which corresponds to Banks

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

the difficulties in finding the appropriate level to use make its empirical interpretation challenging. However, repeat offenders do receive larger fines and this result is thus in line with the theoretical findings in this paper.

[Table 4 here]

4.3.2. US Cartels

The results of the model specifications which concern the US can be found on *Table 5*. Columns (4) and (5) introduce year and sector controls, respectively and the sample size drops as some of the years and sectors have no variability to be explained by the dependent variable[17].

Data on the individual turnover is not available but sales and turnover values are likely to be larger for the cartel leader. It is thus not surprising that the results show that the leader of the cartel is more likely to report and receive immunity of fines. Cartels which act in markets with a moderate and, to a lower extent, large number of buyers are more likely to have one of their members applying for immunity of fines.

The types of industry where immunity applications are more likely to occur and succeed are rubber and plastics (sector 16) and paper and printing (sector 11). These sectors represent only 6% and 4% of the cartels cases in analysis, so the results are not driven by the number of cases but by some specific characteristic of these sectors which leads to a larger number of leniency applications. Similarly to the EU case, these sectors are very competitive.

[Table 5 here]

5. Discussion

When the perceived probability of conviction is high, firms are more inclined to reporting. 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

[17] A total of 580 observations are dropped in specification (4), which correspond to the years of 1984, 1989, 1990, 1991, 1993, 1994, 1995, 2007 and 2008. Further 335 observations are dropped in specification (5) and concern sectors 2, 3, 6, 9, 15, 18, 19, 20, 22, 24 and 27.

cartels from forming. In addition, a pre-emption effect also exists as when firms believe that the signal received by other firms is such that they will report, then the firm has an incentive to report first and receive a fine reduction within the Leniency Programme. While 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 paper extends Harrington's (2011) analysis and is the first to examine the case of firms which are heterogeneous in terms of sales and which receive private information on the probability of investigation and conviction by the Competition Authority, thus eliminating the restrictive assumption of symmetric equilibria.

It is shown that when the level of sales differs among firms, the threshold for reporting is also different. This is, if firms have higher sales, and therefore possibly higher fines, then their equilibrium threshold for reporting is lower, keeping all else constant. This finding has major policy implications, as identifying the most likely reporter in a cartel is key to designing a successful Leniency Programme. The empirical results add to this finding by shedding light on the characteristics of the first reporters and the cartels to which they belong. The results show that EU firms who report the cartel and receive immunity of fines, through the LP, are typically repeat offenders while in the US these firms are likely to be the cartel leader. Repeat offending firms and cartel leaders are often the firms with larger sales in the cartel, so these results validate the findings from the theoretical model.

Some of the characteristics of the cartels in which these reporters take part, as opposed to cartels where an investigation was initiated by the Competition Authority, are also unveiled. In the EU, these cartels tend to be in the sectors of elevators and escalators, and needles and haberdashery, whereas in the US, these sectors are those of rubber and plastic, and paper and printing, and the cartels tend to occur in markets with a moderate number of buyers. All 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 likely not to be credible.

Knowing the characteristics of the reporting firms and the cartels in which they take part is vital to provide the correct incentives for firms so as to dissolve and dissuade cartels and the Leniency Programme should be formulated according to these incen-

tives. These 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. This paper shows that when the correct incentives are in place, firms with the largest sales will more likely report tax infractions such that auditing should focus on firms with a smaller level of sales.

6. Appendix A

Table 2: Summary Statistics - EU Data

Variable		Obs	Mean	Std. Dev.	Min	Max
firm(id)		471	159.90	96.90	1	341
case		471	38099.64	1096.84	33708	39579
cartel		471	39.19	22.70	1	81
sector		471	2.51	1.90	1	9
t(fine)	period in which the cartel was fined	471	2005.38	3.53	1998	2011
immunity_EU	dummy (=1) if the firm received full immunity of fines	471	.10	.30	0	1
Firm1pre	dummy (=1) if firm was the first to report the cartel to the EC, pre-investigation	471	.10	.30	0	1
Firm1post	dummy (=1) if firm was the first to report the cartel to the EC, post-investigation	471	.08	.27	0	1
cartel.dur	cartel duration, in months	471	97.84	72.89	4	419
carteldur2	squared cartel duration					
inv.dur	investigation duration, in months	471	46.89	21.87	3	96
invdur2	squared investigation duration					
N(firms)	number of firms per cartel	471	8.28	4.19	2	17
oth.red	reductions received by a firm, outside the LP, for mitigating circumstances	471	.027	.09	0	1
fine.increase	reductions received by a firm, outside the LP, for aggravating circumstances	471	.24	.55	0	2.9
EEA	dummy (=1) if cartel only affects the EEA market	471	.73	.45	0	1
LP	dummy (=1) if the cartel was discovered due to a spontaneous report	471	.72	.45	0	1
LP_1996	dummy (=1) if the LP of 1996 was applies to the final decision	471	.23	.42	0	1
LP_2002	dummy (=1) if the LP of 1996 was applies to the final decision	471	.52	.50	0	1
RO	dummy (=1) if firm participated in at least 2 cartels	471	.40	.49	0	1
NRO	number of repeat offenders per cartel	471	2.40	2.08	0	8
Def.turnover	deflated turnover of the firm, in the year before conviction	471	21.22	232.94	0	4717.05
Def.fine	deflated fine paid by the firm	471	39.63	74.36	0	586.98

Table 3: 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)	period in which the cartel was fined	2310	2004.76	5.17	1984	2011
cartel_share	cartel share, in %	921	1.61	8.36	.09	97
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
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
N (firms)	number of firms in the cartel	2310	15.18	21.86	2	112
NRO	number of repeat offenders per cartel	2310	3.36	3.78	0	20
RO	dummy (=1) if the firm is a repeat offender	2310	2.93	5.64	0	27
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 Government	2265	3.75	25.69	0	579
Fine_EU	Fine paid by the firm to the EU Government	2255	10.19	49.48	0	1137.7
Fine_total	Total fine paid by the firm	2297	24.60	87.80	0	1729
Prison_US	Months of prison in the US	2303	.69	6.27	0	126
immunity_US	dummy (=1) if the firm received full immunity of fines	2310	.02	.14	0	1
G_US	amount of overcharges paid by the firm	2023	565.43	3634.73	0	46631

Table 4: Regression Results - EU Data - Probit model

	immunity_EU (1)	immunity_EU (2)	immunity_EU (3)
N(firms)	-0.00	0.00	
	(0.00)	(0.00)	
RO	0.10***	0.09**	0.01*
	(0.04)	(0.04)	(0.00)
NRO	-0.01	-0.01	-0.00
	(0.00)	(0.01)	(0.00)
Def.turnover(M)	-0.00	-0.00	0.00
	(0.00)	(0.00)	(0.00)
eea	0.01	0.02	-0.00
	(0.02)	(0.02)	(0.00)
oth.red	-0.10	-0.03	-0.00
	(0.22)	(0.21)	(0.02)
fine.increase	0.00	0.01	-0.00
	(0.01)	(0.01)	(0.00)
LP	0.10***	0.11***	0.32***
	(0.02)	(0.01)	(0.04)
Firm1post	0.14	0.14	0.03
	(0.11)	(0.11)	(0.03)
cartel.dur	0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)
inv.dur	-0.00**	-0.00	0.00
	(0.00)	(0.00)	(0.00)
invdur2	0.00*	0.00	-0.00
	(0.00)	(0.00)	(0.00)
LP_1996	-0.03	0.11	0.98***
	(0.02)	(0.13)	(0.03)
LP_2002	0.04**	0.10	0.32***
	(0.02)	(0.06)	(0.08)
$\widehat{immunity}$	6.9%	6.7%	0.43%
sector2,industrial inputs			-0.00
			(0.00)
sector3, food and detergents			-0.00
			(0.00)
sector4, elevators and escalators			1.00***
			(0.00)
sector6, transport			-0.00
			(.)
sector7, needles and haberdashery			1.00***
			(0.00)
sector8, videotapes, videos and LCD			0.01
			(0.01)
sector9, fine art auctions			0.04
			(0.02)
Year FE		yes	yes
Sector FE			yes
N	470	450	442
Pseudo R^2	11.09%	11.00%	13.62%
Chi^2	89.85	1803.62	.
Log-likelihood	-137.79	-135.96	-131.18
no. iterations	5	8	10

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

Table 5: Regression Results - US Data - Probit model

	immunity_US (1)	immunity_US (2)	immunity_US (3)	immunity_US (4)	immunity_US (5)
N(firms)	-0.00**				
	(0.00)				
leader	0.01	0.01*	0.01*	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Mod_Buyers	0.05*	0.05*	0.06*	0.04	0.07
	(0.03)	(0.03)	(0.03)	(0.03)	(0.08)
Many_Buyers	0.02***	0.02***	0.02***	0.01***	0.00
	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)
RO_Cartel		0.00	0.00	0.00	0.00
		(0.00)	(0.00)	(0.00)	(0.00)
RO_Firm		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)
Fine_EU			-0.00***	-0.00***	-0.00***
			(0.00)	(0.00)	(0.00)
Prison_US			-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)
cartel.dur			-0.00**	-0.00*	-0.00
			(0.00)	(0.00)	(0.00)
$\widehat{immunity}$	1.54%	1.52%	0.96%	0.95%	0.49%
sector4, construction					0.51***
					(0.17)
sector5, Food and beverage					0.64***
					(0.19)
sector11, paper and printing					0.97***
					(0.05)
sector12, organic chemicals for agriculture					0.96***
					(0.04)
sector13, other organic chemicals					0.85***
					(0.10)
sector14, inorganic chemicals					0.95***
					(0.03)
sector16, rubber and plastic					0.98***
					(0.02)
sector17, stone, clay and graphite products					0.60***
					(0.16)
sector21, electronic devices					0.90***
					(0.11)
sector23, transport services					0.49**
					(0.21)
sector25, wholesale and retail					0.61***
					(0.14)
sector26, finance, insurance and banking					0.84***
					(0.10)
sector28, other services					0.91***
					(0.07)
Year FE				yes	yes
Sector FE					yes
N	2310	2310	2228	1648	1313
Pseudo R^2	5.28%	6.42%	9.54%	14.44%	26.95%
Chi^2	18.26	18.13	56.29	656.95	1448.40
Log-likelihood	221.13	-218.45	-209.58	-185.69	-150.43
no. iterations	4	4	6	8	9

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

7. Appendix B

Table 6: Regression Results - EU Data - FE model

	Def.Fine	Def.Fine	Def.Fine	Turnover	Turnover	Turnover
	(1)	(2)	(3)	(4)	(5)	(6)
firms	-0.37	-2.36*	-3.28	1.22	1.73	2.95
	(1.59)	(1.40)	(2.04)	(2.79)	(3.13)	(4.88)
RO	16.37**	13.58*	15.45**	3.30	1.56	10.21
	(7.10)	(7.16)	(7.44)	(27.63)	(27.10)	(28.94)
NRO	0.02	-0.69	-0.99	-1.94	0.03	-1.14
	(2.03)	(1.78)	(1.85)	(6.29)	(6.72)	(7.32)
eea	11.16	7.35	11.19	19.40	15.86	13.55
	(9.17)	(8.69)	(9.29)	(24.83)	(26.84)	(31.05)
oth.red	-43.41**	-29.55**	-29.82**	324.39***	180.46	213.16*
	(16.91)	(13.52)	(13.60)	(117.99)	(119.48)	(125.72)
fine.increase	2.86	8.72	9.37	36.71*	39.68*	41.31*
	(8.04)	(6.48)	(7.14)	(20.95)	(22.51)	(23.31)
LP	-13.46	-4.54	-12.13			
	(18.45)	(9.84)	(12.02)			
cartel.dur	-0.04	0.18	0.18	0.00	-0.01	-0.00
	(0.13)	(0.13)	(0.13)	(0.15)	(0.16)	(0.17)
carteldur2	0.00	-0.00*	-0.00*			
	(0.00)	(0.00)	(0.00)			
inv.dur	-1.95**	0.18	0.18			
	(0.90)	(1.10)	(1.25)			
invdur2	0.02**	-0.01	-0.01			
	(0.01)	(0.01)	(0.01)			
Def.turnover(M)	0.02***	0.02***	0.02***			
	(0.00)	(0.00)	(0.00)			
Firm1pre	-43.79***	-43.63***	-43.08***	1.77	7.93	6.84
	(6.19)	(5.95)	(5.85)	(36.54)	(35.27)	(35.81)
Firm1post	-15.71	-6.32	-7.05	106.99***	69.83*	73.16*
	(13.74)	(8.43)	(8.09)	(40.94)	(41.43)	(42.91)
LP_1996	-12.98	172.60	212.77**			
	(22.00)	(104.16)	(100.31)			
LP_2002	7.32	158.76	150.72			
	(11.73)	(102.57)	(97.81)			
sector2, industrial inputs			11.12			11.55
			(11.56)			(35.09)
sector3, food and detergents			-11.57			11.57
			(10.79)			(63.19)
sector4, elevators and escalators			6.17			-43.95
			(41.57)			(94.44)
sector5, banks			-57.98*			35.01
			(34.37)			(94.08)
sector6, transport			-2.66			-27.72
			(14.19)			(62.84)
sector7, needles and haberdashery			-25.23			-22.21
			(18.70)			(80.85)
sector8, videotapes, videos and LCD			0.42			28.63
			(20.50)			(75.10)
sector9, fine art auctions			10.24			63.41
			(15.93)			(167.27)
constant	87.12**	-156.46	-185.72	-26.20	-91.29	-90.31
	(34.10)	(109.24)	(112.66)	(35.21)	(76.15)	(94.74)
N	470	470	470	470	470	470
R^2	9%	23%	24%	4%	15%	15%
Adjusted R^2				2.38%	10.58%	9.25%
Year FE		yes	yes		yes	yes
Sector FE			yes			yes

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

Table 7: Regression Results - US Data - FE model

	Fine+G (1)	Fine+G (2)	Fine+G (3)	Sales (4)	Sales (5)	Sales (6)
leader	1380.92	1395.91	47.03	-3156.87	-3965.24	712.94
	(1384.02)	(1391.02)	(386.91)	(2532.43)	(3304.46)	(1965.81)
Many_Buyers	-2995.62	-4979.88**	1579.24*	18556.92*	15286.52*	12939.09**
	(2986.66)	(1990.39)	(937.02)	(10109.00)	(8524.79)	(4978.16)
Mod_Buyers	-5005.47	-6294.55**	-1820.08*	16862.24***	15487.19**	18524.86***
	(3985.22)	(3062.33)	(926.99)	(6386.75)	(7585.98)	(5743.75)
Bid_Rigging	-4467.82	-5620.68*	30.81	16288.03	19543.07*	10317.53*
	(3070.76)	(2870.22)	(893.97)	(10244.43)	(11004.99)	(5344.35)
N(firms)	65.12**	8.66	-251.67***	-41.08	128.70	1823.06***
	(28.62)	(51.28)	(67.60)	(173.93)	(141.75)	(362.28)
RO_Cartel	1417.41***	928.27***	388.97***	3319.13***	3217.23*	-1718.34***
	(388.22)	(228.44)	(95.67)	(1263.17)	(1747.35)	(481.49)
RO_Firm	-140.44*	-58.46*	1.13	-789.97***	-345.02*	146.90**
	(76.91)	(30.47)	(9.90)	(282.54)	(181.42)	(64.84)
S_US_cartel	0.08	0.04*	0.40***			
	(0.05)	(0.03)	(0.04)			
S_EU_cartel	0.70*	0.99***	0.17***			
	(0.36)	(0.29)	(0.02)			
Prison_US	38.62	45.59*	5.05			
	(39.50)	(23.10)	(4.27)			
cartel.dur	-117.90**	17.51	-17.34*	-0.42	-0.06	-0.62**
	(54.64)	(24.25)	(10.13)	(0.28)	(0.27)	(0.28)
carteldur2	0.29*	-0.03	0.04			
	(0.15)	(0.09)	(0.03)			
sector2, forestry, timber and roundwood		0.00	0.00		-22170.27*	14992.05*
		(.)	(.)		(11537.58)	(8883.53)
sector3, minerals		6691.71	-1620.88		-7977.71	13791.48*
		(5735.84)	(1436.69)		(8795.97)	(7459.11)
sector4		1051.44	-2603.65**		-13915.92	13782.92**
		(4273.84)	(1173.35)		(11082.72)	(6702.37)
sector5		2522.08	-1222.69		-3282.16	5948.45
		(3224.58)	(896.27)		(8445.89)	(6535.22)
sector6, tobacco		0.00	0.00		-8878.05	0.00
		(.)	(.)		(12228.24)	(.)
sector7, textiles		1570.90	-2794.85***		-1230.24	17198.79***
		(2945.94)	(907.92)		(10168.82)	(6207.63)
sector9, wood and lumber		0.00	0.00		-7498.76	9759.54*
		(.)	(.)		(10116.54)	(5540.24)
sector11		-7917.61*	-1103.48		-10474.79	10969.22
		(4656.21)	(772.46)		(8571.48)	(8317.81)
sector12		1416.94	-396.58		-3289.21	19590.99***
		(3169.20)	(974.79)		(8810.23)	(6146.80)
sector13		2754.69	-251.68		-7519.07	19371.33***
		(4117.12)	(829.70)		(9552.82)	(5843.55)
sector14		5905.31	-2389.90**		-3098.13	13865.31**
		(3685.82)	(955.43)		(8538.43)	(6121.95)
sector15, petroleum products		-2518.88	-3875.89**		-32119.28**	25315.66***
		(8931.53)	(1692.58)		(15982.56)	(9048.94)
sector16		-4270.02	-2000.22***		-11607.06	2570.06
		(3136.73)	(668.27)		(8048.43)	(5938.34)
sector17		3338.03	1974.03*		-12827.99	8445.02
		(3466.50)	(1047.37)		(10525.43)	(6065.97)
sector18, primary metals		-3840.56	-6244.20***		-10078.91	19332.97**
		(4120.03)	(1082.41)		(11783.41)	(8566.31)
sector19, fabricated metal products		453.45	1468.45		-104.51	13005.86***
		(3765.10)	(1090.08)		(8022.09)	(4391.53)
sector20, machinery and parts		-399.96	-1843.24**		-23848.90	23815.59***
		(3393.09)	(720.14)		(16421.47)	(7710.00)
sector21		-22521.19*	197.69		19707.86	38644.39***
		(12937.74)	(1576.22)		(15992.10)	(13342.53)
sector22, instruments		4278.27			-18355.77	9879.51
		(3460.38)			(17618.05)	(7915.68)
sector23		20289.43***	-111.95		7093.44	13176.18**
		(6498.82)	(1165.87)		(19270.71)	(5872.99)
sector24, communication services		689.05	-2617.14***		-5200.11	11136.45**
		(3076.52)	(744.12)		(8396.23)	(5204.25)
sector25		2072.70	-3461.99***		-7332.03	14328.68**
		(3604.96)	(1073.93)		(8004.96)	(5669.33)
sector26		11551.35**	-2726.85		37443.63	33388.32***
		(4868.55)	(2764.73)		(26980.96)	(12722.63)
sector27, water and energy distribution		0.00	0.00		-6556.88	0.00
		(.)	(.)		(12572.45)	(.)
sector28		-508.42	-2975.86		-11369.03	17118.92**
		(3835.76)	(1845.75)		(9628.46)	(7602.97)
constant	3955.47	-1390.21	359.50	-19714.46*	-26086.14**	-19312.53***
	(3491.02)	(4243.35)	(1105.84)	(10637.08)	(13233.96)	(6990.10)
N	993	993	463	2273	2273	904
R^2	65%	83%	98%	11%	23%	68%
Adjusted R^2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

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