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Essays on Regulatory Instruments:
Leniency and Anti-Dumping

by

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A thesis submitted for the degree of

Doctor of Philosophy (Ph.D)

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2014

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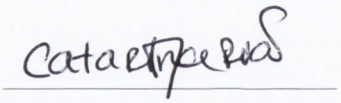

Catarina Marvão

Abstract

In this thesis I explore two specific regulatory instruments, from a theoretical standpoint and from an empirical perspective. In particular, I address the regulation of leniency in relation to EU and US cartels and the regulation of the alleged dumping of products exported into the EU.

The EU Leniency Programme aims to encourage the dissolution of existing cartels and the deterrence of future cartels, through reporting and/or significant cooperation by cartel members during an investigation. However, the European Commission guidelines are rather vague in terms of the factors that influence the granting and scale of fine reductions. In *Chapter 2*, I examine the firm and cartel characteristics that impact the past leniency decisions by the European Commission. I develop a theoretical model where firms are uncertain about their future cartel fines and possible fine reductions. Cartel members have to decide between reporting the cartel, cooperating with an ongoing investigation or remaining unresponsive. I identify the optimal leniency reductions that create incentives for firms to report and the factors which impact on the Commission's decision regarding the leniency reduction granted. I show that the equilibrium reductions for the initial reporters should be higher in smaller cartels and when the likelihood of being caught is perceived as being high. Using self-collected data on 81 EU cartels fined between 1998 and 2011, I further show that the first reporting or cooperating firm receives generous fine re-

ductions and I present some evidence that firms can "learn how to play the leniency game", either learning how to cheat or how to report, as the reductions given to repeat offenders are substantially higher. These results have ambiguous impacts on firms' incentives but potentially major implications for policy making.

In *Chapter 3*, I extend the analysis of the Leniency Programme outlined in *Chapter 2* to identify the characteristics of the first reporting cartel member, which is a vital issue for policy-makers in designing effective legislation / regulation. This is the first theoretical analysis of a cartel where firms are heterogeneous in terms of the cartel fine received and have private information on the probability of conviction. I explore the determinants of the reporting decision and show that firms which expect to receive higher fines, have a lower equilibrium threshold for reporting. To validate this theoretical result and analyze the source of fine heterogeneity, data for both EU and US cartels are used. Being the first reporter is shown to be correlated with recidivism, leadership and some characteristics of the cartels where reports occurred are identified.

In *Chapter 4*, I examine the effects of Anti-Dumping enforcement on EU border prices. The European Anti-Dumping Instrument aims to prevent firms from exporting into the EU at a price lower than "normal" but there is little consensus about its effects on the original export prices. I introduce an innovative theoretical model, where an exporting firm must choose a price at which to sell its output in a EU country, in the presence of uncertain enforcement of the Anti-Dumping law. The set of parameters which leads prices to increase or decrease, in the presence of an Anti-Dumping duty, is clearly identified. The empirical interpretation of the model reveals that duties are more likely to be imposed when the product's exports into the EU are growing quickly and if previous duties have been imposed on the same product. EU border prices (proxied by unit values) are shown to be positively correlated with the duties imposed, the average sector price, the length of investigations, short duties and the likelihood of receiving a duty. The main targets of EU duties, China and South Korea, are also analyzed separately. I find evidence of biased margins or erroneous margin calculations, internalization of the burden of the duty and retaliatory or protectionist motives in the imposition of the duties.

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Publications and Prizes arising from Thesis

Journal Papers:

1. **The EU Leniency Programme: Recidivism**, under review for *Review of Industrial Organization*;
2. **The EU Anti-Dumping Instrument: Empirical Evidence on Prices**, under review for *Review of International Economics*.

Prizes at Conferences:

1. **The EU Leniency Programme: Incentives for Self-reporting** - Selected for "Top specialist paper", at the European Competition and Regulation Conference (CRESSE) 2012;
2. **Heterogeneous Penalties and Private Information** - Selected for the "Rising Star" session at the International Industrial Organization Conference (IIOC) 2013.

Selected Conferences:

1. International Industrial Organization Conference (IIOC): 2013 - *Rising Star Session*;
2. Competition and Regulation European Conference (CRESSE): 2013, 2012;
3. European Association for Research in Industrial Economics (EARIE): 2012, 2011;
4. European Trade Study Group (ETSG): 2012;
5. Catholic Lisbon School of Business and Economics: 2013.

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CHAPTER 1

Introduction

THIS thesis contains three essays which address two important issues surrounding regulatory instruments: (i) the effectiveness of the Leniency Programme for cartels, in providing the correct incentives for firms, so as to dissolve and deter cartels; and, (ii) the impact of the Anti-Dumping instrument on EU border prices.

These instruments deal with problems arising in markets in which competitive forces are weak and economic analysis is essential in their design and in understanding their functioning and evaluating the need for their reform. Two main general areas are examined in this thesis: competition policy, which deals with illegal market behavior such as cartels, which are a formal agreement among competing firms, often taking the form of price fixing; and economic regulation, which refers to price control by the government, through mechanisms such as the Anti-Dumping Instrument. In the context of this thesis, dumping refers to exporting into the European Union at a price lower than its "normal" price in the home country.

Article 101 of the EU Treaty and the Sherman and the Federal Trade Commission Acts in the US, explicitly prohibit the existence of cartels. However, recent

antitrust cases provide ample evidence that cartel agreements are a perennial problem in the EU and US and they are one of the main stated concerns of the European Commission and the US Department of Justice. Since 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 were thus designed to work as a device of deterrence and dissolution of collusive agreements, through the granting of immunity of fines or substantial fine reductions to cartel members who report or cooperate with an investigation. These programmes have been in place since 1978 and 1996, respectively.

In *Chapter 2*, I identify the factors which provide cartel members with incentives to self-report and the factors which impact on the Commission's decision regarding the percentage leniency reduction granted to each cartel member. I introduce an innovative theoretical model where firms may report the cartel or cooperate with an investigation in exchange for leniency. The model is set in discrete time and it examines the behavior of an ongoing cartel with N members. I find that the decision to apply for the Leniency Programme depends not only on the expected fine reduction, but also on the probability of being the first reporter, and thus on the number of cartel members, on the expected probability of detection and prosecution by the relevant Competition Authority and on the level of cartel profits, deviation profits and Nash equilibrium profits. I further show that the "optimal" leniency reductions that incentivize self-reporting or cooperation with an ongoing investigation, should be larger for smaller cartels and when the cooperating firms perceive the probability of being investigated and prosecuted as being low.

I empirically test the model using self-collected data on 81 EU cartels where at least one leniency application was successful. Not surprisingly, I confirm that the first reporter receives significantly higher reductions. More importantly, and interestingly, the results illustrate how the 63 repeat offending firms can apparently play the "leniency game" and receive much higher predicted leniency reductions than

single offending firms. As such, although the Leniency Programme creates an incentive to report the cartel, it may also create an incentive to collude and be the first reporter. To reinforce this finding, I show that the number of sequential repeat offenders in a cartel also has a significantly positive and substantial impact on the predicted individual leniency reduction.

With the above results in mind, in *Chapter 3* I analyze the characteristics of the reporting cartel members. I extend the analysis to US cartels and I develop an innovative theoretical model where cartel members are heterogeneous in terms of the value of the cartel fine. The introduction of heterogeneity makes the model more realistic and gives rise to different equilibrium thresholds for reporting, thus eliminating the restrictive assumption of symmetric equilibria and allowing for more relevant policy recommendations, comparing to the existing literature[1]. I show that the firm with the highest fine has a lower threshold level for reporting 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. These signals are private information and may be generated from public statements issued by EU or US officials, knowledge about the budget allocated to the detection and conviction of cartels, and the proportion of convictions in cartel investigations, among others. I clearly identify the factors impacting the reporting decision and their weight, as well as the sources of fine heterogeneity.

In the empirical analysis, I include self-collected data on 81 EU cartels fined between 1998 and 2011 (the same dataset used in *Chapter 2*) and US data which was made available by John Connor (Purdue University) and which includes 799 US cartels fined in the period of 1984 to 2009, and I validate the earlier theoretical results. I further show that the initial reporters in the US tend to be the leader and act in cartels with a moderate or large number of buyers, whereas in the EU they seem to be repeat offenders who act in smaller cartels but where several cartel members are repeat offenders.

[1] Harrington (2013) explores the issue of a duopoly of homogeneous firms who receive public or private signals on the probability of conviction by a Competition Authority.

The material from *Chapters 2* and *3* make three noteworthy contributions to the existing literature. Firstly, I develop and test an innovative model which focuses on EU cartels and the factors which affect the decisions of cartel members in applying for leniency and of the EU Commission in granting a leniency reduction. This model considers different leniency reductions for each leniency applicant and includes several alternative definitions and measures of recidivism. A second theoretical contribution is the introduction of firm heterogeneity when cartel members have private information on the likelihood of conviction by the Authorities. Thirdly, a new EU dataset, which includes all the cases with at least one successful leniency application, up to July 2011, was self-collected from publicly available reports from the Commission's website and is constructed and analyzed. Overall, the two chapters deepen significantly our understanding of the firm and cartel characteristics that influence the EU leniency decisions and those that identify the reporting cartel members in both the EU and the US. Moreover, the results leave room for policy responses in the form of addressing recidivism, the generosity of EU leniency reductions, improving the clarity of the legislation and the proactivity of the Authorities and aligning the legislation with the optimal incentives for reporting.

Two papers stem from *Chapter 2*. The first paper includes the theoretical model and an extensive analysis of the policy implications of its results. This paper was invited for publication by the CRESSE Conference Committee as it was selected as one of the top specialist papers at the 2012 Conference. The second paper has its main focus on the empirical analysis and, in particular, on the case of repeat offenders. This paper is under review for the *Review of Industrial Organization* Journal.

An extension of *Chapter 3* is part of my Post-Doctoral studies' proposal, which will be funded by an ELEVATE Scholarship, from the Irish Research Council, and will allow me to spend two years at *Stockholm Institute of Transition Economics*, working with Giancarlo Spagnolo. In this extension, I intend to use a continuous time approach to model the beliefs of each cartel member, since firms may receive signals in different time periods or there may exist a time lapse between the re-

porting of the cartel and the initiation of the investigation. Future work will also introduce uncertainty in the amount of the individual cartel fine and a degree of risk aversion in the utility function of each cartel member. It will also assess the behavior of cartel members which merge and where the new firm subsequently participates in a new cartel. This work is likely to be co-authored with Laura Delaney, at City University London.

Chapter 3 also has important implications to the tax revenue literature, in what regards the decision of which firms to audit, so future work will also provide an application of the theoretical model to this literature.

The European Anti-Dumping instrument was created in 1995 as a tool to ensure that international trade is fair and on the optimal long-run path towards free trade. While the instrument allows the current 159 WTO countries to take action against dumped products, the current literature suggests that reasons other than dumping may be at the origin of the imposition of dumping duties and there is little (empirical) consensus on the impact of the duties on export prices.

The aim of *Chapter 4* is to shed further light on the use of the Anti-Dumping instrument in the European Union, with respect to its effect on border prices. This Chapter introduces a new theoretical model of an exporting firm that must choose a price at which to sell its output in a foreign market (ie. the EU) in the presence of the uncertain enforcement of Anti-Dumping law. The theoretical model contributes to this literature by identifying, and measuring, the factors which impact the pricing decision of the exporting firm, while taking into account the possibility of an Anti-Dumping duty being imposed. In particular, with the help of simulations, the set of parameters under which the Anti-Dumping duties lead to a decrease or increase in the unit values of exports into the EU, is identified.

Empirical research on the effect of prices is scarce and conflicting. To my knowledge, I present the first analysis of the evolution of EU border prices using uncertainty in the imposition of the duty and introducing measures of dumping injury, recidivism and retaliation. Using data collected by Chad Bown (*Global Anti-Dumping*

Database), for the years of 1995 to 2009, I show that the unit values tend to increase following the imposition of a duty but they are (in theory) lower for higher expected values of the duty. I also find some evidence of biased margins. Furthermore, a separate country-level analysis is carried for some of the main targets of Anti-Dumping initiations, namely, China and South Korea, and it supports the claims of retaliatory and/or protectionist reasons being at the origin of dumping duties. These results suggest that reasons other than dumping might be at the origin of Anti-Dumping petitions and it seems that a substantial revision of the Instrument is necessary to improve trade relationships and the welfare of EU producers and consumers.

CHAPTER 2

The EU Leniency Programme: Incentives for self-reporting - theory, practice and regulation

ARTICLE 101 [1] of the EU Treaty prohibits explicitly the existence of cartels. However, recent antitrust cases provide evidence that cartel agreements are a perennial problem in the EU: in 2011 and 2012, 23 groups of firms were put under formal cartel investigation by the European Commission DG-Competition.[2]

Following the example of the "successful" US Leniency Programme of 1978, the European Commission launched, in July 1996, the *European Leniency Programme* (*LP*) (European.Commission, 1996, LP). This programme grants immunity or reduction of fines to individual firms that are members of a cartel, in exchange for the initial reporting of the cartel and/or relevant cooperation with the Commission during a cartel investigation. Revisions to the LP occurred in 2002 and 2006 (European.Commission, 2002, 2006, LP), making it more detailed and, in general, more

[1] Article 101 of the Treaty on the Functioning of the European Union, formerly Article 81 of the European Community Treaty.

[2] Cartel members can report either to the national antitrust authority or directly to the European Commission. The cases are then dealt with by the EC (DG-Competition) if they have an appreciable effect on interstate trade or by the national antitrust authority if they are national cases. This chapter only deals with international cartel cases.

"generous".[3]

The procedures are fairly simple: leniency applicants have to submit a fax application, but are advised to call the Commission officials beforehand to obtain some assistance, which can be done directly or through a legal adviser. During the contact, the firm can find out if there is an ongoing investigation in the relevant market. If the firm is not first in line, it may cooperate and qualify for a fine reduction under the LP if, besides additional behavioral conditions, it provides "*significant added value with respect to the evidence already in the Commission's possession*". This is rather vague, since the applicant does not know, when applying, what information the European Commission (EC) has and/or to which extent it can meet the "added value" requirement.

The present chapter attempts to address the following question: what incentives does a firm have to apply to the LP? In other words, which firm or cartel characteristics influence the leniency decision by the Commission? Ideally, the expectations by firms are such that the programme creates a destabilizing effect for existing cartels and deters future cartels but there may exist a divergence between law and the stated guidelines and practice.

There is an extensive economic literature on the topic of the LP. Bloom (2006), for instance, suggests ways of improving transparency and certainty, while Wils (2007) looks at how theory and practice coexist. There are also numerous papers making use of game theory 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 and Motta and Polo (2003) conclude that significant reductions should be given for cooperation even after the investigation has started. Aubert et al. (2006) show that rewarding individuals, such as firm employees, is more ef-

[3]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 were 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 the cartel.

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

ficient 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 (2005) 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 (2012). Indeed, Chang and Harrington (2010) argue that the LP may also increase the rate of cartel formation because the additional caseload makes the authorities less aggressive.

In Harrington (2008), the frequency with which collusion occurs is examined and the author supports the view that the first reporter should be granted total immunity. This theoretical model is the basis for the model developed in the present chapter.

Taken together, then, the theoretical literature is somewhat ambiguous regarding the overall impact of the LP, which suggests the need for a differently focused approach to the topic. Indeed, several experimental papers examine the effects of the LP. Notable amongst them are studies by Hamaguchi and Kawagoe (2005), who find that cartels with more members are more likely to dissolve and Bigoni et al. (2008), who conclude that the LP increases deterrence but stabilizes surviving cartels.

The empirical literature is recent and includes several papers that merely analyze descriptive statistics on the LP (e.g. Connor (2007), Berinde (2008), Veljanovski (2010) and Asker (2010)). One of the first empirical papers using econometric methods is by Borrell and Jimènez-Gonzalez (2008), who look at the drivers of antitrust effectiveness and find it to be increased by the LP. Levenstein and Suslow (2011) estimate the impact of organizational mechanisms, such as moral hazard problems, which are discussed in more detail below, while Miller (2009) finds that the number

of cartels discovered increases in the periods around the introduction of the LP and decreases to pre-LP levels afterwards.

The empirical works that most closely relate to this chapter are by Sjoerd (2005) and Brenner (2009). Sjoerd uses data on 67 EU cartel cases, between 1990 and 2004 while Brenner uses data on 61 EU cartels in the period of 1990 to 2003. Sjoerd finds that the LP, measured by a dummy for whether a firm received maximum leniency or not, is positively correlated with the number of words in the decision (it is assumed that this is an appropriate proxy for the amount of information the Commission had) and the gravity of the infringement. The size of the reduced fine as a share of the firm's turnover is also found to be higher after the LP is introduced. Brenner finds a similar result when looking at the average of the absolute value of both the reduced and total fines. Additionally, both authors find that the duration of the investigation decreases once the LP is in place.

The present chapter contributes to the existing literature by examining, both theoretically and empirically, which factors give incentives to cartel members for self-reporting. This is not only innovative in the setting of a model with different leniency reductions for each applicant and taking into account repeated offenses by the same firm but also in the use of self-collected firm-level data together with the use of a Tobit model.

The theoretical model shows that the decision to apply for the LP depends not only on the expected fine reduction, but also on the probability of being the first reporter, and thus on the number of cartel members, on the expected probability of detection and prosecution by the Competition Authority (CA) and on the level of profits from the cartel, deviation profits and Nash equilibrium profits. It is also shown that the optimal leniency reductions that incentivize self-reporting or initial cooperation should be higher where there is a lower number of cartel members and when the cooperating firms perceive the probability of being investigated and prosecuted as being low.

The empirical investigation of the model focuses on the current LP. Not surprisingly, it confirms that the first reporter receives significantly higher reductions. More

importantly, it illustrates how the 63 repeat offending firms can apparently play the "leniency game" and receive predicted reductions, on average 24 percentage points higher than single offending firms. Although the LP creates an incentive to report the cartel, there may exist at least a temporary incentive to collude and then be the first reporter. To reinforce this finding, it is shown that the number of sequential repeat offenders in a cartel also has a significantly positive and large impact on the predicted individual leniency reduction.

From a policy point of view, at present, more cartels appear to be dissolving. This is either due to an effective LP that is able to encourage the dissolution of current cartels or due to a LP which causes more cartels to form and, as a result, more cartels are subsequently discovered and/or reported. The long-run aim is, or it should be, to deter new cartels from forming but the LP carries a potential problem of moral hazard in the sense that a cartel member might behave differently than if it were to receive no fine reduction. The long-run effect of the LP is not explicitly measured or evaluated in this chapter, but the fact that there are several repeat offenders and that these, within the current LP, seem to receive additional fine reductions, suggests that the long-run underlying trade-off may not be set in an ideal manner.

The organization of the rest of the chapter is as follows. In the next section the theoretical model is introduced. In *section 2.2* the dataset is described and the specific case of repeat offenders is discussed. The empirical methodology is described in *section 2.3* before the results are presented in *section 2.4*. *Section 2.5* offers concluding comments.

2.1 Theoretical Model

2.1.1 Setting of the game

The setting of the model introduced in this section follows from the approach taken by Harrington (2008) but it introduces different leniency reductions for each cartel member, thus leading to a higher robustness of the results. As in Harrington

(2008), the framework is set in discrete time. In this setting, firms do not observe the price and quantity set by the rivals and therefore, this cannot be interpreted as a reason to report the cartel. Finally, the likelihood of being caught is treated as exogenous as the purpose of this model is to find the "optimal" leniency reductions which should be offered by the Commission to each reporting or cooperating firm. In this sense, optimality is defined as the smallest possible fine reduction which provides firms with an incentive to report the cartel.

Consider a firm i which has an opportunity to collude. Given its expectations on the additional gains from collusion, the probability of conviction and its eventual fine, it decides to enter the cartel, with $N-1$ other firms. The rational for cartel participation has been previously discussed by other authors and it is therefore assumed that, in this model, firms find it rational to enter the cartel, even if they later apply for leniency. The game stages are as follows:

(1) ***Pre-investigation reporting stage.*** Each cartel member can decide to report to the Competition Authority (CA), so as to receive immunity or a substantial fine reduction. When a firm reports a cartel, it is assumed that the cartel ends and conviction occurs with certainty, such that reporting and cooperating firms pay a reduced fine ($\theta_i F_i$) and the other cartel members pay the full fine (F_i).

(2) ***Investigation stage.*** If no reporting occurs in (1), the CA investigates the cartel with probability ρ and this leads to a conviction with probability η. In case no investigation is initiated and there is no reporting, then the cartel lasts forever and the game is over.

(3) ***Post-investigation reporting stage.*** If there is an ongoing investigation on the cartel, the members can apply for a leniency reduction, up to 50%, in exchange for cooperation with the investigation. Cooperating firms pay a reduced fine ($\theta_i F_i$) and the other cartel members pay the full fine (F_i).

Before proceeding, the variables used in the model are discussed:

- The fine set by the CA, before the leniency reduction, is denoted by F and it is adjusted according to aggravating (A) and mitigating (M) circumstances.

The duration of the cartel has a positive impact on the value of the fine and recidivism is one of the aggravating factors.[5]

- $\theta = 1 - LRed$, is the fraction of the fine paid by the firm, after the leniency reduction ($LRed$). $\theta \epsilon [0,1]$, where 1 corresponds to no reduction and 0 corresponds to immunity of fines. The bands for the percentage fine reductions are set as shown on *Table 2.1.* The values for θ, according to the current LP, are the following:

$$\theta_1 \begin{cases} = 0 & if\ 1st\ reporter\ pre-investigation \\ \epsilon[0.5,1] & if\ 1st\ reporter\ post-investigation\ (secret\ investigation) \end{cases}$$

$$\theta_2 \begin{cases} = \theta_{21} \quad \epsilon[0.5,0.7] & if\ 1st\ firm\ cooperating \\ = \theta_{22} \quad \epsilon[0.7,1] & if\ subsequent\ firm \end{cases}$$

- The probability of investigation is given by $\rho \epsilon [0,1]$, which is taken as exogenous. $\eta \epsilon [0,1]$ denotes the probability of conviction if an investigation is initiated.

- γ describes the probability that a given cartel member is the first reporter. The number of reporting firms is given by $M \leq N$ such that $\gamma = 1/M$.[6]

- The cartel profits are given by Π^C. Π^D are the profits from deviating and

[5]The fine is set according to the current guidelines on the setting of general fines, updated in 2006: "Guidelines on the method of setting fines". For further information refer to the Guidelines (Commission, 2006b). The final value of the fine is capped at 10% of the total worldwide turnover of the firm in the previous year and special conditions are set in the case of inability to pay. The fine is set as: $F = [k(g_t)Sales_{t-1}][a\%cartel\ duration + b\%][1 + A - M]$. 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. Aggravating circumstances apply in the cases of recidivism, absence of cooperation, obstruction to the investigation or role of cartel leader or instigator. Mitigating circumstances relate to termination of the infringement at the time of the investigation, negligence as the cause of the cartel, limited involvement in the cartel, cooperation with the Commission outside the LP or proof of having been encouraged by public authorities or legislation.

[6]Some firms may be more likely to report if firm heterogeneity is introduced in the form of recidivism or higher expected fines. For the purpose of simplicity, firms are also assumed to be risk-neutral. It is likely that the first firm to come forward is the most risk-averse. However, including risk-aversion makes the model significantly more complicated, without benefiting the conclusions. This would also be difficult to measure in the empirical analysis.

it is assumed that deviation is punished by infinite reversion to static Nash Equilibrium (Π^N), such that $\Pi^D > \Pi^C > \Pi^N$.

Table 2.1: 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

The next two subsections examine the incentive compatibility constraints (ICC) for the reporting decisions in stages (1) and (3) and the game is solved by backwards induction.

2.1.2 ICC in Stage (3)

In this stage, the firm has to decide whether or not to cooperate, given that the CA is investigating the cartel. If the firm cooperates, it earns Nash equilibrium profits from the moment of reporting and its fine is reduced according to whether it is the first or a subsequent cooperating firm. If the firm does not cooperate with the investigation and at least one other cartel member reports, the firm will pay the total fine. The value functions are the following:

$$
\begin{aligned}
V_{Coop(3),i|no\ firm\ reports} &= \Pi^C + \tfrac{\delta}{1-\delta}\Pi^N - F\theta_{21} \\
V_{Coop(3),i|M\leq N firms\ report} &= \Pi^C + \tfrac{\delta}{1-\delta}\Pi^N - F[\gamma\theta_{21} + (1-\gamma)\theta_{22}] \\
V_{NoCoop(3),i|no\ firm\ reports} &= \Pi^C + (1-\eta)\tfrac{\delta}{1-\delta}\Pi^C + \eta(\tfrac{\delta}{1-\delta}\Pi^N - F) \\
V_{NoCoop(3),i|at\ least\ 1\ report} &= \Pi^C + \tfrac{\delta}{1-\delta}\Pi^N - F
\end{aligned}
$$

If no other cartel member reported the cartel, firm i will apply for leniency if

the following ICC holds:

$$\begin{aligned} & V_{Coop(3)|no\ firm\ reports,i} > V_{NoCoop(3),i|no\ firm\ reports} \\ \leftrightarrow\ & \Pi^C + \tfrac{\delta}{1-\delta}\Pi^N - F\theta_{21} > \Pi^C + (1-\eta)\tfrac{\delta}{1-\delta}\Pi^C + \eta(\tfrac{\delta}{1-\delta}\Pi^N - F) \\ \leftrightarrow\ & \eta > \frac{\frac{\Pi^c-\Pi^N}{F}\delta+(1-\delta)\theta_{21}}{\frac{\Pi^c-\Pi^N}{F}\delta+(1-\delta)} \end{aligned}$$

For large values of η, the firm is better off reporting the cartel.

If at least one other cartel member reports, firm i will apply for leniency if the following IC

$$\begin{aligned} & V_{Coop(3),i|M\leq N firms\ report} \\ \leftrightarrow\ & \Pi^c + \tfrac{\delta}{1-\delta}\Pi^N - F[\gamma\theta_{21} + \\ \leftrightarrow\ & \gamma\theta_{21} + (1-\gamma)\theta_{22} > V_{NoCoop(3),i|at\ least\ 1\ report} \\ \leftrightarrow\ & \Pi^c + \tfrac{\delta}{1-\delta}\Pi^N - F[\gamma\theta_{21} + (1-\gamma)\theta_{22}] > \Pi^c + \tfrac{\delta}{1-\delta}\Pi^N - F \\ \leftrightarrow\ & \gamma\theta_{21} + (1-\gamma)\theta_{22} < 1 \end{aligned}$$

The above inequation is always true. This demonstrates that if the CA opens an investigation by its own initiative, as long as one other firm reports, firm i is always better off cooperating so as to receive a leniency reduction, provided that the reward for reporting before an investigation initiates is higher than the reductions granted to post-investigation cooperation. While this might seem to be an obvious statement, empirical evidence shows that firms are often not willing to cooperate as this might have serious consequences to its future, such as punishment by other cartel members or other firms, negative impact on sales due to consumer's perception of the firm and possibly higher penalties due to more evidence being revealed.[7]

Since firms are symmetric, in stage (3) all cartel members report if the likelihood of conviction (η) is high and they will not report otherwise.

2.1.3 ICC in Stage (1)

In stage (1), the firm decides whether or not to report, given that the cartel might never be discovered. The value functions for applying or not are as shown

[7] These factors can easily be introduced in the model, by taking a continuous time approach, with no consequences for the main results.

below:

$$V_{apply(1),i} = \Pi^D + \tfrac{\delta}{1-\delta}\Pi^N \quad -\gamma\theta_1 F \quad -\gamma\theta_{21}F - (1-2\gamma)\theta_{22}F$$

$$V_{not\ apply(1),i|not\ apply(3)} = \rho[(1-\eta)\tfrac{\Pi^C}{1-\delta} + \eta(\Pi^C + \tfrac{\delta}{1-\delta}\Pi^N - F)] \quad +(1-\rho)\tfrac{\Pi^C}{1-\delta}$$

$$V_{not\ apply(1),i|apply(3)} = \rho[\Pi^C + \tfrac{\delta}{1-\delta}\Pi^N \quad -F(\theta_{21}\gamma - (1-\gamma)\theta_{22})] \quad +(1-\rho)\tfrac{\Pi^C}{1-\delta}$$

For low values of η, the firm does not apply in stage (3). In this scenario, in stage (1), the firm chooses to apply if the following ICC holds:

$$\begin{array}{ll} V_{apply(1),i} & > V_{not\ apply(1),i|not\ apply(3)} \\ \leftrightarrow \frac{\Pi^D + \Pi^N(1-\rho\eta)\frac{\delta}{1-\delta} + \Pi^c\frac{\eta\rho\delta-1}{1-\delta}}{F} & > \gamma\theta_1 + \gamma\theta_{21} + (1-2\gamma)\theta_{22} - \rho\eta \end{array}$$

For high values of η, the firm will apply in stage (3). In this case, in stage (1) the firm decides to apply if the following ICC holds:

$$\begin{array}{ll} V_{apply(1),i} & > V_{not\ apply(1),i|apply(3)} \\ \leftrightarrow \frac{\Pi^D + \Pi^N(1-\rho)\frac{\delta}{1-\delta} + \Pi^c\frac{\rho\delta-1}{1-\delta}}{F} & > \gamma\theta_1 + \gamma\theta_{21}(1-\rho) + (\rho - \rho\gamma + 1 - 2\gamma)\theta_{22} \end{array}$$

These inequations can be re-written in terms of the three leniency reductions ($LRed$):

$$\begin{cases} \theta_1^{low\ \eta} \equiv 1 - LRed_1 & < \frac{\Pi^D + \Pi^N(1-\rho\eta)\frac{\delta}{1-\delta} + \Pi^c\frac{\eta\rho\delta-1}{1-\delta}}{F\gamma} - \theta_{21} - \theta_{22}\frac{1-2\gamma}{\gamma} + \frac{\rho\eta}{\gamma} \\ \theta_{21}^{low\ \eta} \equiv 1 - LRed_{21} & < \frac{\Pi^D + \Pi^N(1-\rho\eta)\frac{\delta}{1-\delta} + \Pi^c\frac{\eta\rho\delta-1}{1-\delta}}{F\gamma} - \theta_1 - \theta_{22}\frac{1-2\gamma}{\gamma} + \frac{\rho\eta}{\gamma} \\ \theta_{22}^{low\ \eta} \equiv 1 - LRed_{22} & < [\frac{\Pi^D + \Pi^N(1-\rho\eta)\frac{\delta}{1-\delta} + \Pi^c\frac{\eta\rho\delta-1}{1-\delta}}{F} - \gamma\theta_1 - \gamma\theta_{21} + \rho\eta]\frac{1}{1-2\gamma} \end{cases}$$

$$\begin{cases} \theta_1^{high\ \eta} \equiv 1 - LRed_1 & < \frac{\Pi^D - \Pi^C\frac{1-\rho\delta}{1-\delta} + \Pi^N\frac{\delta}{1-\delta}(1-\rho)}{\gamma F} - \theta_{21}(1-\rho) - \theta_{22}\frac{\rho-\rho\gamma+1-2\gamma}{\gamma} \\ \theta_{21}^{high\ \eta} \equiv 1 - LRed_{21} & < \frac{\Pi^D - \Pi^C\frac{1-\rho\delta}{1-\delta} + \Pi^N\frac{\delta}{1-\delta}(1-\rho)}{(1-\rho)\gamma F} - \frac{\theta_1}{1-\rho} - \theta_{22}\frac{\rho-\rho\gamma+1-2\gamma}{(1-\rho)\gamma} \\ \theta_{22}^{high\ \eta} \equiv 1 - LRed_{22} & < \frac{\Pi^D - \Pi^C\frac{1-\rho\delta}{1-\delta} + \Pi^N\frac{\delta}{1-\delta}(1-\rho)}{(\rho-\rho\gamma+1-2\gamma)F} - [\theta_1 + \theta_{21}(1-\rho)]\frac{\gamma}{\rho-\rho\gamma+1-2\gamma} \end{cases}$$

The above inequations describe the set of optimal fine reductions that provide incentives for cartel members to report and which depend on the level of profits, fine, number of reporting cartel members and the probability of detection. This analysis

focuses on the constraints which must be met in order to have an equilibrium behavior of the cartel members. Antitrust Authorities want to provide incentives to reporting at the lowest possible cost, i.e., offering the lowest possible leniency reduction in exchange for the reporting of the cartel or cooperation with an investigation.

To provide an intuition for how the optimal individual leniency reductions ($LRed_1 = 1-\theta_1, LRed_{21} = 1-\theta_{21}$ *and* $LRed_{22} = 1-\theta_{22}$) change with the size of the cartel and the likelihood of being caught and prosecuted, comparative statics are carried out below. The above inequations are evaluated at their lowest value, to be in line with the objective function of the Antitrust Authority. Each leniency reduction depends on the values of the other leniency reductions, which in turn also depend on the parameters γ and ρ. For this reason, the values of the leniency reductions are taken as exogenous in the examination of the sign of each derivative.

$$\frac{\delta\theta_1^{low\ \eta}}{\delta\gamma} = \frac{\delta\theta_{21}^{low\ \eta}}{\delta\gamma} = -\frac{\Pi^D+\Pi^N(1-\rho\eta)\frac{\delta}{1-\delta}+\Pi^c\frac{\eta\rho\delta-1}{1-\delta}}{F\gamma^2} + (\theta_{22}-\rho\eta)\frac{1}{\gamma^2} < 0$$

$$\forall\ \theta_{22}\epsilon[0.7,1],\ \rho\epsilon[0,1],\ \gamma\epsilon]0,1],\ \delta\epsilon[0,1],\ 0<\Pi^N<\Pi^C<\Pi^D<+\infty,\ F>0$$

$$\frac{\delta\theta_{22}^{low\ \eta}}{\delta\gamma} = \frac{2}{(1-2\gamma)^2}\frac{\Pi^D+\Pi^N(1-\rho\eta)\frac{\delta}{1-\delta}+\Pi^c\frac{\eta\rho\delta-1}{1-\delta}}{F} - \frac{\theta_1+\theta_{21}-2\rho\eta}{(1-2\gamma)^2} \geq 0$$

$$\text{iff } 2\frac{\Pi^D+\Pi^N(1-\rho\eta)\frac{\delta}{1-\delta}-\Pi^c\frac{1-\eta\rho\delta}{1-\delta}}{F} \geq \theta_1+\theta_{21}-2\rho\eta$$

As shown in the Appendix, this derivative is < 0, $\forall\ \rho\epsilon[0,1],\ \gamma\epsilon]0,1]$,
$0=\Pi^N<\Pi^C<\Pi^D<+\infty$, *and* $F=F^{max}=10\%\Pi^C$, $\theta_1=0.5$, $\theta_{21}=0.6$.

$$\frac{\delta\theta_1^{high\ \eta}}{\delta\gamma} = -\frac{\Pi^D-\Pi^c\frac{1-\rho\delta}{1-\delta}+\Pi^N\frac{\delta}{1-\delta}(1-\rho)}{F\gamma^2} + \theta_{22}\frac{1+\rho}{\gamma^2} < 0$$

$$\frac{\delta\theta_{21}^{high\ \eta}}{\delta\gamma} = -\frac{\Pi^D-\Pi^C\frac{1-\rho\delta}{1-\delta}+\Pi^N\frac{\delta}{1-\delta}(1-\rho)}{\gamma^2F(1-\rho)} + \theta_{22}\frac{1+\rho}{\gamma^2(1-\rho)} < 0$$

$$\forall\ \theta_{22}\epsilon[0.7,1],\ \rho\epsilon[0,1],\ \gamma\epsilon]0,1],\ \delta\epsilon[0,1],\ 0<\Pi^N<\Pi^C<\Pi^D<+\infty, F>0$$

$$\frac{\delta\theta_{22}^{high\ \eta}}{\delta\gamma} = \frac{\Pi^D-\Pi^C\frac{1-\rho\delta}{1-\delta}+\Pi^N\frac{\delta}{1-\delta}(1-\rho)}{F}\frac{\rho+2}{(\rho-\rho\gamma+1-2\gamma)^2} - [\theta_1+\theta_{21}(1-\rho)]\frac{1+\rho}{(\rho-\rho\gamma+1-2\gamma)^2} \geq 0$$

$$\text{iff } \frac{\Pi^D-\Pi^C\frac{1-\rho\delta}{1-\delta}+\Pi^N\frac{\delta}{1-\delta}(1-\rho)}{F}(\rho+2) \geq [\theta_1+\theta_{21}(1-\rho)](1+\rho)$$

As shown in the Appendix, this derivative is positive for low values of ρ and δ and negative otherwise.

The share of the individual cartel fine paid by the reporting cartel members is smaller for larger values of γ, which means that the lower is the number of reporting cartel members, the higher should be the optimal leniency reduction [$\uparrow \gamma \equiv \frac{1}{M} \Rightarrow \downarrow M \Rightarrow (\downarrow \theta_1 \; and \; \downarrow \theta_{21}) \Rightarrow \uparrow LRed$]. These results are in line with what is found by Hamaguchi and Kawagoe (2005), regarding the number of cartel members. Granting higher reductions to firms in smaller cartels has a direct impact on the sustainability of the cartel, thus increasing the likelihood of reporting or cooperation with an ongoing investigation.

$$\frac{\delta\theta_1^{low\ \eta}}{\delta\rho} = \frac{\delta\theta_{21}^{low\ \eta}}{\delta\rho} = \frac{\Pi^c-\Pi^N}{F\gamma}\frac{\eta\delta}{1-\delta} + \frac{\eta}{\gamma} > 0$$
$$\frac{\delta\theta_{22}^{low\ \eta}}{\delta\rho} = \frac{1}{1-2\gamma}[\frac{\Pi^c-\Pi^N}{F}\frac{\eta\delta}{1-\delta} + \eta] > 0$$
$$\frac{\delta\theta_1^{high\ \eta}}{\delta\rho} = \frac{\Pi^c-\Pi^N}{F\gamma}\frac{\delta}{1-\delta} + \theta_{21} - \theta_{22}\frac{1-\gamma}{\gamma} > 0$$
$$\frac{\delta\theta_{21}^{high\ \eta}}{\delta\rho} = \frac{\Pi^D+\Pi^c}{F\gamma}\frac{1}{(1-\rho)^2} + [\theta_1 - \theta_{22}\frac{2-3\gamma}{\gamma}]\frac{1}{(1-\rho)^2} > 0$$
$$\frac{\delta\theta_{22}^{high\ \eta}}{\delta\rho} = \frac{\Pi^c(\delta-2\delta\gamma+1-\gamma)-\Pi^N(2\delta-3\delta\gamma)}{F(1-\delta)(\rho-\rho\gamma+1-2\gamma)^2} + \theta_1\frac{\gamma-\gamma^2}{(\rho-\rho\gamma+1-2\gamma)^2} - \theta_{21}\frac{3\gamma^2-2\gamma}{(\rho-\rho\gamma+1-2\gamma)^2} > 0$$
$$\forall\ \theta_{22}\epsilon[0.7,1],\ \rho\epsilon[0,1],\ \gamma\epsilon]0,1],\ \delta\epsilon[0,1],\ 0 < \Pi^N < \Pi^C < \Pi^D < +\infty, F > 0$$

Borrell and Jimènez-Gonzalez (2008) find that antitrust effectiveness is increased due to the LP ($\uparrow \rho$) while Chang and Harrington (2010) argue that the LP makes the CA less aggressive ($\downarrow \rho$). It is thus not surprising that the above comparative statics show that the optimal leniency reductions for cartel members who cooperate with an investigation should be lower when there is a higher likelihood of prosecution. This illustrates the trade-off between the desistance effect created by the probability of the CA prosecuting a cartel and high leniency reductions which incentive self-reporting and/or cooperation.

The empirical interpretation of this model is considered in *section 2.4*.

2.2 Data

2.2.1 Data collection

The data employed in the empirical analysis were self-compiled 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. Within the set of all cartel cases since 1996 (95 cartels), only those in which there was at least one successful LP application were selected (81 cartels).[8] The final decisions on the setting of fines, for the cases in analysis, were taken between 1998[9] and 2011 and include the universe of cases making use of the LP, up to July 15th 2011. The starting date of the investigation for these cases range between 1994 and 2009. The investigation year is the official date in which the Commission started the investigation and hence not necessarily the same date/year in which the cartel was reported. The 81 cartels involve 385 cartel members, in a total of 471 firm-level observations as several firms took part in more than one cartel and are therefore, labeled repeat offenders. This is discussed in subsection *2.3.3*.

Other datasets have been used by other authors in the description and analysis of cartels. These are summarized in *Table 2.2*.

Table 2.2: Dataset and analysis of Cartels

Author	Data	Number Cartels	Number Firms	Analysis	Time Period
Connor (2007)	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

Tables 2.3 and *2.4* define and describe the variables for use in the model specifications. The percentage leniency reduction is used, since the absolute amount of

[8] It is important to note that cartels, and not cases, are analyzed in the chapter, 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. See Table 4.5 for further details.

[9] 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 fine is capped at 10% of the firm's worldwide turnover in the previous year and comprehensive information on the appropriate turnover is not available.[10] Also, the percentage values are more representative when comparing across firms and cases. For each cartel, information was gathered on the duration of both the cartel and the investigation carried out by the Commission, the number of firms and of repeat offenders per cartel, the geographic area in which the cartel impacted, in terms of customer prices (EEA or extra-EEA countries), the specific LP in use (1996, 2002 or 2006), whether or not the case was initiated due to a leniency application, the type of cartel infringement, and the years of reporting of the cartel to the Commission, of initiation of the investigation and final decision. The types of cartel infringement incurred in the cases under analysis are mainly price fixing but also include allocation of tenders, fixation of quotas and sales conditions, sharing of geographic markets, exchange of sensitive information on prices, sales volumes and procurement tenders, elimination of price discounts and bid rigging. Firm-level information was also collected and includes information on the individual fine both before and after the leniency reduction, whether the firm is the first reporter, either pre or post-investigation, and other fine reductions and increases obtained previously to and independently of the application of the LP, due to mitigating and aggravating circumstances.

2.2.2 Data description

The number of cartels discovered since 1998 has been growing as has been the total number of firms involved in cartels, in each year. This is shown in *Table 2.5*, which reports the number of cartel cases closed, the number of firms fined in each year and the number of leniency reductions, for the period between 1998 and July 2011. It is important to bear in mind that the figures presented for the number of cases using the LP may slightly differ from the actual values, due to the cases under investigation (open) and for which public information was not yet available on July

[10]The highest fines imposed, after leniency and other reductions, on a cartel member were for *Saint-Gobain SA*, which was fined 896 million euros after having received, in 2009, 50% leniency reduction, for its participation in a car glass cartel; and for *F.Hoffmann-La Roche AG*, in 2001, 462 million euros (again, after a 50% leniency), for being a member in a vitamins cartel.

Table 2.3: Description of the variables

Variable:	Definition:
LRed	dependant variable: percentage of leniency reduction given to a single firm, or a group of firms jointly fined $= 1 - \theta = \frac{leniency\ reduction\ (euro)}{total\ fine\ (F)\ (euro) - other\ reductions\ (M)\ (euro)}$
Firm1pre	dummy (=1) if firm was the first pre-investigation reporter
Firm1post	dummy (=1) if firm was the first post-investigation reporter
Firm2	dummy (=1) if firm was the second to cooperate with an investigation
Firm3	dummy (=1) if firm was the third to cooperate with an investigation
RO	dummy (=1) if firm participated in at least 2 cartels
NRO	number of repeat offenders per cartel
RO1	dummy (=1) if firm participated in at least 2 sequential cartels
NRO1	number of sequential repeat offenders per cartel
oth.red (**M**)	reductions received by a firm, outside the LP
fine.increase (**A**)	fine increases received by a firm
eea	dummy (=1) if cartel only affects the EEA market
cartel.dur	cartel duration, in months
cartel.dur2	squared cartel duration
inv.dur	investigation duration, in months
inv.dur2	squared investigation duration
firms (**N**)	number of cartel members
y_t	year fixed effects

2011. The figures for "open cases" correspond to the latest update on a case, i.e., the year in which a given case had its last development, as of July 2011. The cases are also separated by what led to the discovery of the cartel. Some cases were found due to the LP, that is, when one of the cartel members reported the existence of the cartel to the Competition Authority before an investigation had initiated. The number of cases found through pre-investigation reporting has increased dramatically, being as high as 83% in 2008 (5 of 6 cases) and 86% in 2009 (6 of 7 cases) and 100% in both 2010 and 2011 as of July. The remaining cases were discovered for other reasons, such as reporting by a third party (e.g. customer or rival firm) or by the Commission's own initiative, perhaps by observing the evolution of prices.

Figure 2.1 shows the allocation of the percentage leniency reductions granted for the periods of 1998-2001 (LP 1996) and 2007-7/2011 (LP 2006). The "generosity" and willingness to provide incentives to self-reporting have visibly increased: 26% of the reductions correspond to immunity in the period of 2007 to July 2011, while full

Table 2.4: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
LRed $(= 1 - \theta)$	0.240	0.311	0	1	471
Firm1pre	0.098	0.297	0	1	471
Firm1post	0.081	0.273	0	1	471
Firm2	0.185	0.388	0	1	471
Firm3	0.127	0.334	0	1	471
RO	0.399	0.490	0	1	471
NRO	2.396	2.084	0	8	470
RO1	0.032	0.176	0	1	471
NRO1	0.183	0.497	0	2	471
oth.red (**M**)	0.027	0.092	0	1	471
fine.increase (**A**)	0.236	0.549	0	2.9	471
eea	0.728	0.445	0	1	471
cartel.dur	97.840	72.885	4	419	471
cartel.dur2	14873.688	25323.368	16	175561	471
inv.dur	46.885	21.868	3	96	471
inv.dur2	2675.425	2368.993	9	9216	471
firms (**N**)	8.276	4.194	2	17	471
t	2005.382	3.526	1998	2011	471

immunity corresponded to a very small share in the initial period (5.7%). Conversely, reductions below 10% became very scarce.

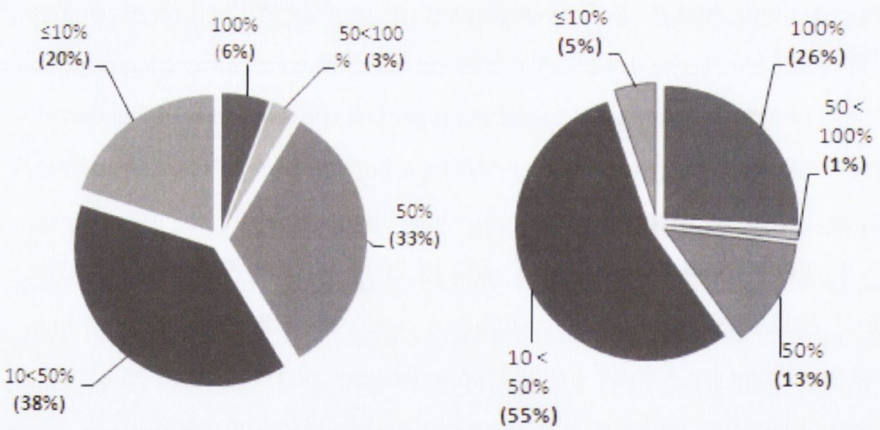

Figure 2.1: Leniency Programme Reductions (%), 1998-2001(left) and 2007-7/2011

Table 2.6 reports the distribution of reductions granted between 1998 and July 2011. Over half of the firms in cartels with leniency applicants, received a fine

Table 2.5: Statistics on cartel cases (using the LP), by decision year

Year	Closed cartels (cases)	Open cases	Cartels found by LP	No.firms	No.LP reductions	No.other reductions	Average cartel duration (years)
1998	2 (2)	-	-	18	10	8	3.7
1999	1 (1)	-	-	24	2	11	6.1
2000	2 (2)	-	1	28	5	23	4.1
2001	15 (7)	-	8	25	25	1	6.3
2002	10 (9)	-	7	48	42	4	7.0
2003	4 (4)	-	3	26	18	3	14.0
2004	3 (3)	-	3	29	8	10	6.8
2005	4 (4)	-	4	39	17	1	11.7
2006	6 (5)	1	6	67	19	3	7.2
2007	15 (8)	-	5	67	67	53	7.0
2008	6 (6)	-	5	34	11	1	6.9
2009	6 (5)	1	6	49	16	2	10.1
2010	6 (6)	6	6	68	33	25	12.0
July 2011	1 (1)	1	1	3	3	-	4.0
total	81 (63)	15	55	525	276	145	-
mean	5.8 (4.5)	-	4	38	20	10	7.6

Source: Author's calculations, using data from EC's website.

reduction and almost 10% received full immunity.[11] These numbers illustrate the increasing importance of the programme, not only in terms of the amount of reductions given in each cartel case but also in the number of pre-investigation leniency applications. It also highlights the need to understand the main factors impacting on the setting of the percentage fine reductions.

Table 2.6: Frequency of Leniency reductions granted in 1998-July 2011

Reduction	Frequency
0%	**209**
1-9%	4
10-19%	46
20-29%	48
30-39%	42
40-49%	25
50%	**46**
61%	1
70%	1
90%	1
100%	**48**
Total	471

Source: Author's calculations, using data from EC's website.

[11] The discontinuity in the amount of fine reductions is due to the range of leniency reductions set in the guidelines, for each reporting or cooperating firm.

2.2.3 Data for Repeat Offenders

The LP Notice is not explicit as to whether or not repeat offenders should receive a lower reduction. Chen and Rey (2012) suggest that they should, while Houba et al. (2009) and the Greek Competition Authority[12] suggest the opposite. *Table 2.7* shows the distribution of the firms fined according to the number of cartels in which they have taken part. The numbers may even be underestimates since there is no information on unknown cartels, both past and present. Most firms (83%) have been found to participate in only one cartel, but more serious are the cases of *Akzo Nobel* and *F.Hoffman-La Roche*, which in the past eleven years, have been fined for their roles in 9 cartels each, and received significant leniency reductions in most of the cases. Details on the involvement of Akzo are shown in *Table 2.8*, as an example of a repeat offending firm.

It is challenging to define the term "Repeat Offender" precisely in the present context. Two firms (*Akzo and Degussa*) started to participate in a new cartel after being previously fined. Four other firms (*Mitsubishi, ABB, FMC and Thyssen Krupp*) only ended their participation in a cartel after being fined for participation in another cartel. Other 22 firms ended their participation in a cartel after an investigation was initiated in another cartel of which they were a participant. Finally, a total of 63 firms have participated, contemporaneously or not, in at least two cartels.

The 2006 Leniency Notice states that a repeat offender is any firm that was previously found to infringe Articles 101 or 102 of the EU Treaty, which corresponds to six of the firms included in this chapter (definition 1, *RO*). 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. Nonetheless, the data show that it does not seem to be the case that firms report cartels in different markets, as happens with the US Amnesty Plus Programme. Instead, it seems that firms learn how to use the LP in their benefit, either by learning what and when to report or how to be the first reporter. Therefore, a broader

[12] Available at:www.epant.gr/faqs.php.

definition of the term is also considered and it includes any firm who was convicted for collusion at least twice, which corresponds to 16% of the firms in the analysis (63/385) (definition 2, *RO1*). Including both definitions in the empirical analysis allows to distinguish between simultaneous and sequential cartels, as these can imply very distinct problems in the design of the leniency rules.

Table 2.7: Number of cartels per firm, 1998-July 2011

	Repeat Offender	No.Cartels	No.Lenincy reductions	No.Full Leniency	No.Other Reductions
firms:	Akzo	9	6	3	0
	Degussa Evonik	5	5	2	0
	Mitsubishi	4	0	0	2
	ABB	3	1	1	0
	FMC	3	1	0	1
	Thyssen Krupp	3	2	0	0
	F.Hoffman-La Roche	9	9	0	0
	Prym	5	4	1	0
	Coats	4	2	0	0
	ENI	4	1	0	0
	SGL	4	2	0	0
	Total	4	2	0	0
	Fuji	3	2	0	0
	Shell	3	1	1	0
	Solvay	3	2	0	0
	Toshiba	3	0	0	1
	YKK Group	3	2	0	0
	Hitachi	3	0	0	2
	Ajinomoto	2	2	0	0
	Arcelor Mittal	2	2	0	0
	Carbone Lorraine	2	2	0	0
	Cheil Jedang	2	2	0	1
	Daesang	2	2	0	1
	Hoechst AG	2	1	0	0
	IMI	2	2	0	0
	Kemira	2	1	1	0
	Mueller Ind.	2	2	2	0
	Nippon Steel	2	1	0	1
	Repsol	2	2	0	1
	Tokai Carbon	2	1	0	0
	35 other firms				
sub-total	63 Repeat Offenders				
	322 Single Offenders				
total	385 firms				

Source: Author's calculations, using data from EC's website.

Table 2.8: Statistics on cartel cases (using the LP) where Akzo took part, by decision year.

Akzo

decision year	invest. year	cartel duration	Len. Red.	Oth. Red	no. Firms	Product	Reduction 000€	Fine 000€
2001	1997	1987-1995	40%	0%	5	Sodium Gluconate	6,753	10,130
2003	2001	1971-1999	100%	0%	6	Organic Peroxyde	214,500	0
2004	1999	1992-1998	0%	0%	3	Choline chloride	0	20,990
2005	2000	1984-1999	25%	0%	4	MCAA acid	28,127	84,380
2006	2003	1994-2000	40%	0%	9	Hydrogen peroxide	16,680	25,020
2008	2003	1994-2000	100%	0%	8	Sodium Chlorate	116,000	0
2009	2003	1991-2000	0%	0%	8	Heat stabilizers	0	40,600
2009	2007	2004-2007	100%	0%	15	Calcium carbide	17,400	0

Source: Author's calculations, using data from EC's website.

2.3 Empirical Model

The econometric work informs about how the Commission makes decisions regarding the Leniency Reductions granted to cartel members. This work does not attempt to identify the characteristics of the reporting firm[13] nor to discuss the optimal design of the Leniency Programme.

Two main criteria influenced the choice of the specific empirical method. Firstly, it is likely that the decisions of granting a leniency reduction and its amount are directly related. Secondly, the purpose of this chapter is to examine which factors incentivize a cartel member to apply to the LP and the differences between the LP Notice and reality. Since the LP only allows for fine reductions, the zeros in the dependent variable need to be modeled. This is rather a problem of censoring than of sample selection bias, so using a censoring model on the data for all the firms in cartels with at least one leniency applicant, should provide consistent results. The appropriate approach is a Tobit which jointly models the factors affecting the decision of granting a fine reduction and its amount, and takes into account the censoring of the zeros.

To jointly model the three leniency programs (of 1996, 2002 and 2006) provides a very small scope for conclusions as the programmes have changed over time. Therefore, separate estimations for each LP produce a more accurate analysis as they

[13] In fact, this is done in the following Chapter.

allow one to study its evolution. This chapter focuses on the current LP (of 2006), since it is the most relevant for policy making. Nevertheless, the same analysis is carried out for the two previous LPs and, while these results are not discussed, they are included in *Table 2.10* in the Appendix.

According to the LPs of 2002 and 2006, the first firm to report a secret cartel receives full immunity[14], so firms who self-reported and received immunity of fines are excluded.

In the theoretical construct shown in *section 2.2*, the following relationships are shown:

$$\theta_1 = f(\theta_{21}, \theta_{22}, \delta, \rho, \gamma, \Pi^D, \Pi^N, \Pi^C, F)$$
$$\theta_{21} = g(\theta_1, \theta_{22}, \delta, \rho, \gamma, \Pi^D, \Pi^N, \Pi^C, F)$$
$$\theta_{22} = h(\theta_1, \theta_{21}, \delta, \rho, \gamma, \Pi^D, \Pi^N, \Pi^C, F)$$

In the empirical approach, the leniency reduction for each cartel member is identified by $Firm1post, Firm2$ *and* $Firm3$ ($\theta_{21}, \theta_{22}, \theta_{22}$ in the theoretical model) and the number of firms in the cartel is given by N (*=firms*), where $\gamma = \frac{1}{N}$ in the theoretical model. As previously mentioned, the fine (F) depends on the duration of the cartel (cartel.dur) and is adjusted by aggravating circumstances (*A=fine.increase*), including recidivism (RO, RO1, NRO, NRO1), and mitigating circumstances (*M=oth.red*), so these variables are all included in the empirical model. Finally, additional variables are included to account for the geographic area of impact by the cartel's activities (*eea*) and the duration of the investigation (*inv.dur* and *inv.dur2*). Therefore, building on the theoretical construct, the canonical specification of the model is of

[14]Immunity is granted provided the firm complies with the CA's conditions. Since the LP of 2002 was put in place, only one initial applicant firm did not receive full immunity, as its reporting was not completely voluntary. Instead, a 90% reduction was granted.

the following form:

$$\begin{aligned} LRed_{ijt} &= \beta_0 + \beta_1 Firm1post_{ijt} + \beta_2 Firm2_{ijt} + \beta_3 Firm3_{ijt} \\ &+ \beta_4 RO_{ijt} + \beta_5 NRO_{jt} + \beta_6 RO1_{ijt} + \beta_7 NRO1_{jt} \\ &+ \beta_8 fine.increase_{ijt} + \beta_9 oth.red_{ijt} \\ &+ \beta_{10} firms_{jt} + \beta_{11} eea_{jt} + \beta_{12} cartel.dur_{jt} \\ &+ \beta_{13} inv.dur_{jt} + \beta_{14} inv.dur2_{jt} + \varpi T_t + \varepsilon_{ijt} \end{aligned}$$

where i and j are the indices for firm and case, respectively, ε is the error term, which is assumed to be *iid* and ϖ is the vector of year dummies (T), where t is the decision year in each cartel case.

2.3.1 Sample Selection Bias

One concern with the data is the possibility of sample selection bias. Four possible biases may arise:

(i) Since cartels are prohibited by the EU Treaty, they are secret so the available data only include cartels that were prosecuted and convicted. Past secret cartels may be so because their members did not have a strong enough incentive to report the cartel. This problem of selection on the unobservables cannot be overcome, but its existence is acknowledged in the interpretation of the results.

(ii) One other issue which may generate selection on the unobservables is the case of "*repeat offenders*". There may be individual unobservable characteristics of these firms that determine their repeated participation in cartels. Nonetheless, this issue requires a more complex analysis of repeat offenders, which is outside the scope of this chapter. In the data, dummy variables controlling for multiple and sequential repeat offenders, are included so as to find whether recidivism is or not relevant in the setting of the leniency reductions.

(iii) The term "*single offender*" may be misleading, either because the firm also 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 underestimated.

(iv) The cases in which there was no successful LP application are excluded (14 cases for the period in use), which makes the data a non-random subset of the total of discovered and secret cartels. Cases without LP applications are, however, irrelevant for this chapter's research question. Nevertheless, a Heckman two-stage model[15] was used to examine the possibility of sample selection bias in the data for leniency reductions, but the inverse mills ratio was not significant, which means that there is no selection bias on the observable variables that have been included in the selection step.

2.3.2 Endogeneity

One other concern with the data is the possibility of reverse causality in what concerns the variable accounting for the duration of the cartel and which is likely to be linked with whether or not a leniency application was received by the Competition Authority. For this reason, an instrumental variable is introduced in the Tobit estimation. To instrument for cartel duration, the current and lagged values of the firm's turnover are used, as these are directly related to the duration of the cartel but are unlikely to be related to the percentage leniency reduction granted to each cartel member. Nonetheless, it is shown that this is not a serious issue as the results are robust throughout the specifications. This is also supported by the analysis of the qualitative information on these cartels, where it is clear that the duration of the cartel is not directly correlated with the level of leniency reductions granted nor with the application for a leniency reduction.

[15] In the Heckman two-stage model (Heckman, 1979), the first stage corresponds to a Probit modeling the probability of receiving a leniency reduction and the second stage is a fixed effects model which measures the amount of leniency reduction granted.

2.4 Results

Table 2.9 presents the Tobit results for the current LP. The values reported correspond to the marginal effects calculated at the sample means of the data, since the coefficients from the Tobit model measure the change in the latent dependent variable. Clustering is done at the cartel level but the results are robust to clustering at case level and there is no serious issue of sample selection bias on the observable variables, as tested by the Heckman two-stage model. The possible existence of a selection bias on unobservables is of course acknowledged.

To control for a possible endogeneity issue in the cartel duration variable, column (4) consists of an instrumental variable Tobit estimation, where the current and lagged values of the individual firm's turnover are used as instruments. Column (5) introduces year fixed effects and column (6) presents an alternative definition of repeat offenders. Finally, column (7) includes the individual fine increase, which is due to recidivism or other aggravating circumstances. Columns (5) to (7) are the preferred specifications.

2.4.1 Reporting and Cooperating

The first firm to report the cartel before the CA launches an investigation receives full immunity of fines, so this is not included in the results. Once an investigation is in place, the first reporting or cooperating firm should be entitled to receive 30 to 50% of leniency reduction. However, the results show that the predicted leniency reduction is higher, at around 67 to 78% (see columns (5)-(7)), at the mean values of the remaining explanatory variables. The second and third firms cooperating with an investigation should receive 30-50% and 20-30% reductions, but receive in fact around 54% and 30 to 36%, respectively. These results are significant and consistent throughout the specifications and although the proportion of leniency reductions is in line with the leniency legislation, the magnitude of the reductions is larger, even when taking into account the size of the standard errors. As shown in *section 2.2*, higher expected leniency reductions increase firms' incentive to report and these empirical results reveal the generosity of the LP of 2006, towards reporting and

Table 2.9: Regression Results - Tobit - Leniency Programme of 2006

(LRed)	LP.2006 (1)	LP.2006 (2)	LP.2006 (3)	LP.2006 (4) IV	LP.2006 (5)	LP.2006 (6)	LP.2006 (7)
Firm1post	0.68***	0.55***	0.67***	0.67***	0.67***	0.78***	0.69***
	(0.08)	(0.09)	(0.13)	(0.14)	(0.14)	(0.20)	(0.14)
Firm2	0.50***	0.47***	0.54***	0.53***	0.55***	0.55***	0.53***
	(0.10)	(0.09)	(0.11)	(0.12)	(0.12)	(0.13)	(0.12)
Firm3	0.38***	0.37***	0.36***	0.36***	0.36***	0.30***	0.34***
	(0.07)	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)	(0.07)
RO	0.21***	0.23**	0.23***	0.23***	0.24***		
	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)		
NRO		-0.03	0.02	0.02	0.05		0.09**
		(0.03)	(0.02)	(0.02)	(0.04)		(0.04)
RO1						0.06	
						(0.17)	
NRO1						0.46***	
						(0.13)	
fine.increase (**A**)							0.49*
							(0.28)
firms (**N**)		-0.02	0.01	0.01	0.03	-0.05***	0.03
		(0.02)	(0.01)	(0.01)	(0.03)	(0.01)	(0.02)
oth.red (**M**)		0.81*	0.39	0.41	0.54	-1.58*	0.34
		(0.45)	(0.32)	(0.34)	(0.52)	(0.94)	(0.54)
eea		0.09	0.06	0.06	0.17	-0.74***	0.11
		(0.10)	(0.10)	(0.10)	(0.14)	(0.25)	(0.10)
inv.dur		0.00	-0.01***	-0.01**	-0.02***	-0.00	-0.02***
		(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)
invdur2			0.00**	0.00*	0.00***	0.00***	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)	(0.00)	(0.00)	(0.00)	(0.00)
year FE	no	no	no	no	yes	yes	yes
pseudo R^2	41.35%	45.58%	55.84%		56.71%	60.44%	52.50%
Log-likelihood	-32.69	-30.33	-24.62	-577.02	-24.13	-22.05	-26.48
$\widehat{lred}$	-0.0559	-0.0584	-0.0552	-0.0509	-0.0574	-0.0567	-0.0591
Chi^2				557.77			
Iterations				9			
Instrument1				turnover			
Instrument2				lagged turnover			
N censored	64	64	64	64	64	64	64
N uncensored	43	43	43	43	43	43	43
N total	107	107	107	107	107	107	107

***, **, * correspond to 1, 5 and 10% significance level, respectively. Standard errors reported in parenthesis. The R^2 corresponds to McFadden's pseudo R-squared.

cooperating firms.

2.4.2 Repeat Offenders

The LP Notice excludes firms with a leading role from receiving immunity but it makes no statement regarding repeat offenders.[16] This is why the most interesting result in this chapter relates to the variables that account for repeat offenders.

As previously mentioned, *RO* includes any cartel member who has been found to collude at least twice, whereas *RO1* accounts for cartel members who colluded sequentially in at least two cartels. This is important in distinguishing between multiple cartels and recidivism, which imply different problems in the design of the leniency rules. The variable *fine.increase*, instead, includes recidivism and any other factors that lead to fine increases.

It is found that, for the observed cartel cases and despite the fact that leniency reductions should not be affected by recidivism, the predicted leniency reduction is around 24 percentage points higher for repeat offenders, in its broad sense (*RO*), than for single offending firms, keeping all the other variables constant. Nonetheless, the number of repeat offenders per cartel (*NRO*) has a small but insignificant impact on the firm's predicted leniency reduction.

When the analysis takes into account sequential offenses (*RO1*), it is only the number of sequential repeat offenders per cartel (*NRO1*) that seems to influence the leniency reduction granted. For each additional sequential repeat offender in a cartel, the predicted leniency reduction is around 46 percentage points higher (for a maximum number of two sequential repeat offenders per cartel), at the sample mean values.

The leniency reduction should also be independent from the fine increase but Sjoerd (2005) finds that the gravity of the infringement increases the leniency reduction. In line with this result, the empirical analysis shows that the predicted reduction, at the mean values, is 49 percentage points larger if the original fine was

[16] Note that recidivism is included in the aggravating circumstances in the setting of the original fine, as stated on *section 2.2*. However, the setting of fine and leniency reductions are independent, as the fine guidelines are very strict and appear to allow very little if any "discretion".

increased and 9 percentage points larger for each additional repeat offending firm in the cartel (up to a maximum of eight repeat offenders), in its broad sense. Again, these results are likely to be underestimated and may carry a problem of selection in the unobservables.

The above discussed results are robust, causal and possibly suggest some strategic behavior: a previously fined firm can arguably learn "the rules of the game" and take advantage of the LP by being the first reporter or by providing better or more extensive information.

In the cases analyzed, fewer than half of the repeat or multiple offenders were the first reporter (32% and 20%, respectively) but a large share received a leniency reduction (59% and 68%, respectively). Repeat offending firms often collude with the same set of firms (eg. *Akzo, Arkema France* and *Degussa Evonik*) and they seem to take turns in the reporting of the cartel to the Commission. It is surprising that a firm would collude in a new cartel (although for a different product) with a firm who reported their previous collusive agreement.

As previously mentioned, some multiple and repeat offending firms also merge with or acquire a firm with whom they previously colluded. It is not clear why firms would enter a collusive agreement if they could merge. A merger is, in theory, a better strategy than collusion since while both may give rise to monopoly gains, a collusive agreement comes with the inherent risk of detection. Moreover, a merger also allows cost savings by increasing efficiency. Hence, firms would be expected to choose to merge instead of colluding, when the two options are available. The existence of the LP may, however, change firms' incentives as the risk of detection is higher but the reporting of the cartel may grant the firm immunity from fines. One example of this scenario is Akzo and BASF. Between 1992 and 1998, Akzo, BASF and four other firms participated in a cartel in choline chloride. When Chinook (one of the cartel members) reported the cartel to the Commission, in 1998, and the firms were fined (with a 20% leniency reduction for BASF and 30% for AKZO), Akzo acquired BASF's decorative coatings business in Europe, increasing its market

share in coatings from 5% to 60%. Although examples of recurrent cartel partners and mergers or acquisitions of previous partners can be found in several industries, these practices are particularly evident in the pharmaceutical industry, which is the industry where most EU cartels occur and in which Akzo is one of the largest players.

There may also be specific characteristics of these firms which make them more prone to colluding. Multiple and repeat offending firms tend to be big in terms of their sales or market share, which may provide them with the means to orchestrate a cartel. They may also be more skillful and thus, better at colluding, even if the firm would have high rates of return without the collusive agreement. One other possibility is the firm's corporate culture or the market in which they act. In India, for example, perhaps because of the lack of fear of sanctions, there is a culture of cartelizing. Depression cartels are allowed in many countries, in industries which require price and production stability. In Japan, such arrangements have been permitted in the steel, aluminum smelting, ship building and various chemical industries.

It is in the EU's interest that firms self-report so that cartel members can be convicted, but it may be that repeat offending firms are, or are becoming, particularly good at providing relevant information and that the LP is actually encouraging collusion. This may also relate to the US Amnesty Plus Programme, where firms report contemporaneous cartels in other markets, once they are being investigated for collusion. Although this does not apply to the EU rules, firms may fear being fined in other cartels and so they report them in advance of a possible investigation.

Recidivism is a serious problem and may well require a different and/or tougher approach in the future calculation of appropriate leniency reductions. The LP should ideally create ex-post deterrence or a desistance effect, which could possibly be achieved through unrestricted and, thus, greater expected sanctions for repeat and multiple offenders, at the cost of fewer reported cartels. This trade-off needs to be carefully assessed. A desistance effect does not seem to exist, since 15% of the fined

cartel members, in the period 1998 to October 2013, have taken part in more than one cartel. In fact, 8% of the firms have participated in at least 3 cartels. Repeat offenders may also be defined by specific firm characteristics, such as industry, nationality and firm size, but this analysis is outside the scope of this chapter.

2.4.3 Other variables

In *section 2.2*, it is shown that the optimal reductions for the first reporting or cooperating firms should be lower for cartels with more members. Indeed, it is found that a higher number of cartel members (*firms*) slightly decreases the leniency reduction of the average firm, although this is only true when the set of repeat offenders is restricted to sequential cartels, thus decreasing the impact of the number of repeat offenders per cartel. This may also mean that in smaller cartels, firms have more and/or better information on the cartel's activity and so they receive slightly larger leniency reductions.

The magnitude of the fine adjustments for mitigating circumstances (*oth.red*) and therefore outside the LP, is also examined. As expected, they seem to be fairly independent from the setting of the leniency reduction. However, it is shown that when considering sequential repeat offenders, the predicted leniency reduction is much lower when other reductions are also granted. This result supports the idea that the reporting firms tend to have a determinant role in the cartel and are thus not entitled to other reductions.

The LP requires that the European Commission is notified of all the jurisdictions where a leniency application was made. Brenner (2009) finds that the number of countries in which the cartel members are based is not correlated with the fine reductions, while Borrell and Jimènez-Gonzalez (2008) find that the average antitrust effectiveness depends on country-specific characteristics. For these reasons, a dummy controlling for cartels that affect exclusively EEA based customers of the cartel's product(s) is included. Firms in cartels which exclusively concern EEA customers are likely to receive a lower fine reduction, although this result is only valid when restricting the set of repeat offending firms to those in sequential cartels.

When other jurisdictions are also affected, they can impose fines (and fine reductions), such that the total fine paid by the cartel member is larger. In this way, EU Authorities can grant larger leniency reductions and have the same impact, in terms of absolute value of the individual fine (in the several jurisdictions).

Harrington (2008) argues that the cartel duration (*cartel.dur*) may be informative as to the change in the total (discovered and not) number of cartels and Levenstein and Suslow (2011) conclude that fluctuations in firm-specific discount rates significantly affect the cartel duration. The LP, however, stipulates that if the first reporter gives further information so that a CA establishes additional facts which increase the duration of the infringement, those will not be taken into account for that specific firm. To control for possible endogeneity, an instrumental variable is introduced, but the coefficients for cartel duration (*cartel.dur*) are consistently zero. This is not surprising as the duration of the cartel is already accounted for in the setting of the initial fine.

Sjoerd (2005) and Brenner (2009) both conclude that the duration of the investigation is decreased by the introduction of the LP as leniency applicants reveal more information to aim for a higher fine reduction. Nonetheless, the coefficients of the duration of the investigation (*inv.dur* and *inv.dur2*) indicate that this variable has a linear and small negative impact on the predicted leniency reduction granted to each cartel member.

2.5 Discussion

What really matters to the setting of the percentage fine reductions within the Leniency Programme? What incentives do firms have to self-report and does the reality match the guidelines? To what extent and in what ways can firms use and possibly abuse the LP?

There are no doubts as to the increasing importance of the LP and the number of firms applying for leniency reductions in exchange for information on secret cartels to which they belong. It is thus of major importance to guarantee that the programme

is efficient in preventing, dissolving and thus increasing the probability of conviction and that it does not constitute an easy way to escape a fine. The best approach to ensure such, is probably making the guidelines very clear and explicit, in an attempt to guaranteeing that firms clearly know the consequences they face and what they can expect.

The analysis carried out in this chapter confirms the main expected result: the first reporter receives much higher fine reductions, whether or not the reporting of the cartel takes place before the Commission started an investigation. This supports both the guidelines and the aim of the LP in providing a significant incentive to reporting, although the reductions seem to be higher than what is outlined in the guidelines.

It is interesting to note that the predicted leniency reductions seem to be larger for firms who take part in smaller cartels, in line with the theoretical results, and in cartels with a wider geographical impact. Leniency reductions also appear to be larger for firms which receive lower fine reductions outside the LP.

However, arguably the main result is that repeat offenders receive higher leniency reductions, which shows some evidence that firms can learn the "rules of the game", repeatedly colluding and reporting the cartel, thus substantially damaging their partners. While the prospect of high leniency reductions may incentivize these firms to report, it may also create an incentive to participate in a cartel and then be the first reporter, thus learning how to "cheat". Due to the ambiguous impact of the LP on firms' incentives, repeat offenders' penalties should be carefully assessed so as to create a desistance effect and the leniency reductions should be independent of recidivism, or else this link should be made explicit in the guidelines.

The existence and application of such a programme has major impacts for society in general and it seems that firms are able to use it in their own benefit, in some unintended ways, although the number of reported cartels has been increasing. This is supported by the previous theoretical and empirical research and seems apparent in the data. It is likely that this means the long term effect of the LP is not being achieved. From the point of view of a firm, it may seem better to enjoy higher

profits of collusion, up to the moment of reporting to the Commission, pay a small or no fine, since the reductions granted are generally very high, and still enjoy the damage caused by the very high fines imposed on the other cartel members, i.e., the competing firms. From the point of view of policy-makers, the existence of firms that have participated in more than four cartels in the last eleven years should be seen across as a warning signal that, despite the increase in the number of cartels reported, the LP may also have pro-collusive effects, which are reinforced by the fact that the cartels reported by a given firm are often in a single market. In summary, it appears clear that the guidelines should be more explicit and less generous, especially in how repeat offenders are treated.

2.6 Appendix

2.6.1 Calibration of the model

To provide an intuition for the sign of the more complex derivatives in the comparative statics, these are calibrated with the average values for the leniency reductions, as stated in the current LP of 2006 and the average number of cartel members. The Nash Equilibrium profits are assumed to be zero. Therefore:

$$
\begin{aligned}
\widehat{\theta_1} &= 0 \\
\widehat{\theta_{21}} &= 0.6 \\
\widehat{\theta_{22}} &= 0.85 \\
\widehat{N} &= 8 \qquad \Rightarrow \widehat{\gamma} = \tfrac{1}{\widehat{N}} = 0.125 \\
\widehat{\Pi^N} &= 0 \\
F = F^{max} &= 10\%\Pi^C
\end{aligned}
$$

(1)
$$
\begin{aligned}
\frac{\delta\theta_{22}^{low\ \eta}}{\delta\gamma} &= -\frac{2}{(1-2\gamma)^2}\frac{\Pi^D+\Pi^N(1-\rho\eta)\frac{\delta}{1-\delta}+\Pi^c\frac{\eta\rho\delta-1}{1-\delta}}{F} - (\theta_1+\theta_{21}-2\rho\eta)\frac{1}{(1-2\gamma)^2} \\
&= -\frac{1}{0.5625}[20\frac{\Pi^D}{\Pi^c} + 20(\frac{\eta\rho\delta-1}{1-\delta}) + (0.6-2\rho\eta)] < 0
\end{aligned}
$$

(2)
$$
\begin{aligned}
\frac{\delta\theta_{22}^{high\ \eta}}{\delta\gamma} &= \frac{\Pi^D-\Pi^C\frac{1-\rho\delta}{1-\delta}+\Pi^N\frac{\delta}{1-\delta}(1-\rho)}{F}\frac{\rho+2}{(\rho-\rho\gamma+1-2\gamma)^2} - (\theta_1+\theta_{21}(1-\rho))\frac{1+\rho}{(\rho-\rho\gamma+1-2\gamma)^2} \\
&= 10(\frac{\Pi^D}{\Pi^C} - \frac{1-\rho\delta}{1-\delta})\frac{\rho+2}{(\rho-\rho\gamma+1-2\gamma)^2} - 0.6\frac{(1-\rho)(1+\rho)}{(\rho-\rho\gamma+1-2\gamma)^2}
\end{aligned}
$$

2.6.2 Regression Results

Table 2.10: Regression Results - Tobit - Leniency Programmes of 1996 and 2002

(LRed)	LP_all (1)	LP_all (2)	LP_all (3)	LP2002 (1)	LP2002 (2)	LP2002 (3)	LP1996 (1)	LP1996 (2)	LP1996 (3)
Firm1post	0.64***	0.59***	0.67***	0.58***	0.53***	0.61***	0.50***	0.52***	0.61***
	(0.08)	(0.09)	(0.08)	(0.13)	(0.14)	(0.13)	(0.12)	(0.13)	(0.12)
Firm2	0.74***	0.74***	0.76***	0.43***	0.38***	0.45***	0.36***	0.39**	0.40***
	(0.06)	(0.07)	(0.06)	(0.09)	(0.11)	(0.09)	(0.13)	(0.15)	(0.13)
Firm3	0.25***	0.29***	0.26***	0.22***	0.26***	0.24***	-0.06	0.09	0.09
	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	(0.07)	(0.06)	(0.09)	(0.07)
RO	0.17***			0.14**			-0.05		
	(0.05)			(0.06)			(0.05)		
NRO	0.04**		0.06***	0.05*		0.06***	0.16**		0.12***
	(0.02)		(0.02)	(0.03)		(0.02)	(0.06)		(0.04)
RO1		0.07			0.09			-0.02	
		(0.14)			(0.17)			(0.07)	
NRO1		-0.02			0.03			-0.31	
		(0.05)			(0.05)			(0.21)	
fine.increase (**A**)			0.12***			0.01			0.25***
			(0.05)			(0.05)			(0.05)
cartel.dur	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)
firms (**N**)	-0.02***	-0.02***	-0.02***	-0.01	-0.00	-0.01	0.02	0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.04)	(0.02)
oth.red (**M**)	-0.18	-0.09	-0.24	-0.39	-0.32*	-0.38	-0.01	0.51*	0.07
	(0.19)	(0.17)	(0.19)	(0.24)	(0.19)	(0.24)	(0.25)	(0.27)	(0.23)
eea	0.01	-0.02	0.02	0.10	0.08	0.11	0.07	-0.19*	0.11
	(0.07)	(0.08)	(0.07)	(0.12)	(0.11)	(0.13)	(0.13)	(0.10)	(0.07)
inv.dur	-0.01	-0.01**	-0.01	0.02	0.02	0.02	0.03	0.03	0.09***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.03)	(0.04)	(0.03)
invdur2	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)
year effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
pseudo R^2	51.73%	43.94%	51.21%	42.62%	34.93%	40.37%	105.86%	95.84%	129.69%
Log-likelihood	-166.30	-193.44	-168.09	-71.43	-80.98	-74.20	3.11	-2.22	15.76
$\widehat{lred}$	0.0880	0.0886	0.0894	-0.0142	-0.0125	-0.0150	0.1899	0.1913	0.1869
N censored	209	209	209	115	115	115	29	29	29
N uncensored	261	262	261	100	100	100	78	79	78
N total	470	471	470	215	215	215	107	108	107

***, **, * correspond to 1, 5 and 10% significance level, respectively. Standard errors reported in parenthesis. The R^2 corresponds to McFadden's pseudo R-squared.

CHAPTER 3

Heterogeneity of Penalties and Private Information - theoretical and empirical findings regarding the initial reporting firm

CARTELS are a perennial problem and they are one of the main explicitly stated concerns of the European Commission and the US Department of Justice. As discussed in the previous chapter, cartels are secret and so, 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 detection rate and/or a higher incidence of cartels. The US and EU Leniency Programmes (LPs) were thus designed to work as a device of deterrence and dissolution of collusive agreements and have been in place since 1978 and 1996, respectively.[1] While the US LP provides the first reporter with immunity from fines in exchange for the reporting of a previously unknown cartel, the EU LP also offers substantial fine reductions to other participants, in exchange for cooperation with an ongoing investigation.

The adequacy or otherwise of the fine reductions has been analyzed extensively

[1]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. See (Department D.O.J., 1978) and see Chapter 2 for further details on the EU LP.

but the characteristics of the reporting cartel members remain unexplained. This chapter addresses this question by being the first to develop and test a model where cartel members are heterogeneous in terms of the value of the cartel fine. The introduction of heterogeneity makes the model more realistic and gives rise to different equilibrium thresholds for reporting, thus eliminating the restrictive assumption of symmetric equilibria and allowing for more relevant policy recommendations. It is shown that the firm with the highest fine has a lower threshold level for reporting 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. 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, and 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 revealing some of the characteristics of the first reporting firms and of the cartels in which they take part.

In addition to the extensive theoretical literature discussed in *section 2.1*, a paper by Harrington (2013), is closely related to this research. Harrington (2013) models a duopoly of homogeneous firms who receive public or private signals on the probability of conviction by a Competition Authority. While Harrington's paper is the first to introduce private signals, the underlying assumption of homogeneity of firms only allows for symmetric equilibria. The main theoretical contribution of the present chapter is thus the introduction of heterogeneity, in terms of the level of the fine among cartel members, and the analysis of its impact on the reporting decision.

As previously mentioned, Sjoerd (2005) and Brenner (2009) estimate the effects of the EU LP and in *Chapter 2*, I estimate the factors that influence the granting and scale of leniency reductions. The present chapter uses EU data which was self-collected and compiled from the publicly available reports and press releases in 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 an innovative EU dataset and in the examination of the characteristics of the firms who report the cartel pre-investigation and receive immunity of fines, and of the associated cartels.

The organization of the rest of the chapter is as follows. In the next section the theoretical model is introduced. In Section 3.3, the EU and US Leniency Programmes are discussed. The empirical methodology is described and discussed in Section 3.4. Section 3.5 offers concluding comments.

3.1 Theoretical Model

3.1.1 Setting of the model and Strategies

The game has two stages. In the first stage, a two-firm cartel collapses for internal reasons.[2] Suppose that the firms (i and j) are risk-neutral and heterogeneous in terms of the value of their expected fine (F_k, where $k = (i, j)$), which could be due to factors such as different sales level, recidivism and leadership or instigation of the cartel. The determinants of the individual EU or US cartel fine are discussed in the next section.

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 $s_k = E(\rho)$ 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 and share of the budget allocated to investigation and/or prosecution of cartels, among others.[3] It is assumed that it is not costly to search for the signal.

[2]This assumption is quite standard in the literature, as it simplifies the mathematical solution of the model. However, 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.

[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. The signals may also be correlated with the number of years in the industry and the firm's products and behavior.

Given the signal received and the expectations on the other firms's behavior, firms decide to report (R) if the signal is above their threshold level (x_k) or not to report (NR).

The potential combination of outcomes, given each firms' strategy, 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 fine. In this model, θF_k denotes the share of the fine paid by each convicted firm. In addition to the penalty set for each cartel member, the cartel sanction includes a payment for damages caused to consumers (overcharges) and other costs inherent to being fined (G_k). It is assumed that the values of G_k are exogenous and common knowledge.

The behavior of firm j is included in the equilibrium condition 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. As in Harrington (2013), to capture the positive correlation between the signals, 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 $H(s_j|s_i = s')$.

The value functions for firm i are the following:[4]

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

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

Each firm decides to report if the additional value from reporting is positive. For

[4]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.

firm i, this is given by $\Delta(s_j, x_j) = V_i^R - V_i^{NR}$. Therefore, the following conditions must hold:

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

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

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

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

$\frac{\partial \Delta}{\partial F_i} = [1 - E(\rho)]\frac{G_i}{F_i^2} \geq 0$

The reporting decision depends on the values of the expected probability of being caught, the fine, overcharges and leniency reduction and on the behavior of the other cartel member. *Table 3.1* defines the variables present in the theoretical model.

Table 3.1: 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
$\phi(s_i, s_j)$	pair of possible actions
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
$H(s_j\|s_i)$	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

3.1.2 Equilibrium

Given the existence of the LP, firms contemporaneously decide whether or not to report. Using the equilibrium condition of firm i when firm j is at its cut-off point

$(s_j = x_j)$, the following condition is true:

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

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 $\Delta(s_i, x_j) < 0$, $\forall s_i < x_i$. The same condition and inference can be made for firm j.

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. $\Phi(.)$ denotes the expected additional value from reporting, taking into account the decision of the other cartel member, such that: $\Phi(x) = H(x|x)\Delta(x, x)$. $H(x|x)$ 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:

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

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

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

When firm j's threshold for reporting is at its minimum, then reporting is strictly preferred for firm i, for all signals, since the rival (firm j) will report. This effect is stronger for larger values of the leniency reduction granted $(1 - \theta)$.

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

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

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

If firm j's threshold for reporting is at its maximum, then firm j will not report and not reporting is also strictly preferred for firm i, for all signals, provided that $\Phi(\overline{s_j}) < 0$. This is graphed in *Figure 3.1.* For the values of the fine and overcharges used in the calibration, it is shown that not reporting is preferred by a cartel member when the probability of prosecution is zero. If this value is increased to 50%, then the firm will choose not to report for leniency reductions below 50%.

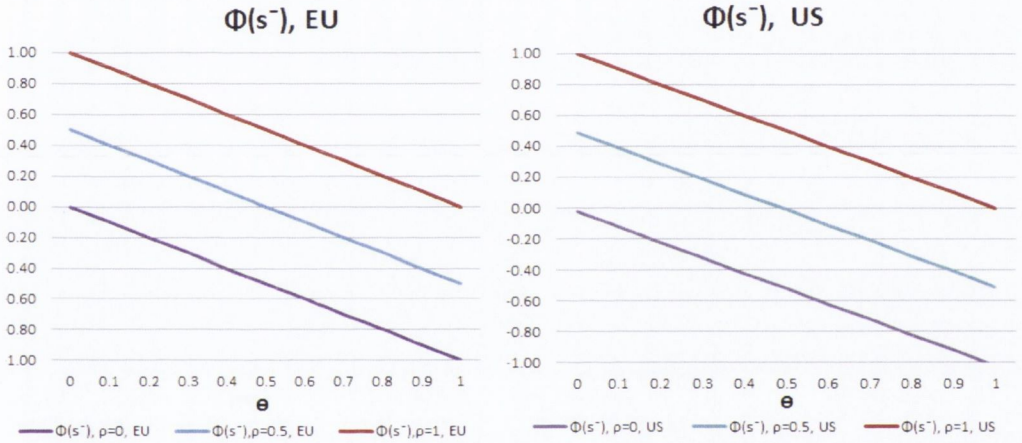

Figure 3.1: $\phi(\overline{s})$, when $\widehat{F(US)} = 24600$ and $\widehat{G(US)} = 565.43$, for several values of θ.

(3) $x_j = s'_j$

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

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

When the threshold level is not at its limits, then 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 $\Phi(s'_j) < 0$. In this case, firm i's decision depends on its own threshold level. This is graphed in *Figure 3.2.* $\Phi(s'_j)$ is higher for larger values of the leniency reduction

and of the likelihood of prosecution.

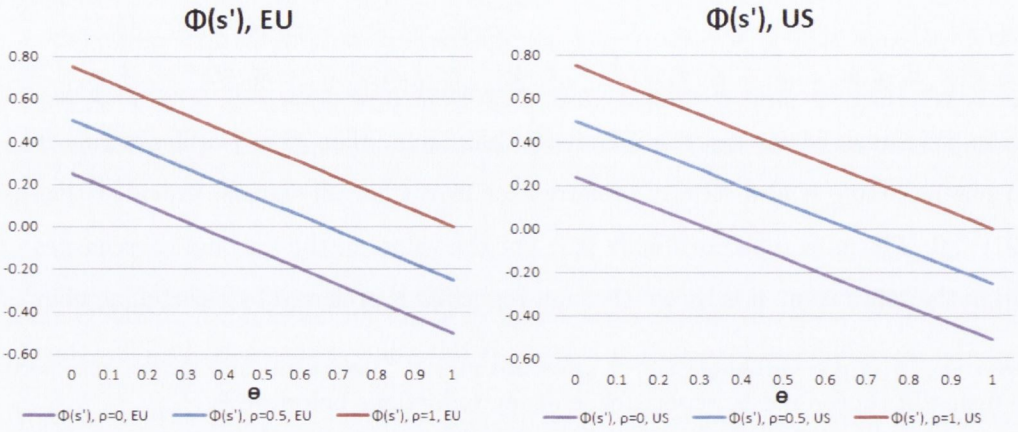

Figure 3.2: $\phi(s')$, when $\widehat{F(US)} = 24600$, $\widehat{G(US)} = 565.43$ and $H(s_j|s_i) = 0.5$, for several values of θ.

Finally, given the equilibrium strategies of the cartel members, the possible pairs of actions which are taken by the firms given their strategies and their outcomes 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* $\Delta(x_j, x_i)$

3.1.3 Relationship between the thresholds

To examine the relationship between the reporting thresholds of the two cartel members, both equilibrium conditions are rewritten below in terms of the fine. This provides an equation for the cut-off level of the fine, which is extremely important for policy making, as it illustrates the magnitude of fine, fine reductions and overcharges that will provide the correct incentives for a cartel member to report, given its own expectations.

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 will receive a higher fine ($F_{t,i} > F_{t,j}$) and, for simplification, that both firms will be charged the same level of overcharges ($G = G_i = G_j$), at the equilibrium cut-off points. Solving the two equilibrium conditions, it follows that:

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

At the equilibrium cut-off points: $s_i = x_i*$, $s_j = x_j*$ and assuming that the expected value of being caught is the same, for a given value of the signal received and merely at the threshold level, such that: $E[\rho|x_j*, x_i*] = E[\rho|x_i*, x_j*] = E[\rho]$, the previous expression becomes:[5]

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

[5] Proof is shown in the *Appendix*.

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* $s_j > x_j$. Conversely, 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 $F_{i,t} > F_{j,t}$, then $x_{i,t}* < x_{j,t}*$.

The model reveals the determinants of the reporting decision and their weight in this decision, given each firm's beliefs on the likelihood of being caught and on its rival's behavior. It is also shown that 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. While this is the main contribution of the model to the current literature, it is also important to discuss the sources of fine variation. This is done in the following section.

There is a discontinuity issue in the threshold levels (the x's) with respect to the value of the overcharges (G). Nonetheless, this is not problematic as there is a lot of uncertainty in the value of what the overcharges would amount to and therefore, the fact that firms know that they will pay overcharges creates an additional incentive for reporting. Furthermore, although firms fined in the EU may 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, future punishment by other firms and possible future damage claims (from customers) show that there is never real immunity.

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.

3.2 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 of the overcharges (G), this section discusses how the equilibrium conditions 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. The source of fine heterogeneity is also discussed.

3.2.1 US Leniency Programme

The D.O.J's decision on the cartel fines is made in accordance with the "U.S. Sentencing Guidelines" and is followed by a plea bargaining. According to Bolotova and Connor (2008), the fine is set as:

$$F^{US} = \alpha + \beta G + \gamma Y' + \pi CD + \vartheta J + \varepsilon$$

Therefore, the relationship between the fines for the two cartel members in the US is as follows:

$$F_{t,i} > F_{t,j} \leftrightarrow \tfrac{\beta}{\gamma}(G_i - G_j) + \tfrac{1}{\gamma}[\vartheta_i J_i - \vartheta_j J_j + \varepsilon_i - \varepsilon_j] + Y_i' > Y_j'$$

Y' and G measure the affected sales and the value of the overcharges, respectively, CD is the duration of the cartel, J is a set of control variables that capture other differences among defendants or jurisdictions and ε is an error term.

Table 3.8 in the *Appendix* shows the determinants of fines and sales level, which are positively correlated. The analysis also demonstrates that the sum of the fine and overcharges paid by each cartel member is positively correlated with the number of repeat offenders per cartel and the criminal sanctions and negatively correlated with cartels which affect small markets, cases of bid-rigging and, perhaps surprisingly,

recidivism and duration of the cartel. Therefore, the sources of firm heterogeneity are recidivism and value of sales and overcharges.

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 takes the value of 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. Therefore, in equilibrium, the following equilibrium conditions must hold:

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

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

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.

3.2.2 EU Leniency Programme

As discussed in section 2.2.1, the EU fine is set in accordance with the "EU Guidelines on the method of setting fines"[6], in the following way:

$$F_t^{EU} = [k(g_t)Y_{t-1}][a\%CD + b\% + (A - M)] \leq 10\%Y_{t-1}$$

The relationship between the individual fines can thus be written as:

$$F_{i,t} > F_{j,t} \leftrightarrow \frac{k(g_{t,i})}{k(g_{t,j})}\frac{aCD_t+b+(A_{t,i}-M_{t,i})}{aCD_t+b+(A_{t,j}-M_{t,j})}Y_{t-1,i} > Y_{t-1,j}$$

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

[6]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.

from entering horizontal price-fixing, market-sharing and output limitation agreements. Y measures the level of worldwide sales in the previous period and CD measures the duration of the cartel, based on the available evidence. A and M are fine adjustments due to aggravating and mitigating circumstances, respectively. The fine is capped at 10% of the total worldwide turnover of the firm in the previous year. Hence, the possible sources of firm heterogeneity in the model are the level of sales, the role of the firm in the cartel and recidivism.

To support these findings and disentangle the determinants of sales, *Table 3.9* in the *Appendix* presents the results of a regression on the determinants of the EU fine and the firm's turnover. The results show that the fine is larger for firms with higher sales, repeat offenders and for firms in cartels with a larger number of members. 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.

After the fines for each cartel member are set, the leniency reductions for reporting and/or cooperating firms are set as stated in *Table 2.1*, in the previous chapter.[7] In a duopoly, 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 may 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 equilibrium conditions must hold:

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

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

[7] 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.

In summary, the sources of US and EU fine heterogeneity are the value of the individual sales, and of the overcharges in the US, recidivism and role in the cartel. 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 ($Y_i = P_i Q_i$) because while the variation in sales is likely to be correlated with the timing of reporting, it is also likely to be constant over time.

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.

3.3 Empirical Model

3.3.1 Data

The US data employed in the empirical analysis is an excerpt from John Connor's "Private International Cartels" dataset.[8] This excerpt covers the years of 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 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. A discussion of the EU dataset can be found in *section 2.3*.

The D.O.J. defines a repeat offender as any firm whom "after release from custody for having committed a crime, is not rehabilitated".[9] In the US, 351 firms are identified as repeat offenders[10] (11%), whereas in the EU, only 6 firms (2%) correspond to the above description (*Definition 1, RO*). EU repeat offenders are defined as in the previous chapter.

The possibility of sample selection bias, as previously discussed, is acknowledged in the interpretation of the results.

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

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

[10] 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.

Tables 3.2 and *3.3* define and summarize the variables for use in the model specifications.

Table 3.2: 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
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
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	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
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 immunity of fines	2310	.02	.14	0	1
G_US	amount of overcharges paid by the firm	2023	565.43	3634.73	0	46631

3.3.2 Method

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

$$\begin{aligned} Immunity_US_{ijts} &= \beta_0 + \beta_1 N_{jts} + \beta_2 RO_{ijts} + \beta_3 NRO_{jts} + \beta_4 S_US_cartel_{jts} \\ &+ \beta_5 S_EU_cartel_{jts} + \beta_6 prison_US_{ijts} + \beta_7 leader_{ijts} \\ &+ \beta_8 many_buyers_{jts} + \beta_9 mod_buyers_{jts} + \varpi T_t + \delta S_s + \varepsilon_{ijts} \end{aligned}$$

$$\begin{aligned} Immunity_EU_{ijts} &= \beta_0 + \beta_1 N_{jts} + \beta_2 RO_{ijts} + \beta_3 RO1_{ijts} + \beta_4 NRO_{jts} \\ &+ \beta_5 Def.Turnover_{ijts} + \beta_6 oth.red_{ijts} \\ &+ \beta_7 fine.increase_{ijts} + \beta_8 firm1post_{ijts} + \beta_9 eea_{jts} \\ &+ \beta_{10} LP_1996_{jts} + \beta_{11} LP_2002_{jts} \\ &+ \beta_{12} inv.dur_{jts} + \beta_{13} invdur2_{jts} + \varpi T_t + \delta S_s + \varepsilon_{ijts} \end{aligned}$$

where i, j, t and s are the indices for firm, case, decision year and sector, respectively

Table 3.3: 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)	year in which the cartel was fined	471	2005.38	3.53	1998	2011
immunity_EU	dummy (=1) if firm received immunity of fines	471	.10	.30	0	1
Firm1pre	dummy (=1) if first pre-investigation reporter	471	.10	.30	0	1
Firm1post	dummy (=1) if first post-investigation reporter	471	.08	.27	0	1
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	471	.027	.09	0	1
fine.increase	fine increases received by a firm	471	.24	.55	0	2.9
EEA	dummy (=1) if cartel only affects the EEA market	471	.73	.45	0	1
LP_1996	dummy (=1) if the LP of 1996 was in place	471	.23	.42	0	1
LP_2002	dummy (=1) if the LP of 2002 was in place	471	.52	.50	0	1
RO	dummy (=1) if firm participated in at least 2 sequential cartels	471	.03	.18	0	1
RO1	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 t-1	471	21.22	232.94	0	4717.05
Def.fine	deflated fine paid by the firm	471	39.63	74.36	0	586.98

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 of fines, in the European Union or the United States. The components of the fine, as described in the theoretical model, are included in the above specifications: the number of cartel members (N), repeat offender dummies (RO for the US and $RO1$ and RO for the EU) and the number of repeat offenders per cartel (NRO). Proxies for the value of the individual sales level are also included, either using the deflated turnover ($turnover$) 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 and cooperation with the investigation outside the LP ($oth.red^{EU}$, eea^{EU} and $inv.dur$) and leniency applications (LP^{EU}, $Firm1pre^{EU}$ and $Firm1post^{EU}$). Additionally, controls for the different EU Leniency Programmes of 1996, 2002 and 2006 (LP_1996 and LP_2002) are also included.

Since the dependent variable has a binary outcome, the appropriate regression method is a Probit.[11] 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.

3.3.3 Results

3.3.3.1 US Cartels

The results of the model specifications which concern the US cartel decisions can be found on *Table 3.4*. Columns (5) and (6) introduce year and sector controls, respectively and the sample size drops since some of the years and sectors have no variability to be explained by the dependent variable.[12]

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 is slightly more likely (1 percentage point) to report and receive immunity of fines, although this result is not statistically significant in all the specifications. With regards to the geographical location, cartels which act in markets with a moderate and, to a smaller extent, large number of buyers (as opposed to small) are more likely to have one of their members applying for leniency and receiving immunity of fines.

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

[11] 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.

[12] 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.

Table 3.4: Regression Results - Probit - US Data

(immunity_US)	(1)	(2)	(3)	(4)	(5)	(6)
N(firms)	-0.00**					
	(0.00)					
leader	0.01	0.01*	0.01*	0.01*	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Mod_Buyers	0.05*	0.05*	0.06*	0.06*	0.04	0.07
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.08)
Many_Buyers	0.02***	0.02***	0.02***	0.02***	0.01***	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)
RO		0.00***	0.00**	0.00**	0.00**	0.00
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
NRO		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)
Fine_EU			-0.00***	-0.00***	-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)	(0.00)	(0.00)
S_EU_cartel			0.00	0.00	0.00	0.00
			(0.00)	(0.00)	(0.00)	(0.00)
cartel.dur			-0.00**			
			(0.00)			
$\widehat{immunity}$	1.54%	1.52%	0.96%	0.99%	0.98%	0.50%
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						0.96***
for agriculture						(0.04)
sector13, other organic						0.85***
chemicals						(0.10)
sector14, inorganic chemicals						0.95***
						(0.03)
sector16, rubber and plastic						0.98***
						(0.02)
sector17, stone, clay and						0.61***
graphite products						(0.16)
sector21, electronic devices						0.90***
						(0.11)
sector23, transport services						0.49**
						(0.21)
sector25, wholesale and retail						0.61***
						(0.15)
sector26, finance, insurance						0.85***
and banking						(0.10)
sector28, other services						0.91***
						(0.07)
Year FE					yes	yes
Sector FE						yes
N	2310	2310	2228	2230	1650	1313
Pseudo R^2	5.28%	6.42%	9.54%	9.23%	14.32%	26.91%
Chi^2	18.26	20.55	56.29	22.13	921.38	1040.78
Log-likelihood	221.13	-218.45	-209.58	-210.35	-186.00	-150.53
no. iterations	4	4	6	6	7	9

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

3.3.3.2 EU Cartels

The results of the model specifications for the EU fines are shown on *Table 3.5.* Columns (3) and (4) introduce year and sector controls, respectively, but the sample size drops as some of the years and sectors have no variability to be explained by the dependent variable.[13]

While the Leniency Programme Notice excludes firms with a leading role from receiving immunity, it makes no statement regarding repeat offenders.[14] The results show that firms who have colluded more than once are around 16 percentage points more likely to report the cartel and receive immunity of fines. For sequential repeat offenders, this number is also statistically significant and around 9 percentage points, at the mean values of the other explanatory variables (see RO and $RO1$ variables in columns (4) and (5)). To reinforce this effect, it is shown that for each additional repeat offender in the cartel, the predicted probability of immunity is 1 percentage point larger. Repeat offending firms should receive higher initial fines, so this finding reinforces the theoretical result that firms who receive larger fines will be the initial reporting firms. It may be that repeat offenders are also larger in terms of sales or they may know better 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. 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 excessive leniency reductions.

Each additional firm in the cartel decreases, on average, the predicted probability of immunity by 1 percentage point (see N), 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

[13] 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.

[14] 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".

reductions, the requirements to obtain each category of leniency reductions may indeed be stricter. Nonetheless, it is shown that the predicted probability of immunity is lower in the LP of 1996, although this result is not robust across the specifications (see LP_1996 in columns (1) and (2)).

Cartels in the sector of fine art auctions (sector 9) are those in which more pre-investigation reports occurred but only account for 1% of the total of cartels fined by the EU. Conversely, cartels in the sectors of transport and videotapes, videos and LCDs (sectors 6 and 8) are the ones 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.

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 worldwide scale relative to other cartel members which is the important factor influencing the decision of reporting. 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 larger fines and this result is thus in line with the theoretical findings in this chapter.

3.4 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 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 be the first reporter 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 chapter extends Harrington's (2013)

Table 3.5: Regression Results - Probit - EU Data

(immunity_EU)	(1)	(2)	(3)	(4)	(5)	(6)
N(firms)	-0.01***	-0.01**	-0.01**	-0.01**	-0.00	-0.01**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
eea	0.01	0.01	0.00	-0.01	0.01	0.00
	(0.02)	(0.02)	(0.03)	(0.04)	(0.03)	(0.03)
Def.turnover(M)	-0.00	-0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Firm1post	0.03	0.05	0.05	0.04	0.05	0.05
	(0.06)	(0.07)	(0.07)	(0.07)	(0.08)	(0.08)
RO1		0.17**	0.19**	0.16*		
		(0.09)	(0.10)	(0.10)		
NRO		0.01**	0.01**	0.01**	0.00	0.01***
		(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
RO					0.09**	
					(0.04)	
fine.increase						0.01
						(0.02)
oth.red		-0.15	-0.09	-0.08	-0.08	-0.11
		(0.24)	(0.23)	(0.24)	(0.24)	(0.25)
inv.dur		-0.00**	-0.00	0.00	-0.00	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)	(0.00)	(0.00)	(0.00)	(0.00)
LP_1996	-0.08***	-0.05*	-0.01	0.27	0.22	0.24
	(0.02)	(0.03)	(0.10)	(0.25)	(0.23)	(0.24)
LP_2002	-0.00	0.02	0.02	0.01	-0.01	-0.00
	(0.02)	(0.02)	(0.08)	(0.08)	(0.08)	(0.08)
$\widehat{immunity}$	9.38%	8.81%	8.28%	7.93%	7.74%	8.18%
sector2,industrial inputs				-0.01	-0.02	-0.03
				(0.03)	(0.03)	(0.03)
sector3, food and				-0.03	-0.03	-0.04
detergents				(0.05)	(0.06)	(0.05)
sector4, elevators and				0.16	0.02	0.12
escalators				(0.11)	(0.06)	(0.10)
sector6, transport				-0.06***	-0.06**	-0.06***
				(0.02)	(0.02)	(0.02)
sector7, needles and				0.00	-0.04	-0.01
haberdashery				(0.09)	(0.05)	(0.08)
sector8, videotapes, videos				-0.05**	-0.05**	-0.06***
and LCD				(0.03)	(0.02)	(0.02)
sector9, fine art				0.26**	0.39***	0.27**
auctions				(0.13)	(0.15)	(0.13)
Year FE			yes	yes	yes	yes
Sector FE				yes	yes	yes
N	471	470	450	442	442	442
Pseudo R^2	3.45%	6.45%	6.29%	8.12%	9.11%	7.03%
Chi^2	20.55	48.24	1482.93	.	120127.04	.
Log-likelihood	-149.73	-144.98	-143.16	-139.52	-138.02	-141.19
no. iterations	4	4	8	9	8	8

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

analysis and is the first to examine the case of firms which are heterogeneous in terms of the expected value of the cartel fine and which receive private information on the probability of investigation and conviction by the Competition Authority, thus eliminating the restrictive implication of symmetric equilibria.

It is shown 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, 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 sources of fine heterogeneity, i.e., the characteristics of the pre-investigation reporters, as well as those of 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 reporting firms are likely to be the cartel leader. Therefore, the main heterogeneity sources are recidivism and leadership of the cartel, which is in line with the findings from the theoretical model and illustrate the need for more proactive Competition Authorities, perhaps through screens which would supplement and enhance leniency.

Some of the characteristics of the cartels in which pre-investigation reporting occurs are also unveiled. In the EU, these cartels tend to be in the sector of fine art auctions, 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 much larger in the sectors of rubber and plastic, and paper and printing, and 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 thus be in line with these

incentives.[15]

[15]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 chapter allow to infer that when the correct incentives are in place, firms with the largest sales level will more likely report tax infractions such that auditing should focus on firms with a smaller level of sales.

3.5 Appendix

3.5.1 Proof for the relationship between the thresholds

$$F_{t,i} > F_{t,j}$$

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

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

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

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

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

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

3.5.2 Regression Results, Fixed Effects Model

Table 3.6: Regression Results - Fixed Effects - US Data

	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, construction		1051.44	-2603.65**		-13915.92	13782.92**
		(4273.84)	(1173.35)		(11082.72)	(6702.37)
sector5, food and beverage		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, paper and printing		-7917.61*	-1103.48		-10474.79	10969.22
		(4656.21)	(772.46)		(8571.48)	(8317.81)
sector12, organic chemicals for agriculture		1416.94	-396.58		-3289.21	19590.99***
		(3169.20)	(974.79)		(8810.23)	(6146.80)
sector13, other organic chemicals		2754.69	-251.68		-7519.07	19371.33***
		(4117.12)	(829.70)		(9552.82)	(5843.55)
sector14, inorganic chemicals		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, rubber and plastic		-4270.02	-2000.22***		-11607.06	2570.06
		(3136.73)	(668.27)		(8048.43)	(5938.34)
sector17, stone, clay and graphite products		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, electronic devices		-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, transport services		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, wholesale and retail		2072.70	-3461.99***		-7332.03	14328.68**
		(3604.96)	(1073.93)		(8004.96)	(5669.33)
sector26, finance, insurance and banking		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, other services		-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.

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

Table 3.7: Regression Results - Fixed Effects - EU Data

	Def.Fine (1)	Def.Fine (2)	Def.Fine (3)	Turnover (4)	Turnover (5)	Turnover (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.

CHAPTER 4

The EU Anti-Dumping Instrument - The effect of duties on prices: theoretical justification and empirical evidence

THE European Anti-Dumping (AD) instrument was created in 1995 in the context of the GATT as a tool to ensure that international trade is fair and in the optimal long-run path towards free trade. The instrument allows the current 159 WTO countries to take action against dumped products, when there exists dumping, proof of material injury caused to producers in the home country and benefits to the home country from the imposition of the duty.[1] However, there have been substantial changes in the economic environment over the past 18 years which led to increasing production by European firms outside Europe and more generally outsourcing. During this period, the use of the AD instrument increased exponentially. The economic justification for its existence is often questioned (see Aggarwal (2002)) and it is argued that it no longer serves its initial purposes. It is therefore vital to

[1]The WTO AD Agreement (Commission, 2004, Anti-Dumping) is reflected in the European Community (EC) Council Regulation 384/96, named *Basic Anti-Dumping Regulation*. Amendments were made to refine the price adjustments (1996 and 2002) and to include Russia, China, Ukraine, Vietnam and Kazakhstan in the list of market economies (1998 and 2000). There were also amendments on technical issues and in 2004 and 2005, it was revised to allow the establishment of normal value in Ukraine.

reflect on the instrument and its potential reform.

In 2006, a dumping investigation on leather shoes being imported from China and Vietnam showed that the duties imposed were in fact hurting the European Union ("*EU*") producers who outsourced their production. This rather extreme case led the then European Commissioner Peter Mandelson to launch a public consultation on the Trade Defense Instruments, *The Green Paper* (Commission (2006a)) but no changes were made. In 2012, the Commission launched the "*Public Consultation on Modernization of Trade Defence Instruments*"[2], which will be analyzed by the Commission services, from July 31st, 2013.

The goal of this study is to shed further light on the use of the AD instrument in the European Union, with respect to its effect on border prices. First, this chapter introduces a new theoretical model of an exporting firm that must choose a price at which to sell its output in a foreign market in the presence of uncertain enforcement of AD law. With the help of simulations, the set of parameters under which the Anti-Dumping duties (*ADDs*) lead to a decrease or increase in the unit values of exports into the EU, is identified. Second, the model is empirically examined and it is shown that the unit values tend to increase following the imposition of a duty and are lower for higher expected values of the duty, meaning a lower price or lower duty. There is also some evidence of biased margins. Additionally, a country-level analysis is carried for some of the main targets of AD initiations.

There is a voluminous theoretical literature on the impact of ADDs on sales and prices. Although there are some exceptions (see Pierce (2011)), it is commonly agreed, in the current literature, that the imposition of ADDs leads to lower export sales, with the most common arguments being: (1) targeted exporters cannot lower their export price, so their product is less appealing;[3] (2) domestic exporters who outsource part of their production, import the intermediate goods at a higher price,

[2]A summary of the contributions to this consultation can be found online at: *www.trade.ec.europa.eu/doclib/docs/2012/october/tradoc*$_1$*49970.pdf*

[3]Egger and Nelson (2011); Niels (2003), among others.

due to the duty imposed;[4] (3) lower volume of cheap imports, since the goods in the domestic market remain at the same price as before[5] and (4) retaliatory reasons for the imposition of the duty.[6]

The effect on prices has been theoretically examined by several authors who find an increase in export prices due to AD enforcement (see Blonigen and Park (2004); Dulleck (2005); Khatibi (2009); Francois (2009); Collie and Le (2010); Dinlersoz and Dogan (2010) and Metge and Weiss (2011)). However, two authors challenge this result: Crowley (2010) finds that many firms decide to sell a lower quantity and still dump the product, therefore eliminating the duty, and Gormsen (2011) concludes that exporters lower their price in the home market, so that the product's "normal value" is then lower and they are able to set a low export price. Similarly to what is done by Blonigen and Park (2004) and by Crowley (2010), the theoretical model present in this chapter includes uncertainty in the imposition of the ADD and it contributes to this literature by identifying, and measuring, the factors which impact in the pricing decision of the exporting firm, while taking into account the possibility of an ADD being imposed.

Empirical research on the effect of prices is scarce and conflicting. A few papers focus on markups (see Pierce (2011); Vandenbussche and Zarnic (2008); Konings and Vandenbussche (2004); Gil-Pareja (2002)) and price-cost margins (see Rovegno (2010); Konings and Vandenbussche (2005)), finding a positive relationship with the imposition of the duty. However, it is not discernible if these effects are due to higher prices or lower costs.

The impact of the duty on prices has been empirically analyzed using year effects (Konings and Vandenbussche (2009) [France], Konings and Vandenbussche (2008) [EU] and Prusa (2001) [US]) or through the inclusion of a treatment group (Pierce

[4]Helpman et al. (2007); Grossman and Helpman (2004); Konings and Vandenbussche (2009).

[5]Prusa (1997); Veugelers and Vandenbussche (1999); Zanardi (2004); Konings and Vandenbussche (2008).

[6]Bekker (2006), Melitz and Ottaviano (2008), Feinberg and Olson (2006) and Blonigen and Bown (2003). Further to these four reasons, Hartigan and Vandenbussche (2010) suggest that the proliferation of AD laws is not driven by retaliatory motives but it is due to a cooperative act amongst WTO members, who use AD as a risk-sharing vehicle in response to adverse shocks incurred by domestic producers.

(2011) [US]), presenting straightforward models that reveal that the duty leads to a price increase in the US, whereas in France, it decreases in the second year of the duty and increases in the fourth; and decreases in the fourth and fifth years for the EU, thus avoiding the imposition of another ADD.

Like in this chapter, the analysis of unit values, as a proxy for export prices, is present in Niels (2003), Rovegno (2011) and Lu et al. (2012). Niels examines the price evolution from Mexican exports and finds that the presence (but not the level) of a duty causes a price increase in a given set of importing countries and sectors. Rovegno finds a significant price increase following the imposition of duties by South Korea. Finally, Lu et al. find that domestic prices are not affected by preliminary nor final ADDs imposed by China.

Two other papers have similarities with this work: Blonigen and Park (2004) show that introducing uncertainty in the imposition of the duty changes the effect on prices and Avsar (2013) includes a measure of threat of a duty. To my knowledge, the present chapter is the first to examine the evolution of EU border prices using uncertainty in the imposition of the duty and introducing measures of dumping injury, recidivism and retaliation.

The results show that the unit values of exports into the EU increase, once the duty is imposed, for a sufficiently high number of firms in the importing country and/or a sufficiently high degree of product substitutability. It is also shown that the evolution of product unit values is in line with that of the sector and that unit values are larger for a higher probability of the duty (but also for lower expected duties). Nonetheless, some evidence of biased dumping margins is found in the fact that changes in unit values are smaller for higher assessed margins and the claims of retaliation and/or protectionist reasons are supported by the finding that the likelihood of imposing a duty is higher when the imports from the target country are increasing. Furthermore, it is shown that longer investigations and shorter ad-valorem duties are more efficient in increasing unit values. The specific cases of

duties imposed on imports from China and South Korea are also analyzed separately and the policy implications of these findings are discussed.

The organization of the rest of the chapter is as follows. The next section introduces the theoretical model. In section 4.3 the dataset and a preliminary analysis of the data are presented. The empirical methodology is described in section 4.4 before the results are discussed in section 4.5. Section 4.6 offers concluding comments.

4.1 Theoretical Model

Suppose *firm i* sells a product in a foreign country[7], where there are also N[8] other identical producing firms who compete in terms of price. The model is set in a static environment and so there is no entry or exit of firms in the foreign market. The degree of substitutability between the products of *firm i* and those produced in the foreign country is given by γ, whose values range from 0 for independent goods to 1 for homogeneous goods. In this sense, competition is modeled through the number of competing firms and the degree of substitutability of the products. These two channels will affect price differently, with the potential introduction of anti-dumping duties on a specific product.

The inverse demand function of *firm i* in the foreign market is given by:

$$p_i(Q) = a - b(q_i + \gamma \sum_{j=1}^{N} q_j) \tag{4.1}$$

where p and q are the price and quantity sold in the foreign market, Q is a vector [(N+1)x1] whose elements represent the output of the (N+1) firms. Given that the variable of interest is the price in the foreign market, and not the quantity, the direct demand function is calculated[9]:

[7]With a CRS production function, the home market can be ignored, without any loss of generality. If the firm sells in both markets, its profit function would be: $max_{p^f,p^h} \prod_i = \prod_i^h + \prod_i^f$.

[8]The number of competitors in the foreign market is not available in the data but it is useful in the discussion of the theoretical results. Therefore, generalizing the model to the case of N=1 seems inadequate.

[9]The mathematical demonstration is shown in Appendix A.

$$q_i = \frac{a(1-\gamma) - (1 + N\gamma - \gamma)p_i + \gamma \sum_j p_j}{b(1 + \gamma - N\gamma - N\gamma^2)} \tag{4.2}$$

Firm i sets the exporting price so as to maximize its own profits, taking into account the presence of AD regulations. The two most common types of duties, ad-valorem and specific, are considered below:

$$max_{p_i} \prod_i = \begin{cases} [p_i(1 - \rho T^{AVD}) - c]q_i, & \text{if duty is ad-valorem (AVD)} \\ (p_i - \rho T^{SD} - c)q_i, & \text{if duty is specific (SD)} \end{cases} \tag{4.3}$$

where T is the Anti-Dumping duty[10], ρ is the probability that the final duty is imposed, given that an investigation was initiated and c is the constant marginal cost.

Two scenarios may arise:

Scenario 1: If no dumping complaint is made to the EU Commission or if a complaint is dismissed, then no ADD is imposed (T=0). Therefore, the problem of profit maximization is reduced to: $max \prod_i = (p_i - c)q_i$ and the optimal Nash-Equilibrium price is: $p_i^* = \frac{c}{2} - \frac{1}{2}\frac{a(1-\gamma)+\gamma\sum_j p_j}{1+N\gamma-\gamma}$. These cases have been widely examined and, since no duty is imposed, they are excluded from the analysis.

Scenario 2: If a complaint made by a EU firm leads to an investigation where evidence of dumping[11] is found, then a preliminary duty is imposed for a maximum period of 9 months, while the investigation continues (T^{low}). If besides dumping, there is material evidence of injury to both producers and consumers, a final ADD is imposed (T^{high}) for a period of 5 years. However, theory suggests that other factors may influence the probability of the final duty being imposed, so this is set in the

[10]The ADD (T) is assumed to be set lower than what would be desired by a Government who maximizes its country's welfare and takes into account the *Community interest test*: $T = T^* - \chi$, where $\chi \epsilon]0, T^*[$.

[11]Dumping occurs when products are exported at a price lower than their normal value, often eliminating the profit margin. The export price evaluated is the export sales price or a constructed one, while the normal value is defined as the price of a like-good in the home or an analogous country or, if none of these is available, a constructed value. Proving material injury is costly, not only monetarily, but it also affects the relationship with the target country with regards to other products and industries, so it is imperative to ensure that the costs are not disproportionate to the benefits to both producers and consumers, which is made through the use of the Community interest test.

model as: $\rho = P(T^{high}|T^{low})$ and it incorporates any factors, other than price, that may influence the decision of imposing a duty. This probability is modeled as an extension of what is done in Bown and Crowley (2009)[12], so as to take into account measures of retaliation and injury. This variable is affected by the bilateral import growth and exchange rate of the foreign country in relation to the home country, the export and import demand elasticities, the standard deviation and growth of imports of the product, potential relation reasons, previous duties on the same product and injury caused to producers and consumers. The empirical interpretation of ρ is discussed in *section 4.3.2.*

In order to solve the profit maximization described in equation (4.3), the first order condition of the profit maximization is:

$$\frac{\partial \prod_i}{\partial p_i} = 0 \Leftrightarrow \begin{cases} [(1-\rho T^{AVD}) - \frac{\partial \rho}{\partial p_i} p_i T^{AVD}] q_i & +[p_i(1-\rho T^{AVD}) - c]\frac{\partial q_i}{\partial p_i} = 0 \text{ or} \\ (1 - \frac{\partial \rho}{\partial p_i} T^{SD}) q_i & +[p_i - \rho T^{SD} - c]\frac{\partial q_i}{\partial p_i} = 0 \end{cases} \quad (4.4)$$

The solution of this maximization problem is shown in *Appendix A* for both specific and ad-valorem duties. However, the analysis below focuses on the case of specific duties as its mathematical representation is simpler, thus allowing for a better intuition on the impact of each variable on price. The optimal price choice, in the presence of a potential specific ADD, is:

$$p^*_{i,SD} = \frac{(1 - T^{SD}\frac{\partial \rho}{\partial p_i})\frac{V}{W} + c + \rho T^{SD}}{2 - T^{SD}\frac{\partial \rho}{\partial p_i}} \quad (4.5)$$

where:

$V = \frac{a(1-\gamma)+\gamma\sum_j p_j}{b(1+\gamma-N\gamma-N\gamma^2)}$

$W = \frac{\partial q_{tik}}{\partial p_i} = -\frac{1+N\gamma-\gamma}{b(1+\gamma-N\gamma-N\gamma^2)}$

$\frac{\partial \rho}{\partial p_i} = \frac{\partial \rho}{\partial p_i} = \psi(\beta' X)(\beta_1 + \frac{\beta_3}{\eta_{xk}+\eta_{mk}})\frac{1}{q_{t-1,ik}}\frac{\partial q_{tik}}{\partial p_i} + \psi(\beta' X)\beta_5 \frac{NER_{hft}}{p_i^h}$

[12] In their paper, this probability is set as: $\rho_{BC} = \psi(\beta' X)[\beta_0 + \beta_1 M_{hfkt} + \beta_2 \frac{1}{\eta_{xk}+\eta_{mk}} + \beta_3 \frac{M_{hfkt}}{\eta_{xk}+\eta_{mk}} + \beta_4 \sigma^m_{hk} + \beta_5 BER_{hft}] + \varepsilon_{hkt}$. Note that some of the variables are labeled differently in Bown and Crowley.

The analysis carried out in this chapter is restricted to the case in which prices in the foreign market adjust following the imposition of an ADD but where domestic prices do not react. While exporters may indeed share the burden of the tax between the foreign and domestic sales, this is not the goal of the duty and if the domestic price increases, firms are likely to sell a lower amount at home. Nonetheless, in this chapter the analysis focuses on the impact in the foreign price, regardless of any changes in the domestic market, as this is essential in the evaluation of the functioning of the ADD instrument.

Due to the mathematical complexity of the optimal prices derived from the profit maximization, comparative statics are difficult to interpret. To identify the set of parameters under which ADDs lead to a decrease or increase in unit values, simulations are carried out and the model's predictions are used to make inferences on the firms' pricing strategies. The values used in the calibration are shown on *Table 4.1.*

The simulations in *Figures 4.1-4.4* are shown for the case of specific duties but

Table 4.1: Calibration of the model

Variable		Value	Source
BER	bilateral net exchange rate	8.7313	data
q(t-1)	quantity in the previous period	191,355.57	data
q(t)	quantity in the current period	206,298.01	data
η_{xk}	elasticity of export demand	0.92	data
η_{mk}	elasticity of import demand	-0.99	data
M	import growth	7.82%	calculations
$\psi(\beta' X)$	CDF	1	random
$\sum_{j=1}^{N} p_j^f$	prices in the foreign country	1000	random
a	constant in demand function	300	random
b	constant in demand function	0.1	random

those for ad-valorem duties present similar patterns, although the thresholds may be different, depending on the values used in the calibration. For this reason, the analysis focuses on the qualitatively and not the quantitatively interpretation of the results.

It is clear that when the prospect of an ADD is taken into account by the exporting firm, whose goal is to maximize its own profits, then prices may actually be

lower for higher levels of the duty, under specific conditions.

When the degree of substitutability (γ) is small, the foreign firm has a bigger competitive advantage in the foreign market and can set a higher price. However, for higher levels of duties, the price decreases, which may mean that the burden of the duty is either internalized or shared with the Government in the exporting country or the importers in the EU, as it is shown in *Figure 4.1*. This effect is likely to disappear in the final year of the ADD, to avoid its extension. When the sum of the marginal cost and the ADD is higher than the optimal price level (*as shown by the red dots*), the firm will stop exporting to the foreign country.

The intensity of competition in the foreign market is negatively related to the optimal price set in that market: if there is a small number of competitors in the foreign market, the firm has a bigger competitive advantage and can set a higher price. In this case and in the presence of AD enforcement, price will decrease for higher levels of the ADD, so that firms can maintain their position in the market and this may be due to internalization or sharing of the burden of the ADD.

When the marginal cost is higher, firms will optimally set their prices higher and for higher levels of the duty, the price will also increase. The third graph in *Figure 4.3*, illustrates a case of predatory dumping ($P < c$).

If the probability of an ADD being imposed is perceived as very low ($\rho < 0.3$), then prices are set at a lower level, perhaps even below marginal cost, and will be lower for higher levels of the ADD, as firms expect to receive no duty. The opposite is also shown to be true.

In summary, these graphs show that the price is positively correlated with the marginal cost and the likelihood of receiving a duty and it is negatively correlated with the number of competitors in the foreign country and with the degree of substitutability between products. Furthermore, it is shown that the export prices increase in the presence and with the magnitude of an ADD, when there is a sufficiently large number of competitors in the foreign country and sufficiently large values of the degree of substitutability and of the likelihood of receiving a duty.

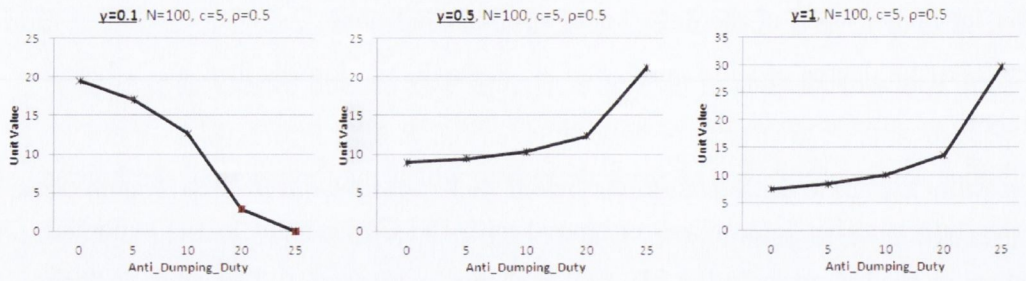

Figure 4.1: Simulation - changes in the degree of product substitutability

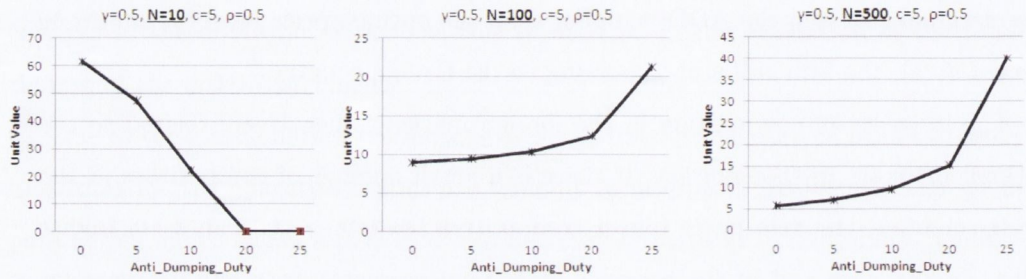

Figure 4.2: Simulation - changes in the number of firms in the importing country (EU)

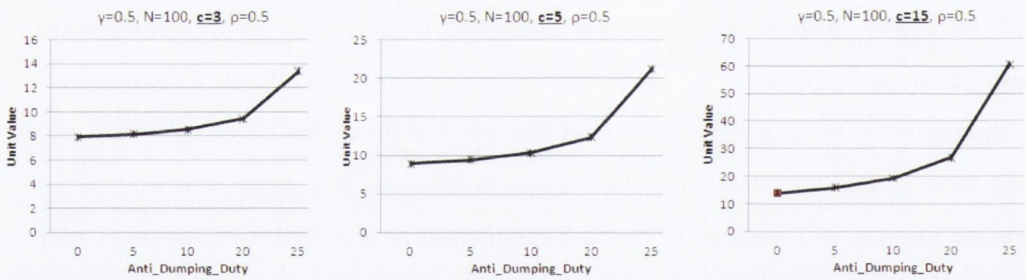

Figure 4.3: Simulation - changes in the marginal cost of the exporter

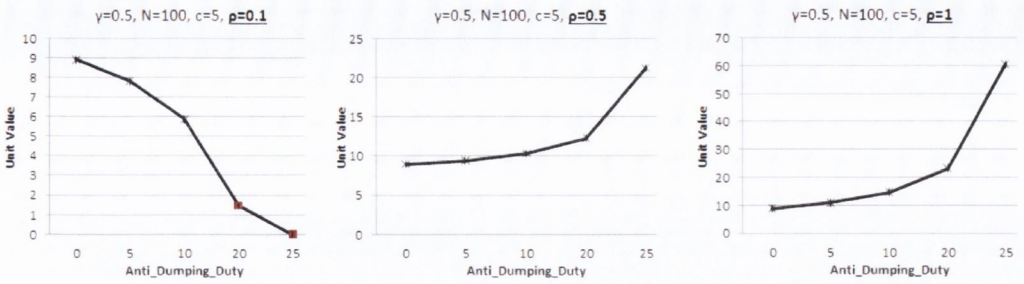

Figure 4.4: Simulation - changes in the probability of the ADD

4.2 Data

In this section, the data sources are discussed. This is followed by a description and preliminary analysis of the data.

4.2.1 Data collection

A newly available and exhaustive database compiled by Chad Bown (*Global Anti-Dumping Database*, version 2.1) is explored. It contains firm-level data on all the dumping petitions which led to the imposition of a preliminary duty, in WTO member countries. Although there is no information on the total number of ADD initiations, prices, bilateral exchange rates and values of import and export demand elasticities, these are self-collected and matched with Bown's Global Antidumping Database.

Data regarding the number of AD initiations and measures were obtained from the WTO AD database, data on bilateral exchange rates were collected from the USDA-Economic Research Services website[13] and the values used for elasticities are those calculated in Tokarick (2010).

To my knowledge, there is also no available data on prices of EU imports. In this case, unit values (UV) can closely approximate true price, so they are used as a proxy. UVs are calculated by the ratio between export value and quantity exported and even though their variation may be driven by changes in quality, cost or pricing strategy, the data refer to a relatively short time period (1998 to 2007) and, on average, in five

[13] "Real Historical Exchange Rates for Baseline Countries/Regions (2005 base year), 1970-2012"; http://www.ers.usda.gov/; calculations are made from IMF data.

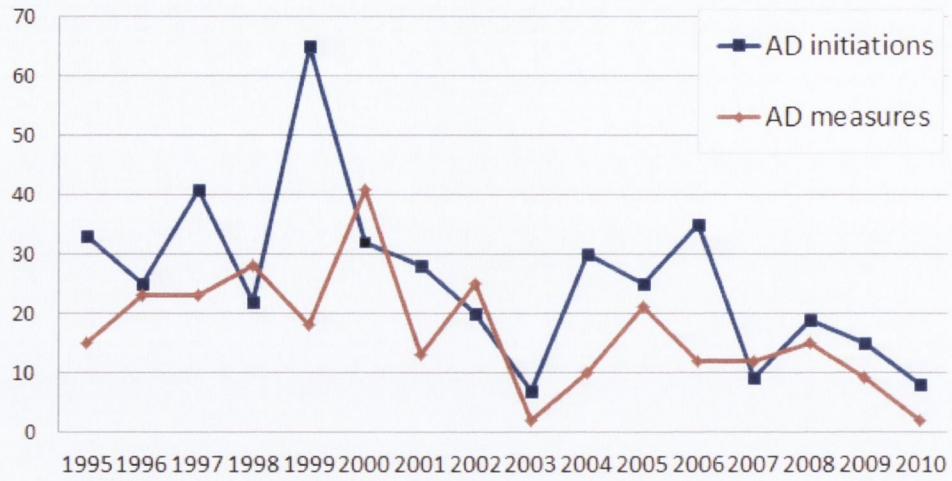

Figure 4.5: Anti-Dumping Initiations and Measures, 1995-30/6/2010

of these years the ADD was in place. Therefore, it is not unreasonable to consider that the main effect driving the change in UVs is the imposition of the ADD and not variations in quality or cost. UVs were collected using Eurostat data and matched with Chad Bown's database using 8-digit HS codes.[14] Cases with missing data on the products' codes or with less than six years of price information were excluded.

The final sample in the analysis includes 630 cases with duties imposed in the period of 1998 to 2007, which correspond to 2797 different products, 40 countries and 8 sectors. One concern with the dataset is the representativeness of the chosen sample, due to the excluded cases. However, the sample size is large and the results are only interpreted for the cases in the analysis.

4.2.2 Data description

Since 1980, there has been a rapid spread of the use of the AD instrument. Although the number of duties imposed by the EU has slightly decreased since 2000, it continues to be quite high, around 20 initiations per year, while the number of measures imposed is around 10 in each year, since 2004. This is shown in the figure below.

[14]The Harmonized System (HS) is a commodity classification system which groups articles according to the nature of the materials of which they are made.

Beside the sector of miscellaneous goods[15], the sectors of mineral products and plastics/ rubbers (see *Table 4.2*) have been, since 1998, the most involved in dumping investigations by the EU, accounting for 40% of the total of dumping investigations. The industries of machinery/ electrical and raw hides/ skins/ leathers appear to be quite immune from dumping practices, or at least from the imposition of measures. It seems that the sectors more prone to be protected are those in which Europe is losing its comparative advantage[16], as imposing duties in foreign, dumped or not, products protects the national producers from foreign competition.

The dumping investigations in the sample were mainly petitioned by Germany and Italy and are largely directed at exporters in emerging economies, mostly in Asia, where there is a growing source of worldwide competition. This is shown in *Tables 4.2* and *4.3*. As other authors report[17], the figures indicate that China has been, since 1995, the main target of EU AD measures, followed, at a considerable distance, by India and South Korea. It is noteworthy that while the EC seems not to file above 20 investigations per year, China appears to become more and more a favorite target of AD investigations.

It is also important to consider the type of dumping decisions (*Table 4.4*). Only in 24% of the cases, the outcome of an investigation is the same for preliminary and final measures, with most investigations leading to the imposition of an ad-valorem duty in both decisions. Price undertakings are the second most common outcome of these investigations, whereas specific duties and measures conditional on the exporters decreasing the price under a given level (DPU) are infrequent.

[15]The sector of miscellaneous is not analyzed due to its wide nature. It includes the following: Optical and Photography instruments and accessories, clocks, musical instruments, arms and ammunition, furniture and bedding, toys and sports equipment, miscellaneous manufactured good (worked ivory, pends, combs, scent sprayers, etc.), and works of art and antiques

[16]According to the EUROMAP Association (European Plastics and Rubber Machinery), China and Japan have been the industry leaders as Europe has been hit by a crisis and has been losing its advantage in this sector, although it seems to be recovering since the end of 2011 (www.euromap.com). S. Foster, development director at MIRO (Mineral Industry Research Organization) also points out that measures need to be taken to recover Europe's competitive advantage in the sector of Minerals.

[17]See Lu et al. (2012).

Table 4.2: Main targets of Dumping Investigations, 2/1998-12/2007

Sector	Percentage	Country	Percentage
Miscellaneous	39.4%	China	19.9%
Mineral Products	23.3%	India	9.9%
Plastics / Rubbers	16.6%	South Korea	5.4%
Footwear / Headgear	7.3%	Taiwan	5.0%
Foodstuffs	6.0%	Vietnam	5.0%
Metals	3.8%	Thailand	4.5%
Raw Hides, Skins, Leather, Furs	2.1%	Russia	4.0%
Machinery / Electrical	1.6%	Ukraine	4.0%
		Malaysia	3.5%
		Turkey	3.2%
		USA	3.1%
		other countries	32.5%

Table 4.3: EU Countries filing successful dumping complaints, 2/1998-12/2007

Reporter	Percentage
Germany	21.3%
Italy	17.1%
France	15.5%
Spain	12.2%
UK	9.6%
Netherlands	5.0%
Bulgaria	3.5%
Portugal	2.2%
Austria	2.0%
other EU countries	8.4%

Table 4.4: Types of Anti-Dumping Decisions

Type		Preliminary	Final
AVD	(ad-valorem duty)	442 (68%)	477 (74%)
PU	(price undertaking)	25 (4%)	106 (16%)
AVD/PU		0	30 (5%)
SD	(specific duty)	5 (1%)	12 (2%)
DPU	(conditional on a min.P)	2 (< 1%)	9 (1%)
m.i.		172 (27%)	12 (2%)
total		646	

4.2.3 Preliminary analysis of the data

This sub-section provides an example of price behavior in the presence of AD enforcement. Japan was chosen as an example because it is representative of the several price patterns following the imposition of an ADD. The four graphs in *Figure 4.6* depict the behavior of the unit values corresponding to the allegedly dumped goods and include a yellow dot for the year in which the final ADD was imposed.

It is visible that the price pattern is neither straightforward nor stable and cannot, by this method, be related with the imposition of duties. While some goods' prices seem to increase, as expected, after the ADD (cases 1388, 1403 and 1366), the most common behavior (7/16 cases) is a time lag of one or two years between the imposition of the final duty and a price increase. Also, in four cases, the price goes straight down after the duty is imposed. This does not allow for any definitive conclusions, since price behavior is affected by several different factors and that is why the chapter proceeds with the econometric model in the next section.

4.3 Empirical Model

This section introduces the empirical interpretation of the theoretical model from *Section 4.2*. The choice of variables and the specifications for the two regressions are discussed below.

4.3.1 Choice of variables

Tables 4.5 and *4.6* define and describe the variables for use in the model specifications. To examine the changes in the unit values of a good imported by the EU, product, case and country-level variables are mapped from the theoretical model. Nonetheless, information on the number of competitors in the foreign country, the level of product substitutability and the marginal cost are not available. In addition to the variables previously described, and to account for general changes in the products' prices, the average unit value in the sector, excluding the unit value of the

product in analysis, is also included (UV_k).

The values of both preliminary and final ADDs imposed (PAD and FAD) are also included as they are often different between themselves and different from the dumping margins, such that they may impact differently in the price level.

Controls for whether the preliminary and final decisions are ad-valorem or specific duties or a price undertaking are also present (*pavd, favd, psd, fsd, ppu and fpu*). Price-Undertakings can be perceived as the imposition of a duty which corresponds to the difference between the dumping price and the new raised price. Also included are the duration, in years, of the investigation and of the duty (*dur(inv)* and *dur(ADD)*). These variables are also not present in the theoretical model, as it is set in discrete time.

Finally, the expected value of the duty is introduced ($\rho * log(1 + PAD)$) to take into account the expectations of each firm before the imposition of the duty. This value is calculated with the value of the preliminary duty so as to overcome the issue of cases with no final duty, which would make its expected value equal zero.

4.3.2 Regression method

The probability of an ADD being imposed ($\hat{\rho_{kft}}$) is predicted and included in the unit values' equation, according to the specification outlined in the theoretical model. In estimating this probability, the dependent variable has a binary outcome, which takes the value of 1 if protection is in place (usually five years, if the ADD is imposed) and 0 otherwise and its distribution is a linear combination of the predictors. The adequate model to estimate the probability of protection is thus a Probit and the specification is the following:

$$\begin{aligned}\rho_{hfkt} &= \psi(\beta' X)[\beta_0 + \beta_1 M_{fk,t-1} + \beta_2 \frac{1}{\eta_{xk} + \eta_{mk}} + \beta_3 \frac{M_{fk,t-1}}{\eta_{xk} + \eta_{mk}} + \beta_4 \sigma_{ik}^m \\ &+ \beta_5 BER_{hft} + \beta_6 G_Importv_lag_{hfkt} + \beta_7 ADD_C5_{ft} + \beta_8 Cases_{fkt} \\ &+ \beta_9 NoInjury_{jkt} + \beta_{10} retaliation1_{ft} + \beta_{11} retaliation2_{ft}] + \varepsilon 1_{ikt}\end{aligned}$$

Table 4.5: Description of the variables

Indices:		**Definition:**
t	$init_t$	year of the initiation of the ADD investigation
t	fad_t	year of the imposition of the final ADD
k	k	sector
f	f	foreign country
m	m	product
h	h	home country (EU)
i	i	firm in the home country
Variable Theory	**Variable Empirics**	**Definition:**
		Dependent variables:
p_i	$log(UV)$	logarithm of the unit value, with $UV = \frac{value\ imports}{volume\ imports}$)
ρ	$\widehat{\rho}$	probability of receiving an ADD
-	UV_k	logarithm of the average unit value in the sector
-	Protection	dummy (=1) if there is an ADD in place, in a given period. Generates $\widehat{\rho}$.
		Independent variables ($\widehat{\rho}$):
NoInjury	NoInjury	dummy (=1) if no final ADD was imposed
Cases	Cases	dummy (=1) if more than one ADD was imposed in a given sector, within a country
BER	BER	bilateral exchange rate between EU and the exporting country
η_{xk}	η_{xk}	elasticity of export demand
η_{mk}	η_{mk}	elasticity of import demand
M	G_Importv	yearly growth rate of imports' value
ADD_C5	ADD_C5	number of ADDs imposed in a given country in the previous five years
retaliation1	retaliation1	number of initiations by a given country, against the EU, by the number of EU initiations against the same country.
retaliation2	retaliation2	number of duties imposed by a given country on EU exports, by the number of duties imposed by the EU on the same country's exports.
		Independent variables (UV):
q_i	Q_UV	quantity exported into the EU in each period, for a given product
Q	Q_k	quantity exported into the EU in each period, for a given sector
$Margin = P^{normal} - P$	$logFMg$	logarithm of the final dumping margin assessed
$Margin = P^{normal} - P$	$logFAD$	logarithm of the final ADD imposed
T^{AVD}	pavd/ favd	dummy (=1) if the preliminary/ final ADD is ad-valorem
T^{SD}	psd/ fsd	dummy (=1) if the preliminary/ final ADD is a specific duty
T^{PU}	ppu/ fpu	dummy (=1) if the preliminary/ final decision is a price undertaking
-	dur(ADD)	duration of the ADD, in years
-	dur(inv)	duration of the investigation, in years
-	ADD_S5	number of ADDs imposed in a given sector in the previous five years

Table 4.6: Summary Statistics

Variable	Obs	Mean	St.Dev.	Min	Max
t	8271	2001.88	4.12	1995	2009
k	8271	66.19	16.55	20	96
f	8271	20.68	12.03	1	40
Dependent variables:					
$logUV$	8271	.45	.68	-1.25	3.05
$logUV_k$	8271	2.36	.86	-5.68	4.15
Protection	8271	.44	.50	0	1
Independent variables ($\widehat{\rho}$):					
noinjury	8271	.15	.36	0	1
Cases	8271	.05	.22	0	1
BER	8271	1785.40	4847.92	.32	20478.29
q(t)	8271	206298	1267858	0	4.09e+07
η_{xk}	8271	.99	.36	.14	2.27
η_{mk}	8271	-.84	.44	-1.85	.03
$\sigma 9509$	8271	1.81e+08	2.77e+08	193834.3	1.59e+09
ADD_C5	8271	57.35	72.97	0	279
M (G_Importv)	8271	.64	40.31	-.94	3656.96
retaliation1	8271	498.46	633.12	0	1344
retaliation2	8271	249.22	262.90	0	612
Independent variables (UV):					
dur(ADD)	8271	4.90	.70	1	10
dur(inv)	8271	1.18	.49	0	3
Q_UV	8271	206298	1267858	0	0.00
Q_k	8271	0.00	0.00	0	0.00
$init_t$	8271	2001.65	3.27	1995	2006
FAD_t	8271	2002.83	3.07	1998	2007
$logFMg$	8271	0.63	1.07	0	4.02
$logPAD$	8271	0.80	1.41	0	8.87
$logFAD$	8271	0.32	1.18	0	8.78
favd	8271	.53	.50	0	1
pavd	8271	.50	.50	0	1
fpu	8271	.08	.28	0	1
fsd	8271	.01	.08	0	1
ADD_S5	8271	83.48	85.05	0	286

where $\psi(\beta'X)$ is the CDF of the standard normal density[18], M_{hfkt} is the bilateral import growth of the foreign country (f) in relation to the home country (h), in year t; η_{xk} and η_{mk} are the export and import demand elasticities, BER_{hft} is the bilateral exchange rate between the home country and the foreign country and σ^m_{hk} is the standard deviation of imports of product m from country h. Also included are the number of ADDs imposed in the past five years, in each given country (ADD_C5), two retaliation variables ($retaliation1$ and $retaliation2$)[19] which are calculated by multiplying the number of dumping initiations and measures, respectively, imposed by the EU on a country's exports by those imposed by the same country on EU exports; and a dummy variable which takes the value of 1 if the same product, in a given country, previously received a dumping duty, and 0 otherwise ($Cases$). If other duties were previously imposed on a specific product, country and/or sector, the DG-Trade may keep their prices under closer surveillance. The regression also includes the lagged value of the growth of imports of a given product from a given country, in year t ($G_Importv_lag$) and a dummy for the cases where there is no injury caused to producers and/or consumers ($NoInjury$).

The canonical specification for quantifying the effect of dumping protection on unit values, for each type of ADD, is a cross-section identified by the dumping cases, and of the following form:

$$\begin{aligned} logUV^{AVD}_{jkft} &= \beta_0 + \beta_1 log(1 + FAD_{jkft}) + \beta_2 log(1 + PAD_{jkft}) \\ &+ \beta_3 log(1 + FMg_{jkft}) + \beta_4 pavd_{jkft} \\ &+ \beta_5 dur(inv)_{jkft} + \beta_6 dur(ADD)_{jkft} + \beta_7 logUV_k_{kft} \\ &+ \beta_8 \hat{\rho_{kft}} + \beta_9 \hat{\rho_{kft}} * log(1 + FAD_{jkft}) \\ &+ \varpi year_t + \varsigma sector_k + vcountry_f + \varepsilon 2_{jkft} \end{aligned}$$

where j, k and f are the indexes for case, sector and country, respectively, t cor-

[18] $\psi(\beta'X) = CDF(\phi(.)) = CDF(\frac{1-(1+e^{-\beta'X})^{-1}}{1+e^{-\beta'X}})$

[19] These retaliation variables were first used in Marvao (2009) and the second was later used by Avsar (2013).

responds to the time period and ϖ, ς, υ are the vectors of year, sector and country dummies, respectively. The same specification is used for the analysis of the dumping decisions, undifferentiated of its type, where the dependent variable is $logUV_{jkft}^{AVD,SD,PU}$.

The prime targets of AD petitions are low quality goods, which are often sold at a lower price and are thus more likely to receive a duty. Due to a potential issue of reverse causality, the standard Fixed Effects (FE) estimations would be inconsistent as the error distribution cannot be considered independent of the regressors' distribution.

To overcome this endogeneity issue in the variable accounting for the final ADD (FAD), the above equation is estimated with an instrumental variable. The number of ADDs per sector, in the previous five years (ADD_S5) is a valid instrument, as it is exogenous, i.e., uncorrelated with the error term in the unit value's specification and significant in explaining the endogenous regressor, such that:

$Cov[ADD_S5; \varepsilon 2_{jkft}] = 0$

$Cov[ADD_S5; log(1 + FAD_{jkft})] \neq 0$

The validity of the instrument is also verified by the F-statistic in the first stage regression. The errors are bootstrapped to prevent issues of heteroscedasticity and subsequent invalid inferences, due to the inclusion of a predicted regressor in the specification. This is also helpful in controlling for the stability of the results.

The results of the linear prediction of ρ and of the IV estimations for the unit values (UVs) are discussed in the next section.

4.4 Results

4.4.1 Probability of the Duty

Table 4.7 reports the results from the Probit model[20] which estimates the probability of a final ad-valorem ADD being imposed. Column (1) includes the absolute

[20]The Probit model requires the sample size to be larger than in OLS regressions, since it uses maximum likelihood estimation techniques, but this is not an issue as the sample size is large, except when the model is restricted to ad-valorem duties imposed on South Korea.

value of the elasticities' ratio and of its growth, while the remaining columns include its logarithm, since the change in these values allows to explain a larger share of the variation in ad-valorem duties. The results for the log-likelihood are reported for comparison purposes. Also for purposes of comparison and generality, *Table 4.9* in *Appendix B* estimates the probability of a final Anti-Dumping penalty (i.e, any ad-valorem duty, specific duty or a price undertaking) being imposed. These results are less accurate since there is a very small number of specific duties and the duty values used in the cases of price-undertakings are proxied by the difference between the unit value and the price set in the agreement.

The results show that the likelihood of an ADD is higher when the elasticities of import demand and export supply (η_{mk} and η_{xk}) are relatively inelastic and when they are decreasing faster, in particular for China (see variable $\widehat{Log\frac{1}{\eta_{xk}+\eta_{mk}}}$). This finding is in line with Bown and Crowley (2012), who find evidence that the probability of an ADD being imposed by the US is higher when elasticities are lower, since it means larger terms-of-trade gains from a duty and smaller domestic efficiency costs.

In general, it is on average 92 percentage points less likely that a new ADD is imposed if a specific product, in a given country, has previously received a duty (*Cases*), although this number slightly decreases for China. This may be because firms ignore the possibility of a second dumping duty or because the duties were imposed for reasons other than dumping.

If an investigation concludes that the dumping action is not causing any material injury to EU producers and consumers (*NoInjury*) then this should not affect the likelihood of the duty, as it is shown for the general case. Nonetheless, in South Korea these cases lead to a much lower probability whereas in China, the probability is increased by 47 percentage points.

Finally, the volatility of import growth (σ) and the bilateral exchange rate (*BER*), as well as the retaliation variables (*retaliation1* and *retaliation2*) and the growth level of imports (*G_Importv_lag*) appear to be independent from the likelihood of protection.

Overall, the results seem to point to protectionist measures being at the origin of dumping protection against China, although they do not support the argument of retaliation, at least in the short-run.

4.4.2 Unit Values

Table 4.9 presents the expected impact of each variable on the change in the unit values of EU imports. The F-statistic and the adjusted R^2 from the first stage regression are reported to validate the choice of the instrument.[21] One concern with the interpretation of the results is that they may be driven by one or a few countries. For this reason, the same analysis is done separately for the most targeted countries: China and South Korea.[22] The specific impact of each of the variables present in the model, on the evolution of the unit values, is discussed below, focusing on ad-valorem duties, as they are the most common type of duty imposed. The same analysis for all the duty types is shown in *Appendix B*. Note that there may be cases where ad-valorem duties and price-undertakings were put in place but for which there is no information in the dataset regarding the type of duty imposed.

The root-mean-square error (Root MSE) is also reported, since it measures the difference between the observed values and those estimated and predicted by the model. The residuals are small for the preferred specifications, which represents a good fit of the model.

4.4.2.1 Dumping duties and dumping margins

Intuitively, higher dumping margins should translate into higher duties, as these are usually set to make up for the difference between the export price and the foreign

[21] The Fixed-Effects results are not reported in the chapter, but were calculated to further validate the use of the instrument in the IV estimations. The instrument is shown not to be significant in explaining the evolution of unit values. The first-stage results from the 2SLS estimation also shows that the chosen instrument is significant in explaining the value of the final duty set.

[22] For South Korea, due to the small sample size, the data was also demeaned as a robustness check and the results are very similar, although of a smaller magnitude.

Table 4.7: Regression Results - Probit - Probability of an ADD being imposed, Ad-Valorem Duties

(Protection)	(1) all	(2) all	(3) all	(4) all	(5) China	(6) S.Korea
$\sigma 9509$	0.00	-0.00***	-0.00***	-0.00***		
	(0.00)	(0.00)	(0.00)	(0.00)		
$\widehat{BER_lag}$	0.00	0.00	-0.00	-0.00	0.02	0.04
	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)	(0.03)
$\frac{1}{\eta_{xk}+\eta_{mk}}$	0.00					
	(0.00)					
$\widehat{\frac{1}{\eta_{xk}+\eta_{mk}}}$	0.01**					
	(0.00)					
$Log\frac{1}{\eta_{xk}+\eta_{mk}}$		0.04	-0.04	-0.05**		
		(0.02)	(0.03)	(0.03)		
$\widehat{Log\frac{1}{\eta_{xk}+\eta_{mk}}}$		0.10*	0.09	0.08	1.02***	-5.99
		(0.05)	(0.06)	(0.06)	(0.39)	(5.47)
Cases			-0.92***	-0.92***	-0.64***	
			(0.18)	(0.18)	(0.19)	
NoInjury			-0.09	-0.07	0.47***	-1.64***
			(0.08)	(0.08)	(0.16)	(0.40)
G_Importv_lag			-0.03	-0.03	0.21	-1.62
			(0.06)	(0.06)	(0.28)	(1.21)
retaliation1			-0.00***			
			(0.00)			
retaliation2				-0.00***		
				(0.00)		
constant	2.24***	2.51***	2.99***	3.02***	2.07***	2.48***
	(0.22)	(0.24)	(0.25)	(0.25)	(0.41)	(0.83)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	2900	2048	2048	2048	880	73
Log-Likelihood	-1118.85	-1545.96	-1046.15	-1048.89	-327.60	-34.75
Chi^2	880.48	591.85	738.49	729.55	357.39	26.70
$\widehat{\rho}$(at means)	45.59%	43.20%	46.00%	46.11%	28.11%	52.50%

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

firm's price at home. Therefore, the price should increase by a similar amount to that of the duty. As expected and as found by Rovegno (2010) for the US and Niels (2003) for Mexico, the overall effect is that for higher final duties (FAD) the price increases, although this effect is dampened by a price decrease due to the imposition of a preliminary duty (PAD). On average, price decreases by 0.31% following a 1% increase in the preliminary duty and it increases by 0.61% with each 1% increase in the final duty. These results support the simulations carried out in *Section 4.3*. If the number of producers of a similar good in the exporting country is large and the degree of substitutability between the two products is high, exporters will raise the prices to avoid further duties and remain in the market.

Rovegno (2012) shows a small price increase for South Korea which is also found in this analysis, provided the data is not restricted to ad-valorem duties (see *Table 4.8*, columns (8) and (9)). It seems that this price effect is driven by the preliminary amount of the duty, other than the final duty imposed, which suggests that the fact that a duty is imposed and not necessarily its amount is the main driver of price changes. As in this chapter, Lu et al. (2012) find that the final duties have no impact on unit values of Chinese exports. This is surprising as competition in the Chinese market is often more intense, leading to lower export prices which may originate higher duties imposed. However, it is shown that although Chinese unit values do not react to the final duty imposed, they increase upon the imposition of the preliminary duty. As such, this provides some support to the extensive literature which claims that the duties imposed by the EU on its main targets (of which China and South Korea) are often motivated by retaliation, protectionism and political reasons and not by dumping.

The value of the final dumping margin assessed (FMg) seems to lead to a decrease in the unit values, although a positive and strong effect occurs in China. This suggests that the margins assessed may be biased, as pointed by Blonigen (2004). If firms expect their assessed margins to be higher than the alleged ones, they are less likely to cooperate with the investigation, leading to biased numbers. As Moore and Fox (2008) indicate, when Chinese firms do not cooperate, their assessed margins

are in fact higher than the margins alleged by the domestic competitors.

4.4.2.2 Duration of the duty and investigation

The duties are usually imposed for a period of 5 years. However, the results show that for longer durations, the unit values are lower, although the magnitude and robustness of this effect is small (see $dur(ADD)$). This result is in line with Vandenbussche and Konings (2008 and 2009), who find that EU unit values only increase in the fourth and fifth year of the duty, and only in the fourth year, for France; and also with Bown and Crowley (2004) who observe an increase in unit values in the first year the duty is imposed, followed by a decrease in the second year. For South Korean imports, each additional year during which the duty is in place leads to unit values which are, on average, 31 percentage points higher, presumably to avoid the extension of the duty.

The opposite impact on unit values derives from the duration of the dumping investigation ($dur(inv)$). Longer investigations seem to lead to further unit value increases (around 24 percentage points, on average), as they may increase the perceived probability of an ADD. It is not surprising that when price-undertakings and specific duties are imposed on China, they are the outcome of shorter investigations, not only because China is one of the favorite targets but because price-undertakings set a price floor and not a duty. Also, specific duties are often lower in value and thus, more easily accepted by the producers (see columns (6) and (7)).

4.4.2.3 Probability of the ADD

The simulations of the theoretical model show that exporting firms take into account the probability of the duty and set their prices accordingly. This is also the case in the empirical analysis, even though this effect is not robust to the introduction of sector controls. In China and South Korea, the evolution of the unit values is independent of this probability which may indicate protectionist and/or retaliatory

reasons by the EU. Furthermore, the expected value of the duty ($\widehat{\rho} * log(1 + PAD)$) is negatively correlated with the change in unit values. While this is unexpected, it may be due to biased margins or erroneous calculations which bias the expectations. In China, the most targeted country, the relationship between unit values and the expected duty is positive and strong, perhaps due to the several duties previously imposed on Chinese imports. One other explanation may be that once a firm receives an ADD, it stops the "dumping" behavior so as to avoid another ADD.

4.4.2.4 Other variables

The type of preliminary and final dumping measures also influences the price evolution. The preferred specification shows that if the preliminary duty is ad-valorem, unit values seem to be lower than otherwise (see variable *PAVD*). This is either because the preliminary duty is set too high, or because a price-undertaking takes place. Nonetheless, this does not seem to be the case in South Korea, where this effect is strong and positive and where preliminary ad-valorem duties mostly lead to ad-valorem final duties.

To control for general changes in each sector's unit values, its evolution is analyzed and shown to be positive and significant. The inclusion of this variable increases the reliability of the additional effect of duties on the price of the firm which is subject to this measure. The impact of this variable means that, in the absence of an ADD, the unit values of the analyzed products follow the same general path as that of the sector and the remaining changes in unit values are explained by the variables above discussed. The case of price-undertaking is different as the duty is only imposed if the price goes below a certain value, so it seems that the price is closely related to this value and negatively related with the average unit values in the sector. For the specific case of South Korea, no correlation is found between the behavior of unit values and that of the sector. This variable can also capture the cost shocks that affect the sector.

Table 4.8: Regression Results - 2SLS - Unit Values, Ad-valorem Duties

(logUV)	2SLS all (1)	2SLS all (2)	2SLS all (3)	2SLS all (4)	2SLS all (5)	2SLS China (6)	2SLS China (7)	FE S.Korea (8)	FE S.Korea (9)
log(1+FAD)	1.02***	2.11***	2.58***	2.77***	0.61*	-2.45	-6.42		
	(0.27)	(0.50)	(0.86)	(0.61)	(0.53)	(60.45)	(14.06)		
log(1+PAD)	-0.63***	-0.67*	-0.77*	-0.83**	-0.31***		3.01***	-0.01	0.08
	(0.17)	(0.46)	(0.48)	(0.40)	(0.12)		(6.59)	(0.02)	(0.06)
log(1+FMG)	-0.09**	-0.22**	-0.25*	-0.29**	-0.08*	1.93	1.25**	0.00	0.00
	(0.04)	(0.10)	(0.15)	(0.14)	(0.04)	(48.55)	(2.93)	(.)	(.)
PAVD	-0.05	0.05	0.13	0.32***	-0.10*	-2.39	-2.23**	1.16***	1.12***
	(0.04)	(0.06)	(0.09)	(0.12)	(0.11)	(55.62)	(5.94)	(0.07)	(0.05)
log_UV_k	0.12***	0.16***	0.16***	0.11***	0.07***	0.63	1.45***	-0.08	0.11
	(0.02)	(0.04)	(0.04)	(0.04)	(0.02)	(4.96)	(2.65)	(0.19)	(0.13)
dur(inv)	0.25***	0.04	0.00	0.09*	0.24***	0.49	1.35***	1.00***	1.11***
	(0.03)	(0.05)	(0.06)	(0.08)	(0.07)	(17.39)	(3.38)	(0.05)	(0.07)
dur(ADD)	-0.10***	0.02	0.05	0.09	0.00	-0.28	-0.18**	0.29***	0.31***
	(0.02)	(0.04)	(0.07)	(0.07)	(0.03)	(2.00)	(0.38)	(0.01)	(0.05)
$\widehat{\rho}$		0.46***	0.90***	0.81*	0.23		-1.08		-0.06
		(0.11)	(0.28)	(0.49)	(0.22)		(4.57)		(0.11)
$\widehat{\rho} * log(1 + PAD)$		-0.90*	-1.16**	-1.17*	-0.16		1.72*		-0.13**
		(0.56)	(0.76)	(0.66)	(0.37)		(4.18)		(0.07)
constant	0.55***	-0.06	-0.25	-1.09*	0.34	1.38	-1.89	0.00	0.00
	(0.13)	(0.26)	(0.43)	(0.62)	(0.37)	(7.31)	(7.53)	(.)	(.)
Year FE			Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE				Yes	Yes				
Sector FE					Yes	Yes	Yes	Yes	Yes
Observations	4369	2048	2048	2048	2048	1314	880	226	73
R^2	.	.	.	.	23%	.	.	.	.
Root MSE	0.69	0.95	1.11	1.14	0.53	1.76	2.69	0.16	0.06
bootstrapped vce	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
robust vce	No	No	No	No	No	No	No	Yes	Yes
1st stage:									
F-stat	941.52	445.59	222.29	126.90	105.48	52.69	94.27		
AdjR^2	60.12%	66.16%	66.05%	66.99%	67.12%	51.52%	72.67%		
Overall R^2								89.76%	96.86%

***, **, * correspond to 1, 5 and 10% significance level, respectively. Standard errors are bootstrapped and reported in parenthesis.

4.5 Discussion

Despite the growing importance of the Anti-Dumping instrument to international trade, there is little consensus on its impact on export prices. This is of major importance for policy makers, since this instrument is the primary form of trade protection worldwide and its repercussions affect trade flows and political relationships. Its analysis is also important to understand how exporting firms react to a major tariff shock.

To examine this issue, a theoretical model is introduced and the set of parameters under which the uncertain enforcement of AD law causes a decrease or increase in the unit values of exports into the EU, is identified. To further explore the evolution of EU border prices, the model is empirically estimated, using worldwide data on exporting firms. Measures of dumping injury, recidivism and retaliation are also included.

It is shown that the unit values of EU imports increase due to the presence of an ADD and there is some evidence of biased margins since unit values react less to dumping duties when the assessed margins are larger. In China, the unit values are higher for larger values of the preliminary duties and dumping margins, whereas these do not seem to affect South Korean unit values. This may be due to sharing the burden of the duty with the importing country or the Government in the exporting country, outsourcing firms or merely due to retaliatory reasons which make the exporting country irresponsive to the dumping penalties.

It is unusual that the predicted probability of a dumping duty is higher when the imports from the target country are increasing and if previous duties have been imposed on the product under investigation. Furthermore, if Chinese imports are found to cause no injury, the likelihood of China receiving a duty is higher. Therefore, it is not surprising that the probability of receiving a duty has no impact on Chinese unit values. The evolution of the analyzed unit values seems to follow the general pattern in the sector, except in South Korea. It is also shown that longer investigations and shorter ad-valorem duties are more effective in increasing unit values.

The above findings suggest that reasons other than dumping might be at the origin of ADD petitions and decisions, as a means of diminishing the loss to national producers caused by other ADDs imposed on EU exports. Dumping margins have to be more accurately assessed, perhaps by providing firms with an incentive to cooperate. Furthermore, if dumping duties have previously been imposed on a given product, these cases should be handled more carefully to prevent scenarios of retaliatory or protectionist motives in the dumping decision. Longer investigations are likely to be more accurate, so investigations on the alleged dumping actions should be as thorough as possible. In general, it seems that AD protection is causing more injury than benefits to producers and consumers in both importing and exporting countries. A substantial revision of the AD instrument is thus necessary to improve trade relationships and welfare of EU producers and consumers.

4.6 Appendix A

(i). Mathematical Proof of the Direct Demand Function:

The inverse demand function of *firm* i in the foreign market is given by:

$$p_i(Q) = a - b[q_i + \gamma \sum_{j=1}^{N} q_j], \ \forall \ i\epsilon[1, N+1]$$

In matrix notation, this can be expressed as:

$$p = a\tau - b[I + \gamma(\tau\tau' - I)]Q$$

which means that the quantity vector is:

$$\begin{aligned} q_i^f &= [I + \gamma(\tau\tau' - I)]^{-1} && (a\tau - p)b^{-1} \\ &= [1 + (N+1)\gamma - [(N+1) - 1]\gamma^2]^{-1}A && (a\tau - p)b^{-1} \\ &= \tfrac{I[1+(N+1-2)\theta]-[\tau\tau'-I]\theta}{1+(N+1-2)\theta-(N+1-1)\theta^2} && (a\tau - p)b^{-1} \\ &= \tfrac{I[1+(N-1)\theta]-[\tau\tau'-I]\theta}{1+(N-1)\theta-N\theta^2} && (a\tau - p)b^{-1} \\ &= \tfrac{a(1-\gamma)-(1+N\gamma-\gamma)p_i^f+\gamma\sum_j p_j^f}{b(1+\gamma-N\gamma-N\gamma^2)} \end{aligned}$$

where:

$$A = \begin{pmatrix} [1+(N+1)-2]\gamma & -\gamma & \dots & -\gamma \\ -\gamma & [1+(N+1)-2]\gamma & \dots & -\gamma \\ \vdots & \vdots & \ddots & \vdots \\ -\gamma & -\gamma & \dots & [1+(N+1)-2]\gamma \end{pmatrix}$$

Q= vector [(N+1)x1] of quantities

p= vector [(N+1)x1] of prices

τ= vector [(N+1)x1] of ones

I= identity matrix [(N+1)x(N+1)]

(ii). Mathematical Solution of the profit maximization - Ad-Valorem Duty:

The first order condition of the profit maximization is:

$\frac{\partial \prod_i}{\partial p_i} = 0 \Leftrightarrow [(1 - \rho T^{AVD}) - \frac{\partial \rho}{\partial p_i} p_i T^{AVD}] q_i + [p_i(1 - \rho T^{AVD}) - c][\frac{\partial q_i}{\partial p_i}] = 0$

Solving $\frac{\partial \rho}{\partial p_i}$:

$\frac{\partial \rho}{\partial p_i} = \frac{\partial[\psi(\beta' X)[\beta_0 + \beta_1 M_{hfkt} + \beta_2(\eta_{xk} + \eta_{mk})^{-1} + \beta_3 \frac{M_{hfkt}}{\eta_{xk} + \eta_{mk}} + \beta_4 \sigma_{hk}^m + \beta_5 BER_{hft} + \beta_6 ADD_C5_{kt}]]}{\partial p_i^f} + \ldots$

$+ \frac{\partial[\psi(\beta' X)[\beta_7 retaliation1_{hft} + \beta_8 retaliation2_{hft} + \beta_9 Cases_{mft} + \beta_{10} G_Importv_lag_{hfkt}]]}{\partial p_i^f} + \ldots$

$+ \frac{\partial[\psi(\beta' X)[+\beta_{11} NoInjury_{hfkt}] + \varepsilon_{hkt}]}{\partial p_i^f}$

Given that:

- $\frac{\partial ADD_C5_{kt}}{\partial p_i} = \frac{\partial retaliation1_{hft}}{\partial p_i} = \frac{\partial retaliation2_{hft}}{\partial p_i} = \frac{\partial G_Importv_lag_{hfkt}}{\partial p_i} = \frac{\partial NoInjury_{hfkt}}{\partial p_i} = \frac{\partial \varepsilon_{hkt}}{\partial p_i} = 0$
- $\frac{\partial M_{hfkt}}{\partial p_i^f} = \frac{\partial \frac{q_{tik} - q_{t-1,ik}}{q_{t-1,ik}}}{\partial p_i} = \frac{\partial \frac{q_{tik}}{q_{t-1,ik}}}{\partial p_i} = \frac{1}{q_{t-1,ik}} \frac{\partial q_{tik}}{\partial p_i}$
- $\frac{\partial BER_{hfk}}{\partial p_i} = \frac{\partial NER_{hft} \frac{p_i}{p_i^h}}{\partial p_i} = \frac{NER_{hft}}{p_i^h}$
- **Assumption 1** (A1): The elasticities are constant over time (for simplification purposes): $\frac{\partial \eta_{xk}}{\partial p_i} = \frac{\partial \frac{\partial q_i^h}{\partial p_i^h} \frac{p_i^h}{q_i^h}}{\partial p_i} = 0$ and $\frac{\partial \eta_{mk}}{\partial p_i} = \frac{\partial \frac{\partial q_i}{\partial p_i} \frac{p_i}{q_i}}{\partial p_i} = 0$
- **Assumption 2** (A2): The importing country grows at a constant rate. Then, the variance in the total imports of a given product is constant ($\sigma_{ik}^m = \sigma_k^m$), such that: $\frac{\partial \sigma_{hk}^m}{\partial p_i} = \frac{\partial \sqrt{\frac{\sum_{t=1}^{\Upsilon} [(Q_{ft}^m - \overline{Q_f^m})^2]}{\Upsilon - 1}}}{\partial p_i^f} = 0$, where $Q_{ft} = \sum_{i=1}^{N+1} q_{ift}$

Then:

$\frac{\partial \rho}{\partial p_i} = \frac{\partial[\psi(\beta' X)(\beta_1 M_{hfkt} + \beta_3 \frac{M_{hfkt}}{\eta_{xk} + \eta_{mk}} + \beta_4 \sigma_{hk}^m + \beta_5 BER_{hft}]}{\partial p_i^f}$

$= \psi(\beta' X)(\beta_1 + \frac{\beta_3}{\eta_{xk} + \eta_{mk}}) \frac{1}{q_{t-1,ik}} \frac{\partial q_{tik}}{\partial p_i} + \psi(\beta' X) \beta_5 \frac{NER_{hft}}{p_i^h}$

Therefore, the first order condition of the profit maximization becomes:

$\frac{\partial \prod_i}{\partial p_i} = 0$

$\Leftrightarrow [(1 + [\psi(\beta' X)[\beta_0 + \beta_1 M_{hfkt} + \beta_2 \frac{1}{\eta_{xk}+\eta_{mk}} + \beta_3 \frac{M_{hfkt}}{\eta_{xk}+\eta_{mk}} + \beta_4 \sigma^m_{hk} + \beta_5 BER_{hft} + U -$

$\varepsilon_{hkt}] + \varepsilon_{hkt}](-T^{AVD})) + [\psi(\beta' X)(Z)\frac{1}{q_{t-1,ik}}(-Wp_i) + \psi(\beta' X)Y]p_i(-T^{AVD})]q_i + [p_i(1 +$

$[\psi(\beta' X)[\beta_0 + \beta_1 M_{hfkt} + \beta_2 \frac{1}{\eta_{xk}+\eta_{mk}} + \beta_3 \frac{M_{hfkt}}{\eta_{xk}+\eta_{mk}} + \beta_4 \sigma^m_{hk} + \beta_5 BER_{hft} + \beta_6 ADD_C5_{kt} +$

$\beta_7 retaliation1_{hft} + \beta_8 retaliation2_{hft} + \beta_9 Cases_{mft} + \beta_{10} G_Importv_lag_{hfkt} +$

$\beta_{11} NoInjury_{hfkt}] + \varepsilon_{hkt}](-T^{AVD})) - c][-Wp_i] = 0$

where:

$V = \frac{a(1-\gamma)+\gamma \sum_j p_j}{b(1+\gamma-N\gamma-N\gamma^2)}$

$W = \frac{\partial q_{tik}}{\partial p_i} = -\frac{1+N\gamma-\gamma}{b(1+\gamma-N\gamma-N\gamma^2)}$

$U = \beta_6 ADD_C5_{kt} + \beta_7 retaliation1_{hft} + \beta_8 retaliation2_{hft} + \beta_9 Cases_{mft} +$

$\beta_{10} G_Importv_lag_{hfkt} + \beta_{11} NoInjury_{hfkt}$

$Y = \beta_5 \frac{NER_{hft}}{p_i^h}$

$Z = \beta_1 + \frac{\beta_3}{\eta_{xk}+\eta_{mk}}$

Assuming: $\varepsilon_{hkt} = 0$ **and** $\psi(\beta' X) = 1$**, then:**

$\frac{\partial \prod_i}{\partial p_i} = 0$

$\Leftrightarrow [1 + [\beta_0 + ZM_{hfkt} + \beta_2 \frac{1}{\eta_{xk}+\eta_{mk}} + \beta_4 \sigma^m_{hk} + Yp_i + U](-T^{AVD}) + [Y - Z\frac{W}{q_{t-1,ik}}]p_i(-T^{AVD})](V -$

$Wp_i) - p_i W(1 + [\beta_0 + ZM_{hfkt} + \beta_2 \frac{1}{\eta_{xk}+\eta_{mk}} + \beta_4 \sigma^m_{hk} + Yp_i + U](-T^{AVD})) - cWp_i = 0$

$\Leftrightarrow (p_i)^3[W^2(-T^{AVD})(3Y - \frac{ZW}{q_{t-1,ik}})]$

$+(p_i)^2[-2YVW(-T^{AVD}) + 2W^2 - 2(-T)W^2(Z + \beta_0 + \frac{\beta_2}{\eta_{xk}+\eta_{mk}} + \beta_4 + U)]$

$+p_i[-2WV + V^2(-T)(Y - \frac{ZW}{q_{t-1,ik}}) + 2V(-T)W(Z + \beta_0 + \frac{\beta_2}{\eta_{xk}+\eta_{mk}} + \beta_4 + U) +$

$TZWq_{t-1,ik}]$

$+[V - cW - T^{AVD}VZ - TZq_{t-1,ik} - TV(\beta_0 + \frac{\beta_2}{\eta_{xk}+\eta_{mk}} + \beta_4 + U)][V - W] = 0,$

which is of the form $Ap_i^3 + Bp_i^2 + Cp_i + D = 0$

The optimal value for p_i is found with the help of *Mathematica*:

$p^*_{i,sol.1} = -\frac{B}{3A} - \frac{2^{1/3}(-B^2+3AC)}{3A[-2B^3+9ABC-27A^2D+\sqrt{4(-B^2+3AC)^3+(-2B^3+9ABC-27A^2D)^2}]^{1/3}} + ...$

$$+\frac{[-2B^3+9ABC-27A^2D+\sqrt{4(-B^2+3AC)^3+(-2B^3+9ABC-27A^2D)^2}]^{1/3}}{3(2^{1/3})A}$$

$$p^*_{i,sol.2} = -\frac{B}{3A} - \frac{(1+\sqrt{3})(-B^2+3AC)}{3A(2^{2/3})[-2B^3+9ABC-27A^2D+\sqrt{4(-B^2+3AC)^3+(-2B^3+9ABC-27A^2D)^2}]^{1/3}} + ...$$
$$+\frac{(1-\sqrt{3})[-2B^3+9ABC-27A^2D+\sqrt{4(-B^2+3AC)^3+(-2B^3+9ABC-27A^2D)^2}]^{1/3}}{6(2^{1/3})A}$$

$$p^*_{i,sol.3} = -\frac{B}{3A} - \frac{(1-\sqrt{3})(-B^2+3AC)}{3A(2^{2/3})[-2B^3+9ABC-27A^2D+\sqrt{4(-B^2+3AC)^3+(-2B^3+9ABC-27A^2D)^2}]^{1/3}} + ...$$
$$+\frac{(1+\sqrt{3})[-2B^3+9ABC-27A^2D+\sqrt{4(-B^2+3AC)^3+(-2B^3+9ABC-27A^2D)^2}]^{1/3}}{6(2^{1/3})A}$$

(iii). Mathematical Solution of the FOC of the profit maximization - Specific Duty:

The first order condition of the profit maximization is:

$$\frac{\partial \prod_i}{\partial p_i} = 0 \Leftrightarrow [1 - \frac{\partial \rho}{\partial p_i} T^{SD}]q_i + [p_i - \rho T^{SD} - c][\frac{\partial q_i}{\partial p_i}] = 0$$

$$\Leftrightarrow p_i = \frac{(1-T^{SD}\frac{\partial \rho}{\partial p_i})\frac{V}{W} + c + \rho T^{SD}}{2 - T^{SD}\frac{\partial \rho}{\partial p_i}}$$

$$\Leftrightarrow [1-T^{SD}\psi(\beta' X)((\beta_1+\frac{\beta_3}{\eta_{xk}+\eta_{mk}})\frac{1}{q_{t-1,ik}}\frac{\partial q_{tik}}{\partial p_i}+\beta_5\frac{NER_{hft}}{p_i^h})]\frac{a(1-\gamma)-(1+N\gamma-\gamma)p_i+\gamma\sum_j p_j}{b(1+\gamma-N\gamma-N\gamma^2)} -$$
$$[p_i + [\psi(\beta' X)[\beta_0 + \beta_1 M_{hfkt} + \beta_2(\eta_{xk}+\eta_{mk})^{-1} + \beta_3\frac{M_{hfkt}}{\eta_{xk}+\eta_{mk}} + \beta_4\sigma^m_{hk} + \beta_5 BER_{hft} +$$
$$\beta_6 ADD_C5_{kt} + \beta_7 retaliation1_{hft} + \beta_8 retaliation2_{hft} + \beta_9 Cases_{mft} + \beta_{10} G_Importv_lag_{hfkt} +$$
$$\beta_{10} NoInjury_{hfkt}](-T^{SD}) - c]\frac{(1+N\gamma-\gamma)}{b(1+\gamma-N\gamma-N\gamma^2)} = 0$$

$$\Leftrightarrow [1 + WT^{SD}\psi(\beta' X)(Z)\frac{1}{q_{t-1,ik}} + Y]V + W[p_i + [\psi(\beta' X)[\beta_0 + ZM_{hfkt} + \beta_2(\eta_{xk} +$$
$$\eta_{mk})^{-1} + \beta_4\sigma^m_{hk} + \beta_5 BER_{hft} + U] - \varepsilon_{hkt}]T^{SD} - c] = 0$$

Assuming: $\varepsilon_{hkt} = 0$ **and** $\psi(\beta' X) = 1$:

$$\Leftrightarrow [1 + WT^{SD}Z\frac{1}{q_{t-1,ik}} + Y]V + W[p_i + [\beta_0 + ZM_{hfkt} + \beta_2(\eta_{xk} + \eta_{mk})^{-1} + \beta_4\sigma^m_{hk} +$$
$$\beta_5 BER_{hft} + U](-T^{SD}) - c] = 0$$

which is of the form $Ap_i^2 + Bp_i + C = 0$ and where:

$$A = W[-1 + tY - T^{SD}Z[1 + \frac{W}{q_{t-1,ik}}]]$$
$$B = W[-1 + Y + T^{SD}U + c - T^{SD}Z(1 + \frac{W-V}{q_{t-1,ik}}) + T^{SD}(\beta_0 + \frac{\beta_2}{\eta_{xk}+\eta_{mk}} + \beta_4\sigma^m_{hk})]$$
$$C = V[1 + Y + T^{SD}Z\frac{W}{q_{t-1,ik}}]$$

Then:

$$\Leftrightarrow p_i^* = -\frac{1}{2} + \frac{1}{2}\frac{Y+Z\frac{V}{q_{t-1,ik}}+\beta_0+\frac{\beta_2}{\eta_{xk}+\eta_{mk}}+\beta_4\sigma_{hk}^m}{Y+Z(1+\frac{W}{q_{t-1,ik}})+\frac{1}{T^{SD}\psi(\beta' X)}} \pm$$

$$\frac{\sqrt{[Y-1+T^{SD}U+c-T^{SD}Z(1+\frac{W-V}{q_{t-1,ik}})-(\beta_0+\frac{\beta_2}{\eta_{xk}+\eta_{mk}}+\beta_4\sigma_{hk}^m)]^2-4WV[-1-T^{SD}(Y+Z(1+\frac{W}{q_{t-1,ik}}))][1+Y+T^{SD}Z\frac{W}{q_{t-1,ik}}]}}{2\sqrt{W}[-1-T^{SD}Y-T^{SD}Z[1+\frac{W}{q_{t-1,ik}}]]}$$

4.7 Appendix B

Table 4.9: Regression Results - Probit - Probability of an ADD being imposed, All Duties

(Protection)	(1) all	(2) all	(3) all	(4) all	(5) China	(6) S.Korea
σ9509	0.00***	-0.00***	-0.00***	-0.00		
	(0.00)	(0.00)	(0.00)	(0.00)		
$\widehat{BER_lag}$	-0.00	-0.00	-0.00	-0.00	0.00	0.02
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)
$\frac{1}{\eta_{xk}+\eta_{mk}}$	0.00***					
	(0.00)					
$\widehat{\frac{1}{\eta_{xk}+\eta_{mk}}}$	0.00					
	(0.00)					
$Log\frac{1}{\eta_{xk}+\eta_{mk}}$		0.08***	-0.00	-0.03		
		(0.02)	(0.02)	(0.02)		
$\widehat{Log\frac{1}{\eta_{xk}+\eta_{mk}}}$		0.02	0.01	0.01	1.04***	0.28
		(0.04)	(0.05)	(0.05)	(0.29)	(0.81)
Cases			-0.84***	-0.81***	-0.70***	-1.42***
			(0.12)	(0.12)	(0.16)	(0.28)
NoInjury			0.08	0.08	0.60***	0.08
			(0.07)	(0.07)	(0.13)	(0.19)
G_Importv_lag			0.01	0.01	0.56**	-0.33
			(0.06)	(0.06)	(0.24)	(0.38)
retaliation1			-0.00***			
			(0.00)			
retaliation2				-0.00***		
				(0.00)		
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
constant	2.47***	2.58***	3.20***	3.28***	2.11***	1.28***
	(0.20)	(0.22)	(0.22)	(0.22)	(0.38)	(0.31)
N	5858	4253	4253	4253	1400	329
Log-Likelihood	-2163.70	-2989.04	-1969.68	-1972.16	-551.98	-180.51
Chi^2	2112.97	1536.45	1924.48	1919.54	587.40	72.85
$\widehat{\rho}$(at means)	45.68%	46.44%	45.63%	45.63%	30.70%	63.58%

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

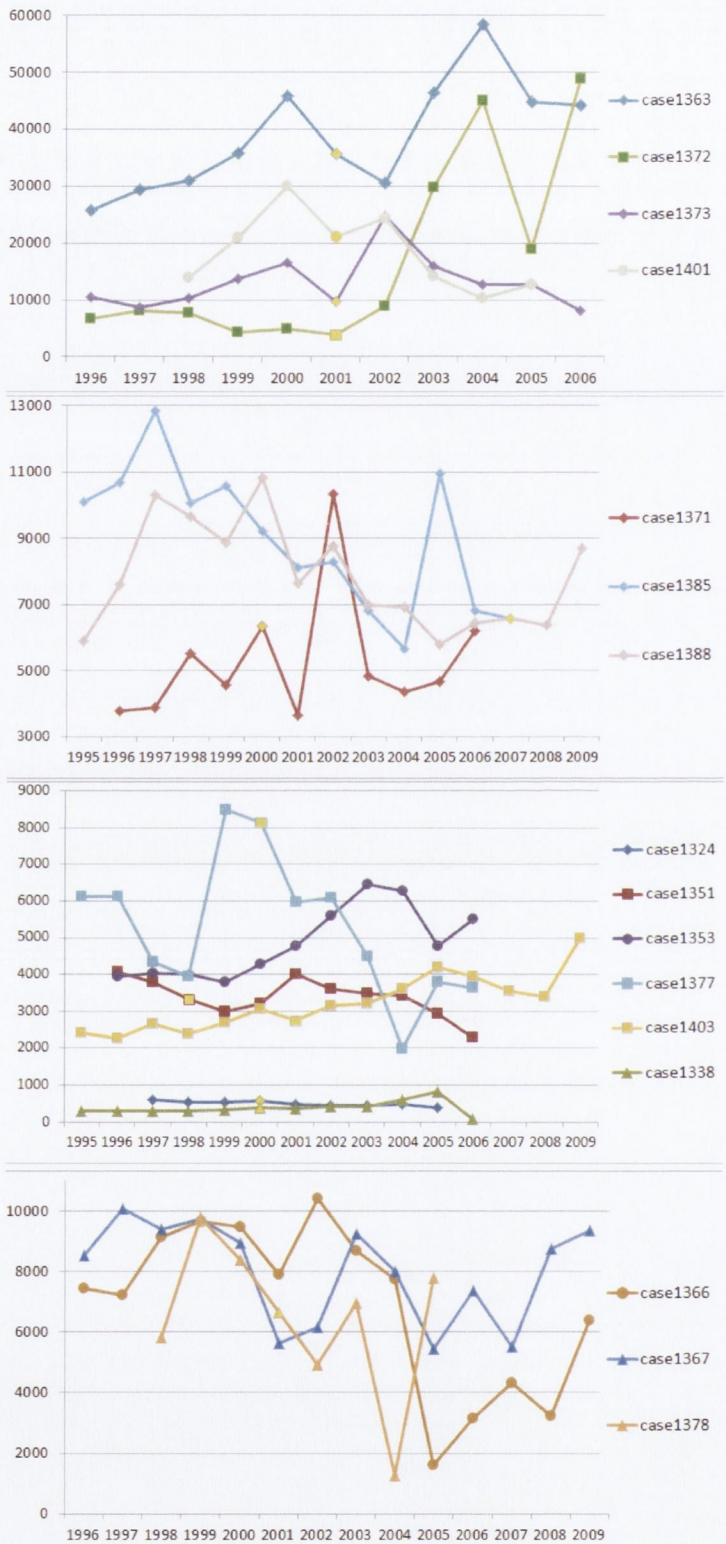

Figure 4.6: Pattern of price change in EU imports from Japan, 1995-2009

Table 4.10: Regression Results - 2SLS - Unit Values, All duty types

(logUV)	2SLS all (1)	2SLS all (2)	2SLS all (3)	2SLS all (4)	2SLS all (5)	2SLS China (6)	2SLS China (7)	2SLS S.Korea (8)	2SLS S.Korea (9)
log(1+FAD)	4.91	9.34	15.19	9.36	0.45	1.00	1.14	-15.49	8.62
	(3.51)	(15.97)	(81.86)	(18.72)	(0.35)	(29.81)	(0.74)	(23.90)	(5.35)
log(1+PAD)	-2.31	1.45	2.58	1.33	-0.25**		-0.31*	4.23	3.39*
	(1.78)	(4.10)	(17.48)	(4.70)	(0.10)		(0.28)	(6.93)	(2.83)
log(1+FMG)	-0.39	-0.94	-1.46	-0.86	-0.05*	-0.69	-0.22**	3.35	-3.27
	(0.29)	(2.18)	(8.94)	(1.79)	(0.04)	(19.53)	(0.10)	(6.06)	(2.36)
PAVD	0.21	0.60	1.01	0.68*	-0.12*	0.50	0.37***	0.56	0.03
	(0.17)	(1.14)	(6.37)	(0.82)	(0.06)	(6.52)	(0.06)	(0.83)	(0.48)
log_UV_k	-0.12	0.13	0.17	0.25**	0.08***	0.20	0.12	13.90	-7.83
	(0.15)	(0.32)	(1.85)	(0.13)	(0.03)	(5.09)	(0.15)	(21.68)	(5.30)
dur(inv)	0.01	0.15	0.23	0.20	0.26***	-0.09	-0.14**	1.11	-0.38
	(0.09)	(0.46)	(2.38)	(0.78)	(0.04)	(0.21)	(0.07)	(1.73)	(0.34)
dur(ADD)	0.15	0.35	0.65	0.35	-0.01	-0.19	-0.18**	1.87	-1.15**
	(0.25)	(0.74)	(4.97)	(0.83)	(0.02)	(1.63)	(0.08)	(2.69)	(0.55)
$\widehat{\rho}$		1.31	3.39	2.13	0.12		0.19		1.38
		(2.36)	(19.32)	(3.73)	(0.21)		(0.24)		(1.51)
$\widehat{\rho} * log(1 + PAD)$		-7.23	-11.96	-7.14	-0.10		-0.50		-6.40
		(14.15)	(67.74)	(15.35)	(0.22)		(0.79)		(4.95)
constant	0.23	-2.20	-5.58	-4.36*	0.09	0.87	0.92	-40.67	32.00
	(0.83)	(5.42)	(47.12)	(8.47)	(0.25)	(6.23)	(0.58)	(63.11)	(20.18)
Year FE			Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE				Yes	Yes				
Sector FE					Yes	Yes	Yes	Yes	
Observations	8271	4253	4253	4253	2215	1921	1400	520	329
R^2	.	.	.	.	0.27	.	.		
Root MSE	2.76	4.09	6.65	4.02	0.52	0.80	0.69	7.93	3.57
bootstrapped vce	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
1st stage:									
F-stat	900.20	411.86	195.19	108.23	111.70	47.38	93.26	22.50	14.27
AdjR^2	43.22%	46.51%	46.46%	47.59%	67.21%	39.48%	63.16%	50.87%	45.94%

***, **, * correspond to 1, 5 and 10% significance level, respectively. Standard errors are bootstrapped and reported in parenthesis.

CHAPTER 5

Conclusion

5.1 Concluding Remarks

FIRMS in a competitive market act with the aim of having a competitive edge over their competitors, so as to maximize their profits. However, many firms' behavior limits, distorts or prevents competition, depriving consumers from choice, low prices and potentially new products and/or services and hurting other competing firms at a national or international level. Overall, anti-competitive behavior undermines economic growth and it is thus essential to adequately penalize these firms. Among the most serious breaches of competition law are cartels and predatory pricing. This thesis provides an analysis of issues related to these two offences.

When firms act together with the intent to drive up their profits, instead of competing with each other, consumers and competing firms are injured. Not only do cartel agreements tend to lead to higher prices as they often reduce innovation and investment by protecting inefficient cartel members, preventing new firms from entering the market and perhaps damaging competitors who are not part of the cartel.

In *Chapter 2*, I present an analysis of the factors impacting on the setting of the percentage fine reductions within the EU Leniency Programme from the perspectives of firms and regulators. My research shows that the first reporter receives very generous fine reductions but that these reductions are larger for firms who take part in smaller cartels and cartels with a wider geographical impact. However, arguably the main result is that repeat offenders receive higher leniency reductions, which suggests strongly that firms can learn the "rules of the game", repeatedly colluding and then reporting the cartel, thus substantially damaging their partners. While the prospect of high leniency reductions may incentivize these firms to report, it may also create an incentive to participate in a cartel and be the first reporter. Due to the ambiguous impact of the Leniency Programme on firms' incentives, repeat offenders' penalties should be carefully assessed so as to create a desistance effect and the leniency reductions should be independent of recidivism, or else the link should be made more explicit in the guidelines.

In *Chapter 3*, by introducing firm heterogeneity in the analysis of cartel members which have private information on the likelihood of conviction, I aim to contribute to the ongoing exploration of cartel behavior. This study is, to the best of my knowledge, the first to analyze the characteristics of the reporting firms, which is key to the design of a successful Leniency Programme. I find that if firms expect to receive a higher cartel fine, then their equilibrium threshold for reporting is lower, keeping all else constant. The empirical results add to this finding by shedding light on the sources of fine heterogeneity, of which recidivism and leadership of the cartel are key, and on the characteristics of the cartels in which pre-investigation reporting occurs.

Together, these chapters represent a significant contribution to our understanding of cartel behavior, in the EU and the US. From a policy perspective, the results hold two main lessons. First, the need to make the leniency guidelines clearer and more explicit so as to guarantee that firms clearly know the consequences they face. The generosity of the reductions granted to each reporting and/or cooperating firm, and in particular to repeat offenders, should be carefully assessed so as to create a

desistance effect and deter new cartels from forming. Furthermore, the legislation should target firms and sectors with similar characteristics to those of previous reporters, as identified in *Chapter 3*. Second, the vital need to increase the perceived probability of conviction. This can be done by increasing the proactivity of Competition Authorities, perhaps through screens which would supplement and enhance leniency.

When firms have considerable market power or market share, they often set prices at a sufficiently low level with the intent of damaging competitors and ultimately competition. Like cartels, this predatory behavior deters new firms from entering the market. Consumers are hurt, as once the firm gains additional market power, it increases the prices and exploits consumers. However, notwithstanding the growing importance of the Anti-Dumping instrument in international trade, there is little consensus on its actual impact on export prices. This is of major importance for policy makers, since this instrument is the primary form of trade protection worldwide and its repercussions affect trade flows and political relationships. Its analysis is also important to understand how exporting firms react to a major tariff shock.

In *Chapter 4*, I explore the evolution of EU border prices, in the presence of uncertain Anti-Dumping enforcement. I provide evidence that the unit values of EU imports increase due to the presence of an Anti-Dumping Duty and I find some evidence of biased margins since unit values' changes are smaller for higher assessed margins. I further show that the imposition of preliminary and final duties has no significant effect on South Korean export prices, which suggests that the burden of the duty is shared with the importing country (in the EU) or the Government in the exporting country, outsourcing firms or this effect may be due to retaliatory reasons which make the exporting country irresponsive to the dumping penalties. Moreover, I find that if Chinese imports are found to cause no injury, the likelihood of China receiving a duty is higher.

My findings suggest that reasons other than dumping might be at the origin of Anti-Dumping petitions and decisions, as a means of diminishing the loss to national

producers caused by other Anti-Dumping Duties imposed on EU exports. Dumping margins should be more accurately assessed, perhaps by providing firms with an incentive to cooperate. Furthermore, if dumping duties have previously been imposed on a given product, these cases should be handled more carefully to prevent scenarios of retaliatory or protectionist motives in the dumping decision. I further show that longer investigations tend to be more accurate, so investigations on the alleged dumping actions should be as thorough as possible. In general, it seems that Anti-Dumping protection is causing more injury than benefits to producers and consumers in both importing and exporting countries. A substantial revision of the Anti-Dumping instrument is thus necessary to improve trade relationships and welfare of EU producers and consumers.

Future Work

An extension of the theoretical model presented in *Chapter 3* will be sponsored by an ELEVATE Post-Doctoral Scholarship, granted by the Irish Research Council, and it will be developed in cooperation with Giancarlo Spagnolo, at Stockholm Institute for Transition Economics. Different firms may receive signals in diverse time periods or they may not report instantaneously even if the signal is above their threshold, due to each firms' beliefs on the behavior of the other cartel members. Therefore, it is likely that a time lapse exists between the reporting and the initiation of the investigation. This suggests the need to use a continuous time approach to model the beliefs of each firm.

Future work will incorporate uncertainty in the amount of the individual cartel fines and a degree of risk aversion in the utility function of each cartel member. It will also assess the behavior of cartel members which merge and where the new firm subsequently participates in a new cartel.

Chapters 2 and 3 show that recidivism is an important issue in designing efficient legislation that dissuades and deters cartels. There may be individual characteristics of these firms that determine their repeated participation in cartels, such as

industry, nationality and firm size. Future work will use a case-study approach to examine, in detail, the specific characteristics and behavior of repeat offenders.

The results from *Chapter 3* also suggest 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. I posit that when the correct incentives are in place, firms with the largest sales level will more likely report tax infractions such that audits should focus on firms with a smaller level of sales. Thus, future work will provide an application of this model to the tax revenue literature.

Another area for future research lies in the determination of an alternative or substantial reform of the Anti-Dumping instrument. While many changes to the current instrument have been suggested, these have generated so many conflicts of interests between producers, trading companies, consumer groups, trade unions and political power that they have all been suspended. Future work must identify the gains and losses for all the involved parties, from each alternative. The initial changes should perhaps involve tighter criteria in the definition of the exact circumstances in which the Anti-Dumping instrument should take action, and increased weight and transparency in both the investigations and in the calculations of dumping margins.

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