Collusion in Industrial Economics and Optimally Designed Leniency Programmes - A Survey

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1 Introduction

The first fundamental theorem of welfare economics crystallizes that a system of competitive equilibria is Pareto optimal. No redistribution of resources could make anyone strictly better-off, without simultaneously making someone else worse-off. Nonetheless, there are situations where free markets fail to efficiently allocate the scarce resources of an economy. One blatant example of market failure is collusion among firms. In his famous book on the '*Wealth of Nations'* Adam Smith[1] acknowledged that the market system inherently provides a fertile ground for the development of orchestrated behaviour by firms.[2] The inimical effects of collusion to the welfare of consumers calls for government intervention; antitrust policy is one such manifestation of this. Its goal is twofold; dissolve existing cartels and deter new cartels to form in the future.

Because of the clandestine nature of cartels, Antitrust Authorities, which are public agencies designated to enforce antitrust law, face two major challenges.[3] The first transpires because of the limited resources they have to combat cartels. The stringency of an antitrust authority's budget unequivocally restrains its investigative competency. The second is due to the asymmetry of information between an antitrust authority and cartel members. Contrary to the antitrust authority, a firm knows whether it participates or not in a cartel. Given the high standard of evidentiary proofs required by courts, an antitrust authority cannot prosecute cartels unless it discovers incriminating evidence.[4] Importantly, reliable and cogent incriminating evidence is not costlessly obtainable.

A powerful policy tool that antitrust authorities have at their disposal in order to overcome the informational disadvantages *vis-à-vis* cartels, is

[1] Adam Smith (1723-1790) was a Scottish moral philosopher. He is considered to be the ideological father of the freedom of choice of individuals.

[2] Smith [1776] lucidly observed that "*people of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices*".

[3] As Hovenkamp and Leslie [2011] put it: "*Firms that engage in price fixing may try to reduce their probability of antitrust liability in a number of ways. First, members of a price-fixing conspiracy go to great lengths to conceal their illegal activities from antitrust enforcers.*"

[4] Theoretically, the decision of a firm as to whether to participate or not in a cartel is endogenous. In real life, however, things are more complex and less straightforward than in theory. An illuminating study case is *Graphite Electrodes*. For a dicussion of the concerns that surfaced in that particular case see Hviid and Stephan [2009]. Petrinent also is the discussion on whether tacit collusion should be considered as illegal. For a discussion, see Turner [1962], Vaska [1985], Feuerstein [2005], Odudu [2006] and Buccirossi and Spagnolo [2006].

leniency programmes. Essentially, leniency programmes are information revelation mechanisms aiming to incentivise colluding firms to come forward and denounce their unlawful conduct. More formally, a leniency programme specifies a set of rules for granting reduction of fines (or even offering rewards or bounties), to firms or individuals, for actively collaborating with the antitrust authority, either before or after the commencement of an investigation procedure.[5] Depending on whom the beneficiary is, leniency programmes are distinguished between those addressed to firms and those addressed to individuals.

By incentivising the instability of cartels, such programs can trigger the collapse of existing cartels (*desistance effect*). More importantly, they may render cartels less profitable, and thus less likely to form (*deterrence effect*). However, leniency programmes do not unambiguously reinforce the efficacy of antitrust law enforcement; poorly designed leniency programmes may exacerbate cartel behaviour and can potentially provoke cartel formation.[6] A sound understanding of the functioning of cartels is essential to gain a thorough insight into leniency programmes and their effect on firms' incentives to collude. Prominently, the literature on leniency programmes in antitrust draws insights from the economic literature on generic law enforcement. An overview of this literature can provide useful background knowledge such that the advancements in the literature on leniency programmes in antitrust can be fully realized.

The economic theory of antitrust law enforcement builds on the pioneering work of Becker [1968].[7] Becker was the first to explicitly use rational choice theory to analyze the supply side of crimes. Since Becker [1968], the study of how criminals respond to incentives has flourished. Importantly, Becker's seminal work led to the development of a branch of economics known as the '*Economic Theory of Public Enforcement of Law*'.[8] The analysis of the effects of self-reporting schemes for individual crimes advanced, more than two decades after Becker's contribution, with the ground-breaking research by Malik [1990] and Kaplow and Shavell [1994]. This literature has been the

[5] It is worth noting that the provision of lenient treatment (or amnesty) to wrongdoers is not a novelty of antitrust law. Lenient treatment has a long history of use in various fields of law. For instance, bounties against wanted criminals before capture but after detection, tax evasion, unreturned library books, parking tickets, draft evasion and illegal immigration. See Marceau and Mongrain [2000].

[6] For instance, see Ellis and Wislon [2003] and Buccirossi and Spagnolo [2006].

[7] As Becker [1968, 1993] himself concedes, the discussion has its origins to the representatives of the enlightenment era in the 18^{th} century, and, in particular, to philosophers Beccaria [1986] and Bentham [1931].

[8] For a comprehensive survey of the economic literature on the enforcement of law see Polinsky and Shavell [2000] and Garoupa [1997].

lodestar for a recently developed literature on the optimal design of leniency programmes in antitrust law enforcement. Remarkably, this literature forged 25 years after the implementation of the Corporate Leniency Policy in the US in 1978, with the highly influential papers by Motta and Polo [2003] and Spagnolo [2004].[9]

This paper surveys the literature on collusion and the optimal design of leniency programmes. It also reviews the literature on the economics of law enforcement, with a focus on self-reporting schemes, both for individuals and groups of individuals. The objective is to encapsulate the most influential contributions, highlighting their main findings and limitations, in a systematic and useful and pedagogical way for the reader. Moreover, the paper intends to pin down possible shortcomings and areas that require further research.

In particular, the paper considers: 1) the economic literature on collusion (how cartels form, what challenges they confront, their effects on consumers, the empirical estimation of overcharges, the challenges an antitrust authority encounters in enforcing antitrust law, the policy tools available to combat illegal cartels), 2) the literature on public enforcement of (generic) law, with a focus on the effects of self-reporting schemes, both for individual violators and groups of violators, 3) the literature on antitrust law enforcement, 3) the literature on the optimal design of leniency programmes, with an emphasis put on the impact of such programs on firms' incentives to collude and, 4) the empirical literature on the effectiveness of leniency programmes.

The paper develops as follows: section 2 examines the economics of collusion with a focus on cartel formation and cartel sustainability; section 3 provides a systematic, yet non-exhaustive, review of the literature on optimal law enforcement; section 6 reviews the economic literature on leniency programmes in the realm of antitrust policy and finally; section 8 concludes.

2 Collusion in Industrial Economics

The overarching priority of antitrust authorities in various jurisdictions across the globe is the detection of existing cartels, and, ultimately, the deterrence of cartel formation in the future.[10] Collusive agreements among firms constitute the most serious and egregious form of anticompetitive behaviour. Such

[9] See also the earlier working papers by Motta and Polo [1999] and Spagnolo [2000].

[10] For instance, see OECD, Hard Core Cartels: Third Report on the Implementation of the 1998 Recommendations, 2006; EU Competition Commissioner Mario Monti, Speech/00/295, 11/9/2000; Mario Monti, Fighting cartels: Why and How? Why should

agreements may adversely affect consumers and the economy as a whole. On account of their pernicious effects to consumers, collusive agreements have been aptly portrayed as a '*major drain*'[11] and '*carcinoma*'[12] on the free market economy.[13] Apart from the tangible malign effects to welfare, such agreements have also intangible and non-measurable effects, i.e., ethical issues. In the words of Smith [1776], almost 230 years ago, a collusive agreement constitutes a conspiracy[14] against consumers.[15]

From an economic point of view, collusion describes a situation where prices are higher than some competitive benchmark.[16] The benchmark is usually considered to be the equilibrium of a strategic scenario where firms meet only once in the marketplace (the stage game equilibrium) and at which collusion is infeasible. Essentially, every subgame perfect equilibrium that is distinct from a Nash equilibrium of the stage game is considered as collusive.[17]

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we be concerned with cartels and collusive behavior, 3rd Nordic Competition Policy Conference, Stockholm, 11-12/9/2000; Nelly Kroes, Speech/09/375, European Economic and Social Committee, Internal market section, Brussels, 9/9/2009; Report on Competition Policy, 2009, Brussels 3/6/2010, COM(2010) 282; US DoJ Assistant Attorney General R.H. Pate, Speech at the Third annual conference on international and comparative law, London, UK, 16/5/2003; Makan Delrahim, Deputy Assistant Attorney General, Antitrust enforcement priorities and efforts towards international cooperation at the US Department of Justice, 15/11/2004, Taipei, Taiwan.

[11] OECD Report, Hard Core Cartels, [2001], p. 7.

[12] Mario Monti, Fighting cartels: Why and How? Why should we be concerned with cartels and collusive behavior, 3rd Nordic Competition Policy Conference, Stockholm, 11-12/9/2000.

[13] Some authors argue that collusion, under some conditions, may be beneficial for consumers and/or society as a whole. For instance, see Fershtman and Pakes [2000], Deltas et al. [2009], Doyle and Martijn [2005], Bos and Pot [2010].

[14] The word '*conspiracy*' is used in Section 1 of the Sherman Act: "*Every contract, combination in the form of trust or otherwise, or conspiracy, in restrain of trade or commerce among the several states, or within foreign nations, is declared to be illegal*".

[15] The statement by James Randall (then CEO of ADM - one of the firms participating in the notorious *Lysine cartel*) is enlightening: "*We are gonna get manipulated by these God damn buyers. [...]. They can be smarter than us if we let them be smarter [...] They are not your friend. They are not my friend. And we gotta have 'em. Thank God we gotta have 'em, but they are not my friends. You are my friends. I wanna be closer to your than I am to any customer 'cause you can make us [...] money*".

[16] The enduring temptation of firms to coordinate their conduct in the market is not new for economists. Almost 230 years ago Smith [1776] observed that "*people of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices*".

[17] For instance, in a homogeneous good market with price (quantity) competition, a collusive outcome exists whenever prices are higher than the one-shot Bertrand (Cournot) equilibrium.

Motta [2004] contends that in economics collusion coincides with an outcome (sufficiently high prices) and not with the specific form whereby that outcome is attained. See Motta

The same holds for finitely repeated supergames.[18]

A collusive agreement can manifest in various ways. For instance, fixing prices, restricting production, allocating (geographically or otherwise) market shares or consumers, and rigging bids in auctions.

Collusive agreements are classified into two broad categories: explicit and tacit. The former involves an explicit communication between firms and typically takes place in the framework of an organized cartel, while the latter involves collusion in a non-cooperative manner without any explicit communication between firms. For instance, as Rotemberg and Saloner [1990] show, in an oligopoly firms may arrive at a viable coordination without explicit cooperation or agreement by tuning their prices to that of the largest firm in the market. Coordinating to a commonly acceptable collusive equilibrium, when firms tacitly collude, normally postulates costly experimentation in the market. On the contrary, explicitly colluding firms evade this cost. Therefore, the core of the distinction between tacit and explicit collusion is centred on the way whereby an equilibrium is reached.

Regardless of the type of collusion, tacit or explicit, its sustainability depends on the existence of a compliance monitoring mechanism and a mechanism to punish unilateral defections by colluding firms.[19] Importantly, the explicit coordination does not necessarily guarantee the sustainability of the collusion, since firms communication might simply be '*cheap talk*'.[20] It has to be remarked though that the motive to deviate from the collusive equilibrium exists both with explicit and tacit collusion. Hence, the underlying economics is the same for the two types of collusion (tacit and explicit). The crucial point with either type of collusion however, is that the collusive agreement must be self-enforcing in order to be sustainable.

The (tacitly or implicitly) coordinating firms will ideally aim to repro-

[2004], p. 138.

[18] Supergames are games for which the strategic form is endogenous (the strategic form or the beliefs over the strategic form evolve), i.e. durable goods, inventories, switching costs etc. For these type of games any equilibrium which is distinct from a *Markov Perfect Equilibrium* (MPE) is considered as '*collusive*'.

A MPE is a subgame perfect equilibrium in which all players use Markov strategies. Informally, a Markov strategy depends only on payoff-relevant past events. This type of strategies were introduced by Maskin and Tirole [2001].

[19] Stigler [1964] was the first to argue that cartels are intrinsically unstable because of the individual cartel member's incentive to benefit from defecting from the agreement by means of secret price cuts. Therefore, apart from being profitable, a cartel must also be feasible. The latter requires a mechanism to monitor firms' compliance to the agreement and a credible punishment mechanism for defecting firms.

[20] In Game Theory '*cheap talk*' is the communication between players which does not directly influence the payoff of the game. See Farrell and Rabin [1996] and Crawford and Sobel [1982].

duce, in an artificial manner, the outcome of a monopoly. However, this does not necessarily mean that the welfare implications of a cartel are identical to that of a monopoly. Such a statement would erroneously imply that a cartel is equivalent to a merger that results in a monopoly. Indeed, it is totally different to have one or more firms with market power as a result of competition on the merits (i.e., successful product or process innovation and/or exploitation of economies of scale), and firms with market power gained as a result of a conspiracy to impair and contravene free market competition. The subversion of the competitive process may result, among others, in the survival of productively less efficient firms in the market[21] or the existence of unexploited economies of scale. Moreover, it can result in less product variety, and thus freedom of choice, both for firms and consumers.

Taking the above into consideration, a starting point to describe the welfare implications of a cartel is the standard microeconomics textbook analysis of a monopoly.[22] To begin with, a cartel causes allocative inefficiency. The consumers that continue to purchase the cartel product see the margin between their maximum willingness to pay and the price they actually pay squeezed. As a consequence their welfare diminishes. Although transferred from consumers to cartel members, it is claimed that these resources should be considered as a deadweight welfare loss. The heart of the argument is that those resources are wasted by cartel members in rent seeking activities, which do not generate, either directly or indirectly, any value for society.[23] On the other hand, there are also consumers who stop purchasing the product because the collusive price is greater than their maximum willingness to pay. These consumers divert to other products to which they attribute a lower value. Thus, given that the prices cease to send the right signals to economic agents (consumers and firms), the market fails to allocate resources to their highest and best use (*allocative inefficiency*).

Moreover, the lack of competitive pressure, as an outcome of the formation of a cartel, ultimately results in organizational and/or managerial slack.[24] Protected from the competitive forces and having secured supra-

[21] Competition, among others, can be described as a selection process whereby only the most efficient firm(s) survive in the market against the less productive and efficient firms (Darwinian '*survival-of-the-fittest*'). For more on '*concepts of competition*' see Vickers [1995].

[22] For an elegant exposition of the welfare effects of market power see the trade-off model by Williamson [1968].

[23] These resources can be used by cartel members to secure or even to increase their market power. For instance, lobbying and bribing, detection avoidance activities, prosecution litigation, and developing (and maintaining) mechanisms to administer and monitor the compliance of cartel members to the collusive agreement.

[24] Adam Smith maintains that "*Monopoly ... is the greatest enemy of good management,*

normal profits, colluding firms may fail to produce at the lowest possible cost ('*x-inefficiency*').[25] Finally, firms may experience less pressure to improve their competitive position in the market by investing in new products and/or new and more advanced production processes. As a result, the dynamic efficiency may also be unfavorably affected by the existence of collusion.

2.1 Empirical estimation of cartels overcharges

The empirical assessment of the welfare effects of cartels exclusively focuses on the quantitative estimation of overcharges to consumers. It has to be emphasized that this method may not always lead to an accurate estimation of the total harm caused to society by cartels. If, for example, the demand is insensitive to price changes, then an increase in the price may lead to a transfer from consumers to cartel members, which from a social welfare point of view is not inefficient. Another remark is that the estimation of the overcharges is based on data from detected cartels. Thus, if the most successful cartels are those who remain undetected, then the empirical estimation may underrate the overcharges of the total population of cartels.

The relevant literature comprises of two different methodologies:[26] the first estimates the overcharge of each individual cartel; the second uses a meta-analysis[27] to estimate the average overcharge for various cartels in different time periods and across a range of geographical areas. Regardless of their differences, the existing studies conclude that many cartels were effective in achieving significant overcharges.[28] Clearly, some cartels were more

which can never be universally established but in consequence of the free and universal competition which forces every body to have recourse to it [i.e. good management] for the sake of self-defence". See Smith [1776], pp. 163-164.

[25] The term '*x-inefficiency*' has its origin to Leibenstein [1966]. Hicks [1935] vividly declared that "*the best of all monopoly profits is quiet life*".

[26] Although there are several studies that investigate and estimate the welfare loss of monopolies (for instance, see Harberger [1954], Schwartzman [1960], Worcester [1973], Kamerschen [1966] and Jenny and Weber [1983], Cowling and Mueller [1978]), the estimation of the corresponding welfare loss due to the existence of cartels is not as straightforward. This is mainly ascribed to the ignorance of the number of cartels that actually exist in markets. What could be potentially estimated empirically is the deadweight welfare loss caused by the detected cartels. This typically requires the estimation of the Hicksian demand functions.

[27] A *meta-analysis* is a statistical technique for combining the findings from independent studies.

[28] The differences of these papers are mainly the sample selection method, the approach that is used to estimate the overcharge, and the specification of the econometric model employed.

successful than others at raising prices.[29]

For instance, according to Connor [2001] US citizens would have paid \$65-134 million less in the absence of the notorious *Lysine cartel* (1992-1995). Connor and Lande [2008] also estimate the actual overcharge[30] of the *vitamins cartel* (1990-1999) to \$11.5 billion globally and \$3.6 billion for the US economy. For the *graphite electrode cartel* (1992-1997), the overcharge is estimated to 50% in the EU and 65% in the US.[31] Moreover, the overcharge for the *citric acid cartel* is estimated to 30%, both for US and globally, which corresponds to \$1.5 billion.[32]

Other studies focus on the estimation of overcharges in bid rigging auctions and other procurement contests. For instance, Porter and Zona [1999] estimate the overcharge in the procurement of milk to southwest Ohio schools to be, on average, 6.5%, however, in many areas the overcharges soar to 49%. Froeb et al. [1993] estimate the average overcharge paid by the US Defence Department for the procurement of frozen perch to be in the range of 23-30%. Kwoka [1999] estimates the undercharge[33] to the real estate auctions in Washington DC. to 32%. Similarly, Howard and Kaserman [2004] estimate the overcharge for the public procurements of sewer construction projects to be approximately 36%.

As has already been alluded to, the relevant literature encompasses numerous meta-analysis surveys. In one of his several studies, Connor [2005] uses a comprehensive sample, which includes around 1000 cartels, to estimate an average overcharge of 25%. The same study estimates the average overcharge for US to 19%, while for international cartels the average overcharge is significantly higher and amounts to 32%. Connor and Lande [2008] estimate the average overcharge to 27.8%, which corresponds to \$711 million, while the median[34] overcharge is estimated to 27%, which corresponds

[29] The empirical literature concentrates on the welfare effects of detected cartels. Apparently, there is a data selection bias, as we do not have information with regard to the non-detected cartels. Therefore, measuring the welfare effects of all existing cartels (detected and undetected) is a rather complex, if not impractical, task. This is a semantic difference between the empirical literature on cartels and mergers. Unlike cartels, potentially merged firms are obliged to notify to the antitrust authority their plans to merge, and, therefore, data for all proposed mergers exists (approved and blocked). This allows a more thorough estimation of the welfare effects of mergers, compared to cartels.

[30] The actual overcharge takes also into consideration the overcharge of other firms that supply the same product but do not participate in the cartel.

[31] OECD, Report, Hard Core Cartels, 2000, OECD, Report - Fighting Hard Core Cartels: Harm, Effective Sanctions and Leniency Programmes, 2002 and OECD, Hard Core Cartels – Recent progress and challenges ahead, 2003.

[32] OECD, Report, Hard Core Cartels, 2000.

[33] This is because bidders collude to lower, rather than to increase, their bids.

[34] In general, the statistical average can severely influenced by the existence of extreme

to $63.5 million. On an individual cartel level, the range of the overcharge is $0-14,256 million, while the overcharge as a percentage of the sales ranges from 0 to 79.5%. Similarly, Bolotova [2009] estimates the average overcharge for all cartels in the period 1770-2006 (legal, illegal, US and international) to 21.88%, while the median overcharge amounts to 20%. On an individual cartel level, the range of the overcharge is -5.3-81.8%.[35] By using a subsample of 157 modern international cartels in the period 1991-2005, covering more than 80 different markets, the same study estimates the overcharge to 27.81% and the median overcharge to 28%. The range of the overcharge on individual cartel level is 0-90.9%.

More recently, Boyer and Kotchoni [2011] conduct a refined meta-analysis and show that the overcharges are significantly lower than previously estimated in the literature. In particular, the authors estimate, after correcting biases in the estimation method and the publication source of data, an average overcharge of 17.5%, with median overcharge of 14.1%.[36]

2.1.1 Functioning of cartels

Before exploring the effects of leniency programmes, it may be worthwhile to analyze the microfoundations of cartels (i.e., comprehend how a cartel operates and what constraints, intrinsic or extrinsic, it copes with). For this the focus initially is to delineate the underlying rationale for firms' participation to cartels. Subsequently, the spotlight is turned to the factors that potentially facilitate or hamper cartels' sustainability.

According to economic theory, the restrictions that a cartel encounters boil down to two fundamental equations: the *participation constraint* and the *incentive compatibility constraint.* The former determines the incentives to form or to join a cartel. A profit maximizing firm will join a cartel if the (ex-

values (outliers) in the sample and the selection of a non-representative set of observations. When the distribution exhibits asymmetry, it is more appropriate to use a measure which is based on the median of the sample of observations. The median can estimate with greater accuracy the central tendency of the distribution rather than the average.

For the empirical estimation of cartel overcharges, the statistical average can be sometimes misleading, especially when there is a small number of cartels that were extremely successful in raising prices. That is why, by convention, both, the average and median, are calculated.

[35] Evidently, some cartels were not successful at setting positive overcharges for their products.

[36] For other empirical studies estimating cartels overcharges see, Werdem and Simon [1987], Griffin [1989], Cohen and Scheffman [1989], Gallo et al. [2000], Connor [2001], Posner [2001], Connor [2003], Werden [2003], Connor and Bolotova [2006], Levenstein and Suslow [2006], Connor and Lande [2008], Bolotova et al. [2007] and Miller and Connor [2010].

pected) benefits exceed the (expected) costs associated with its participation to the cartel. The benefit is the additional (supra-competitive) profits due to the coordinated behavior, while the expected cost is the fine that a firm has to pay in case of detection and conviction by an antitrust authority.[37] Noticeably, the level of the expected cost of the cartel, contrary to the expected benefit, is influenced by the level of the fine and the probability of detection; two policy instruments. Nonetheless, a cartel's sustainability in the long-run is precarious because of the innate temptation of its members to defect from the illegal agreement. This will be the case if the deviation profits exceed the loss entailed from the ensuing retaliatory measures by other cartel members and the concomitant deprivation of future supra-normal profits. The relationship between the compliance and non-compliance profits is encapsulated by the incentive compatibility constraint.

Correspondingly, the economic literature on collusion consists of two strands. The first deals with the procedures of cartel formation and examines cartel stability. It uses the static game theory approach, and thus by its very nature leaves unexplained why some cartels are more successful than others (i.e., last for a longer period of time). In other words, it concerns explicit rather than tacit collusion. Notably, this branch of the literature is closely related to the one on non-cooperative games of coalition formation with payoff externalities.[38] The second focuses on the enforcement of the collusive behavior. In particular, it uses the supergame-theoretic approach to explore the factors that reinforce or hinder the sustainability of cartels. Furthermore, it investigates the factors that facilitate the adoption of a commonly acceptable collusive equilibrium. Clearly, this literature concentrates on firms' incentive compatibility constraints, leaving unexplained the participation constraints.

2.1.2 Cartel Formation

As mentioned above, the heart of the literature on cartel formation is based around the stability of cartels.[39] A cartel is said to be stable if it is individually rational for every firm participating in the cartel to remain in the cartel (internal stability) and for every firm not participating in the cartel to

[37] Realistically, the cost of a cartel also takes into account the potential 1) private damages actions, 2) individual sanctions (e.g. risk of criminal proceedings, disqualification of directors, personal damages) and 3) reputational damages because of adverse publicity.

[38] See Bloch [1996, 2005] and Yi [1997].

[39] A crucial assumption of this literature is that cartels are sustained with binding agreements or enforceable contracts. This implicitly entails that collusive firms' conduct does not change when a defection occurs in the market.

remain outside the cartel (external stability).[40]

A central remark of this literature is that a cartel is basically a public good. A firm that decides to stay an outsider cannot be excluded from the positive externality that is generated by the coordinated conduct of cartel members.[41] The public good properties of a cartel give rise to a free-riding problem. Invariably, the opportunistic behaviour undermines a cartel's fragile stability. However, this line of argument disregards the effect on the equilibrium price, and consequently the impact on firms profits, after a change in firms membership of the cartel.

The process of cartel formation was originally analyzed by Selten [1973]. The main conclusion of the study is that under Cournot competition, the process of forming a cartel in a market that comprises of more than five firms is quite difficult and most probably will be futile. With more than five rivals, it becomes more advantageous to stay out of the cartel formed by others. This is because the position of an outsider becomes more attractive as the number of competitors increases.[42] More precisely, the numerical analysis by Selten [1973] demonstrates that if there are four or less rivals, then a cartel forms with certainty. If there are five, the probability that all five collude is 0.22. If there are more than five rivals, this probability drops to approximately 0.01.[43]

Contrary to Selten [1973], who considers the cartel as another firm in a Cournot-competition game, d'Aspremont et al. [1983] focus on the formation of a dominant cartel. A dominant cartel acts as a price leader, whereas all firms outside the cartel remain price-takers. In a model of collusive price leadership with increasing marginal cost, d'Aspremont et al. [1983] show that there is always a stable cartel, provided that a finite number of firms exists. Moreover, the authors show that the fraction of the firms that participate

[40] The concepts of internal and external stability were originally introduced by d'Aspremont et al. [1983].

[41] The intrinsic difficulty in convincing firms to form a cartel was originally pointed out by Stigler [1950, 1983] in a discussion of horizontal mergers. Stigler [1950] maintained that "*If there are relatively few firms in the industry, the major difficulty in forming a merger is that it is more profitable to be outside a merger that to be a participant. The outsider sells at the same price but at much larger output at which marginal cost equals price.*" Stigler [1950] p. 25. It is noteworthy to remark the resemblance between firms' incentives to merge and form a cartel. In both scenarios firms have similar incentives to free ride. Thus, in principle, the two literatures, on cartel formation and mergers, are alike.

[42] This does not imply that it is more difficult to enforce the collusive agreement if there are more rivals in the market. Indeed, in Selten's [1973] model there is no room for cheating since cartels appear as non-cooperative Nash equilibria with perfect and complete information.

[43] For a simplified exposition of Selten's [1973] model, see Phlips [1995], pp. 23-28.

in a stable cartel diminishes with the number of firms that are active in the market.[44] This is because, the smaller the size of the cartel (in relation to market), the poorer the effect of the marginal collusive firm on the equilibrium price. Similar conclusions apply when the strategic decision of firms is at the level of production (and not the price), as Donsimoni et al. [1986] show.

In another study, Donsimoni [1985] examines the effects of the existence of asymmetry in costs, assuming increasing marginal costs. The main result of the study is that heterogeneous stable cartels, i.e., cartels with different types of firms, are feasible. Stable cartels comprise of the most efficient firms, while the less efficient firms remain independent outsiders.

Shaffer [1995] demonstrates that when the strategic variable is the level of production, and when there is a Cournot fringe, the stable cartel comprises of 50% of the firms, regardless of the total number of firms in the market.[45] However, Escrihuela-Villar [2004] shows that when firms simultaneously make their strategic decisions, then 80% of them participate in the stable cartel.[46] The intuition is that a cartel member appropriates a higher share of collusive profits when only a small number of firms participate in the cartel. At the same time, joining the cartel is more appealing since outside cartel competition is fierce. Conversely, if the number of cartel participants is large, cartel profits are distributed among many firms, and, therefore, abandoning the cartel becomes more tempting. The profits of the firms that remain outside the cartel are relatively high compared to cartel profits.

The role of private information on firms' incentives to form a cartel is examined by Hviid [1992]. The author assumes that the cartel operates as a quantity leader and focuses the analysis on an involuntary information transmission from the cartel to any outside firms. The information pertains

[44] The size of the market is determined by the number of active firms. Technically, this is due to the assumption that the demand function is homogeneous of degree one with respect to the number of firms in the market. This implies that i) the equilibrium price depends on the number of firms in the market and ii) the profits per firm, when the price is chosen optimally, depend on the fraction of firms in the dominant cartel. As d'Aspremont et al. [1983] admits it remains an open question whether this conclusion holds with more general demand and cost functions.

[45] This confirms previous findings by Selten [1973], d'Aspremont et al. [1983] and Donsimoni et al. [1986]. Moreover, it resembles to Kamien and Zang [1990] who show that by prohibiting mergers that result in firms acquiring more than 50% of the the firms in the market partial, monopolization is completely eliminated.

[46] Note the similarity of this finding with the *merger paradox* result by Salant et al. [1983]. The authors show that a merger (that entails no efficiency gains) between two or more firms in a Cournot oligopoly with homogeneous good is not profitable unless it accounts for more that 80% of the total number of firms in the market.

to a common random parameter in the demand function. The main finding of the paper is that private information dampens firms' incentives to form a cartel. Apart from the existing free-riding effect, Hviid [1992] shows that outsiders also benefit from the correct inference of the cartel's output choice.

A significant contribution to the literature focusing more generally on coalition formation procedures is made by Bloch [1996, 2002]. The author illustrates the difference between simultaneous and sequential games of coalition formation, and games of open and exclusive memberships. In simultaneous procedures, the formation of a cartel is not feasible because firms have an incentive to free-ride on a cartel that is formed by other firms. Contrarily, in sequential move games the formation of a (partial) cartel is feasible because of the ability of the firms, and, in particular, those firms that move first, to credibly commit to stay out of the cartel.[47] Moreover, Bloch [2002] investigates the prospect of signing bilateral market sharing agreements between firms, whereby firms commit not to enter each other's market territory.[48]

2.1.3 Cartel Sustainability

In spite of the absence of an explicit agreement, firms can circumvent the competitive pressures that squeeze their profits by recognizing the interdependence of their strategic choices. This idea originates form Chamberlin [1929, 1933] and it has been formally developed by Friedman [1971]. Friedman [1971] shows that collusion can be sustained if firms condition their conduct in the market on the history of their strategic interaction.[49] In particular, the author demonstrates that firms are able to maintain a collusive equilibrium by adopting grim trigger strategies. This type of strategy calls for an eternal reversion to the *stage game equilibrium* in case of deviation from the collusive equilibrium.[50] A weakness of these strategies is that they preclude the possibility to adapt the level of punishment, if a deviation from the collusive equilibrium occurs.[51] Abreu [1986, 1988] remarks

[47] The sequence of moves has a commitment value.

[48] For a selective survey on the major contributions of the literature on cartel formation see Bloch [2005].

[49] Essentially, the collusive outcome can be supported in equilibrium if firms are sufficiently patient (i.e., if the discount factor is sufficiently high).

[50] This is because trigger strategies set an upper bound, which is defined by the Nash Equilibrium of the stage game, to the severity of the punishment when a defection is detected. Another weakness of grim trigger strategies is that they are not *renegotiation-proof*. That is, it is in the interests of firms to negotiate again in order to restart collusion, depriving the grim trigger of credibility, and thus effectiveness. For more on *renegotiation-proof equilibria* in repeated games see Farrell and Maskin [1989] and van Damme [1989].

[51] For other significant studies characterizing the optimal penal codes see Lambson [1987, 1994, 1995] and Häckner [1996].

that if the payoff at the punishment phase is positive, then the severity of the punishment can be strengthened.[52] This would decrease the stream of post deviation profits, and, hence, facilitate the sustainability of the collusive equilibrium. Specifically, Abreu [1988] defines the concept of '*optimal penal codes*' as a particular trigger strategy that entails a punishment, which may lead firms to make losses for a number of periods (the '*stick*') in case of defection from the collusive equilibrium. The optimal penal code prescribes that firms will return to the collusive equilibrium (the '*carrot*') provided that all of them participate in the punishment phase for a given number of time periods; otherwise, firms will remain in the punishment phase.

The above suggests that an essential condition for the success of tacit collusion is repeated interaction of firms in a market. Without repeated interaction, firms will be confronted with a Prisoners' Dilemma situation; although all of them can make higher profits by coordinating their actions, each of them can expropriate more by unilaterally diverging from the collusive equilibrium. On the contrary, with repeated interaction, the firm that is tempted to renege from the collusive equilibrium, by imposing, for instance, a lower than the agreed price, acknowledges that its benefit from the deviation will be ephemeral if the other collusive firms are competent enough to trace and reciprocate such a behavior. Thus, another essential condition for the sustainability of collusion is the existence of sufficient transparency to enable or facilitate the detection of such deviations. Indeed, Stigler [1964] argues that the greatest challenge to the sustainability of a cartel is secret price cuts. The weakness or inability to monitor the compliance to the agreement may trigger or precipitate the occurrence of price wars among cartel members. According to Stigler [1964], price wars signal the collapse of the cartel.

However, Green and Porter [1984] argue that price wars do not always confirm Stigler's conclusion. In particular, Green and Porter [1984] maintain that occasional price wars are a property of the collusive equilibrium, even if no actual deviation occurs. Effectively, price wars are a mechanism that incentivises colluding firms to abstain from opportunistic behavior.

As already mentioned, a difficulty that firms face with tacit collusion is the coordination to a commonly acceptable equilibrium, given that there is a plethora of potential candidates.[53] The feasible set of equilibria consists of a set that ranges from the competitive to the monopoly equilibrium. With repeated interaction firms can enforce any of these equilibria, provided that they sufficiently discount future profits. Many theorems have been developed

[52] As we will see in section 6 the punishment strategies adopted by colluding firms significantly impact on the magnitude of the deterrence effects of leniency programmes.

[53] Tirole called this the '*embarrassment of riches*'. See Tirole [1988], p. 244.

in the literature, commonly known as '*Folk theorems*', that allow for the justification of the selection of specific collusive equilibria in infinitely repeated games.[54] In effect, Folk theorems provide an appropriate tool for the analysis of the sustainability mechanism of collusion.

The second strand of the economic literature on collusion focuses on the identification of factors that enables firms to coordinate and sustain their cooperation without necessarily resorting to an explicit agreement. Although the assumptions of the papers in the relevant literature differ, the underlying mechanism that drives their results is the same. The mechanism operates through i) the effect on firms' ability to coordinate to a commonly acceptable collusive equilibrium and ii) the costs and benefits that emanate from cartel defection. Among the factors that are considered to facilitate the sustainability of collusion are the following: small number of firms[55]; high market concentration rate[56]; high frequency of interaction[57]; multi-market interaction[58]; market transparency[59]; and information exchange[60]. On the other hand, factors that facilitate surpassing the problems of a cartel's sustainability include: barriers to entry[61]; cost asymmetries[62]; buyer power[63] and; asymmetric information[64]. The effects of restrictions in productive capacity of firms[65], asymmetries in the size and distribution of productive capacity of firms[66], product differentiation[67] and business cycles[68], are less clear-cut.

[54] For instance, see Friedman [1971], Aumann and Shapley [1976], Rubinstein [1979] and Fudenberg and Maskin [1986].

[55] Shapiro [1989].

[56] Bain [1956].

[57] Snyder [1996].

[58] Bernheim and Whinston [1990], Spagnolo [1999] and Scott [2008].

[59] Porter [1983], Green and Porter [1984] and Abreu [1986].

[60] Porter [1983], Farrell [1987], Kandori and Matsushima [1998], Compte [1998], Athey and Bagwell [2001] and Kühn [2001].

[61] Bain [1956], Modigliani [1958], Labini [1969], Tirole [1988], Neven [1989] and Wilson [1992] – for empirical research see Levenstein [1995], Clay and Troesken [2002] and Levenstein and Suslow [2006].

[62] Bain [1948], Rothschild [1999] and Miklós-Thal [2009].

[63] Stigler [1964] and Snyder [1996].

[64] Roberts [1985], Cramton and Palfrey [1990], Kihlstrom and Vives [1992], Athey and Bagwell [2001], Athey et al. [2004], Compte [1998], Kandori and Matsushima [1998] and Verboven [1998].

[65] Brock and Scheinkman [1985] and Davidson and Deneckere [1990].

[66] Compte et al. [2002].

[67] Deneckere [1983], Chang [1991], Ross [1992], Raith [1996] and Symeonidis [2002].

[68] Rotemberg and Saloner [1986], Haltiwanger and Harrington [1991], Staiger and Wolak [1992] and Bagwell and Staiger [1997].

2.2 Asymmetry of information between antitrust authorities and colluding firms

The possibility of firms' engagement in illegal collusive activities brings to the surface an acute information problem. This emanates from the existence of asymmetric information between an antitrust authority and the firms that participate in a cartel. Rational firms, fully conscious of the illegality of collusive agreements, adopt a '*code of silence*' to conceal their unlawful conduct, and remain undetected by antitrust authorities. Consequently, the greatest challenge for an antitrust authority is to gather or elicit incriminating evidence to expose and eventually convict illegal cartels and their members. The hunt for evidence may not always be fruitful as collusive firms may manipulate or even destroy the evidence. Additionally, market investigations and appeal processes are costly for an antitrust authority, as they require the commitment of resources. More importantly, even though an antitrust authority detects such evidence it will nevertheless be hard to convict the cartel because of the high standard of evidentiary proof required by courts.

2.2.1 Enforcement policy instruments

The portfolio of standard policy instruments an antitrust authority has to combat illegal cartels comprise of i) market investigations and ii) fines for convicted cartels. These two instruments significantly impact on cartel deterrence, as they jointly determine the expected fine for a cartel. An increase, either in the magnitude of the fine or the probability of detection, suffices to alter the relationship between the expected costs and benefits emanating from the participation to a collusive agreement, as is reflected by the participation constraint. Moreover, by changing the balance of the relationship between deviation and compliance profits, as reflected by the incentive compatibility constraints, such changes may instigate the collapse of existing cartels.

The efficacy of such an enforcement policy hinges on the size of the maximum feasible fine[69] and the resources available to the antitrust authority.

[69] Becker was the first to explicitly argue that fines are bounded by the offender's wealth. See Becker [1968], pp. 183-185 and pp. 191-193. In a similar vein, antitrust fines are also argued to be bounded. The argument is twofold. Firstly, high fines may jeopardize a firm's financial vigor, and even its market survival, contrary to the ultimate objectives of antitrust policy. Thus, antitrust fines are bounded to avoid bankruptcy. Secondly, the principle of proportionality applies. According to this principle the severity of the fine must be correlated to the magnitude of the harm caused by the offender. In other words, the punishment should fit the crime. Taking also into account the possibility of legal errors, which implies that fines are not socially costless, the application of this principle

The latter constrains the number of market investigations and, hence, the probability of detection. Ideally, the probability of detection would be equal to 1, assuming that all cartels retard competition and produce malign welfare effects.[70] However, given the scarce resources an antitrust authority has at its disposal, the actual probability of detection is significantly less than this level.[71] Therefore, the cap on the fine and the limited resources of the antitrust authority condition the efficiency of the enforcement policy.

The boundaries to the effectiveness of the enforcement policy may be relaxed with the advent of an information revelation mechanism, such as a leniency programme. Essentially, leniency programmes are mechanisms that incentivise collusive firms and/or individuals to come forward and denounce the cartel. A properly designed leniency programme can break the walls of secrecy that surround the cartel and its members from inside. The concession may range from a reduction in the fine to the grant of a positive reward/bounty to the whistle-blower(s).

A leniency programme has many constituent elements. Specifically, it stipulates, among other things, the number of possible beneficiaries of leniency, the stage of the investigation procedure at which leniency is offered (before or after the investigation), whether a ringleader or a repeated offender is qualified to apply for leniency, the size of the fine reduction and the impact of the quantity and quality of information, and the sequence with which such information is provided. The transparency and confidentiality are two other influential elements for the effectiveness of leniency programmes. All these elements are crucial for the design of leniency programmes achieving the optimal level of cartel deterrence.[72]

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also restricts the level of the fine. For a recent discussion on the optimal antitrust fines, see Buccirossi and Spagnolo [2007] and Houba et al. [2011].

[70] We deliberately neglect the possibility of welfare enhancing effects as this is not the focus of this survey paper.

[71] Bryant and Eckard [1991] estimate the probability of detection to be at most in the range of 13-17% for the US using data from 1961-1988. A similar study by Combe et al. [2008] estimate the probability of detection at EU level to be in the range of 12.9-13.3% using data from 1969-2007. A more recent study by Ormosi [2011] estimates that cartel detection rate in the EU has stayed below 20% for most of the analyzed period (1985-2005), and it frequently dropped under 10%.

[72] Hammond distinguishes three essential cornerstones of an effective Leniency Program: 1) severe sanctions for those firms participating in cartels, 2) increased fear of detection by antitrust authorities for non-reporting firms and, 3) transparent leniency programme so that firms can predict with a high degree of certainty how they will be treated if they apply for leniency, and what the consequences will be if they do not. See, Scott Hammond, Director of Criminal Enforcement, Antitrust Division, US Department of Justice, ICN Workshop on Leniency Programmes, 22-23/11/2004, Sydney, Australia.

A leniency programme can have both deterrence and desistance effects. It may enable, respectively, the deterrence of cartels that would otherwise have formed, and the detection of existing cartels that would otherwise have gone undetected. As a result of the introduction of a leniency programme, the efficacy of antitrust enforcement may improve. To fully comprehend the underlying working mechanisms of such programs, we first need to identify the costs and benefits emanating from a leniency application. The determinative benefit for a cartel member that applies for leniency is its privileged treatment with regard to the level of the fine it will pay in case of conviction by the antitrust authority. This benefit is a function of the avoided fine, the probability of successful prosecution of the cartel, once detected, and the probability with which the whistle-blower actually receives leniency. On the other hand, the cost for a firm that actively collaborates with an antitrust authority, on the basis of a leniency programme, is represented by the collusive supra-normal profits that the firm forgoes due to the collapse of the cartel, and the likely retaliation measures by its ex partners.

The next subsection briefly cites the main effects of leniency programmes, both on cartel stability and cartel sustainability. A more systematic exposition of these issues is reserved for Section 6.

2.3 Deterrence effects of leniency programmes

To begin with, a leniency programme may have direct deterrence effects.[73] Theoretically, it is possible that a leniency programme achieves the first best of complete deterrence of cartels without the antitrust authority incurring any cost for active investigations.[74] Spagnolo [2004] proves that if only the first self-reporting firm is eligible for leniency, and if this firm is rewarded with the fines imposed on all other cartel members, then the efficacy of the enforcement policy would reach its maximum at zero cost.[75] A similar finding is uncovered by Buccirossi and Spagnolo [2006]. Moreover, Motchenkova [2004] demonstrates that when fines are proportional to the accumulated

[73] The deterrence effects of Leniency Programs are explored in more details in Section 6.

[74] Notably, this theoretical result contradicts the results of a recent experimental study by Bigoni et al. [2012]. These authors show that deterrence is enhanced when positive rewards are not available to self-reporting (experimental) subjects.

[75] Houba et al. [2011] confirm this result in a more general setting without imposing any restrictions on functional forms and the mode of competition between firms. The main novelty of this paper is that it relaxes the assumption regarding the protection of a deviator form the punishment by other cartel members.

collusive profits and the application procedure for obtaining leniency is confidential (firms cannot instantaneously react to the actions of their rivals), then complete deterrence is feasible, provided that the fine is sufficiently high.[76]

The deterrence power of the enforcement policy may also amplified by a leniency programme that offers bounties to individual self-reporters. As shown by Aubert et al. [2006], when such a leniency programme is available, firms must pay higher compensations to their employees in order to preserve their silence. Markedly, the higher the compensation, the higher the cost of collusion. Therefore, cartel deterrence may be fostered by the introduction of a leniency programme that is available to individuals.

A leniency programme may also impact on cartel deterrence indirectly. The collapse of cartels' secrecy walls from inside and the ensuing desistance of cartels may relieve prosecution costs and accelerate the judicial procedures. As demonstrated by Motta and Polo [2003], the released resources of the antitrust authority could be used to enhance cartel detection rates, and thereby leniency programmes can indirectly increase cartel deterrence.

2.4 Desistance effects of leniency programmes

A leniency programme may also trigger the collapse of existing cartels by undermining their (internal) stability.[77] In particular, as shown by Spagnolo [2004] and Harrington [2008], a leniency programme may increase the payoff of cheating in the market by protecting the defector from antitrust fines. This will be the case if a firm simultaneously defects in the market and applies for leniency. This impacts on firms' incentive compatibility constraints, and, thus, cartels' sustainability. Even if a firm is unwilling to blow the whistle, there is a genuine danger that some other firm will. This potential undermines the fragile trust among cartel members. Effectively, a leniency programme thrusts firms into a Prisoners' dilemma through a '*race to the court*' which ultimately squeezes the expected profits from collusion. Thus, by undermining the already feeble trust among firms, a leniency programme may increase the *riskiness of collusion*. However, this effect transpires only when the whistle-blowers are offered advantageously discriminate treatment with regard to the rate of fine reduction.[78] A similar result exists for pro-

[76] However, contrary to Spagnolo [2004], the optimal rate of law enforcement is positive. In other words, to achieve the complete deterrence of cartels, the antitrust authority must credibly commit some of its resources to market investigations.

[77] The desistance effects of leniency programmes are thoroughly explored in Section 6.

[78] An extreme example is when only the first self-reporting firm is eligible to receive lenient treatment.

grams offering leniency to individuals. In effect, with the introduction of such programs, firms are not only in a race with their rivals but also in a race with their culpable employees.

Leniency programmes may also vitiate the punishment mechanisms that firms use to curb opportunism and secure the conformity to the agreement. As shown by Spagnolo [2004], a leniency programme may increase the future fines and reduce the expected profits from continuing the participation to the cartel.[79]

Despite their benefits, the economic literature highlights that only properly and carefully designed leniency programmes can fruitfully induce self-reporting. Indeed, the relevant literature underscores that poorly designed leniency programmes may result in counterproductive side effects. For instance, wrongly designed leniency programmes may exacerbate collusive behaviour or provoke cartel formation. As Motta and Polo [2003] argue, leniency programmes essentially decrease the expected cost of cartels, and thereby can, contrary to their principal objection, cultivate cartel formation. Moreover, Ellis and Wislon [2003] and Motchenkova and Leliefeld [2010] maintain that leniency programmes may provide collusive firms with a disciplining device to thwart defections from the illegal agreement. Similarly, Buccirossi and Spagnolo [2006] demonstrate that leniency programmes may alleviate the inherent hold-up problems of some types of previously infeasible collusive arrangements. Aubert et al. [2006] also show that leniency programmes may prevent benign cooperation between firms (i.e., legitimate joint ventures) or detrimentally affect the internal structure of colluding firms.

The next section presents a systematic review of the literature on the optimal enforcement of (generic) law.

3 The Economics of the Optimal Enforcement of Law

The economic literature on the optimal law enforcement begins with the seminal paper by Becker [1968].[80] Becker's pioneering ideas have been the locomotive for the development of rigorous economic analysis of crime and

[79] This will be the case if i) the collusive agreement is sustained by two phase stick and carrot punishment strategies à la Abreu [1986, 1988] and ii) a recidivist is severely punished.

[80] For a systematic and meticulous survey of this literature see Polinsky and Shavell [2000] and Garoupa [1997].

punishment. The investigation of criminal behavior was, until then, dominated by sociologists and psychologists who argued that crime reflects social environment problems (e.g., problematic families, social inequality, class warfare, subculture and social oppression), and that criminals were helpless '*victims*'. Crime was also linked to biological characteristics (e.g. natural-born criminals, heredity, organic disorders) or to psychopathological characteristics (e.g., mental illness, distress, dysfunction). However, none of these *theories* managed to adequately interpret the causes of criminal behavior, nor had any such theory focused upon the premise that all individuals are potential criminals.

Becker's work is built on the assumption that individuals are rational expected utility maximizers. As such, their decision to engage in criminal activities is based on the comparison between the expected net returns from committing a crime, and the benefit derived from legitimate activities (the opportunity cost of crime). A public agency which implements and enforces law (enforcement agency) aims to minimize the social cost caused by crimes. The social cost of crimes involves both the harm caused to society by the illegal act and the enforcement costs. The latter includes all expenditures the agency makes for police and the courts. Prominently, these expenditures determine the probability of detection and conviction.[81] The law enforcement agency can choose the type of punishment (e.g. imprisonment or fines) as well as the severity of punishments.

In this framework, the optimal level of enforcement is attained when only those illegal acts for which the net gain that accrues to a violator is lower than the harm caused to society are prevented (inefficient crime).[82] Those criminal activities for which the individual benefit to the violator exceeds the loss caused to society should not be deterred (efficient crime). Thus, according to Becker's analysis only the socially inefficient crime must be deterred.[83]

Becker concludes that the least costly policy to enforce the law is to set the fine at its maximum feasible level[84] and to use the probability of apprehension as a complement to the fine. The idea is that the expected

[81] As we will see in Section 6, Motta and Polo [2003] discriminate the probability of detection from the probability of conviction. The rationale is that detection does not always guarantee conviction.

[82] This rule resembles to the contemplations of Beccaria [1986]. According to Beccaria, the main objective of law enforcement is to reduce the frequency of inefficient outlawed courses of action.

[83] This result is known in the literature as the '*Becker's rule*'.

[84] The maximum feasible fine is restricted by individuals' wealth so as to prevent bankruptcy.

fine must be at a level that optimally deters crime.[85] This conclusion is crucially grounded on two assumptions. The first is that an increase either in the fine or in the probability of apprehension increases the expected cost of criminal behavior. The second is that fines are costless transfers. Although the former assumption seems to be realistic, the latter is controversial because of the non-binding nature of the enforcement agency's decisions and the costs associated with administrative control (e.g. possibility of erroneous decisions).

In particular, Becker's assumption that fines are simple transfers from criminals to taxpayers (and thus the cost of collecting a fine is unrelated to its size) does not hold when violators: i) engage in socially costly detection avoidance activities (Malik [1990]), ii) have an aversion to risk (Polinsky and Shavell [1979]) and, iii) can commit crimes of different gradation of seriousness (Stigler [1970]). In those instances, the optimal fine may not be the maximum feasible fine.

Finally, Becker argues that fines are preferred to other types of punishment, such as imprisonment. Unlike fines, imprisonment is socially costly, since a prisoner suffers a utility loss. In addition, with imprisonment the government ultimately ends up spending[86], rather than gathering resources, in order to maintain correctional institutions and facilities. Besides, Becker argues that prisoners are unable to productively work during their time in prison; hence the diminished labor force represents an additional cost to society. Nevertheless, he maintains that if fines are not feasible, then the enforcement agency ought to resort to imprisonment to achieve the optimal level of crime deterrence.

Malik [1990] contests, and indeed invalidates, Becker's main thesis, namely, that the optimal fine must be set at its maximum feasible level. He argues that if individuals can potentially engage in activities that reduce the probability of detection (avoidance activities), then it will not be optimal to impose the maximum feasible fine. The underlying rationale is that a higher fine induces individuals to invest more resources into socially unproductive avoidance activities.[87] This implies that fines are not costless transfers, as

[85] In Becker's model the probability of detection serves as a '*price*' incentive that induces the quantity of offences '*supplied*' by individuals.

[86] Resources used for establishing and maintaining jails and other correctional facilities.

[87] A limitation in Malik's analysis is that it disregards the possibility of cross-effects between crime and avoidance. This is basically due to the assumption that individuals make a binary decision, namely, to commit an illegal act of a specific degree or not. Any changes in the magnitude of the punishment (fine or probability of detection) may affect an individual's decision to commit a crime but not the severity of the crime. Thus, a change in the level of the punishment gives rise to two direct effects: the deterrence effect and

assumed by Becker [1968]. In the light of this, the design of the optimal law enforcement policy, should serve, in contrast to Becker [1968], two conflicting goals; optimizing deterrence and minimizing avoidance activities.

In this context, Malik shows that the optimal fine is such that the marginal benefit of a higher fine in reducing the enforcement cost of deterrence is equal to the marginal cost of raising wasteful avoidance efforts. The optimal level of the fine is, in principle, below the maximum feasible fine. He also argues that the social costs associated with avoidance activities provide a rationale to screen individuals and impose fines that are type dependent (i.e., fines that depend on the private benefits accrued to individuals by their criminal activity). In effect, screening allows the enforcement agency to eliminate the avoidance activities of those individuals whose private gain exceed the harm caused to society by their illegal act, without deterring them from engaging in the illegal activity. On the contrary, without screening, the optimal enforcement policy may deter the occurrence of socially efficient criminal activities for which the private benefit to the violator exceeds the cost caused to society. Hence, the possibility of screening a violator's private benefit may enable the law enforcement agency to reduce the avoidance costs without sacrificing efficient deterrence.

Polinsky and Shavell [1979] discuss the importance of individuals' attitudes towards risk. The authors argue that when individuals are risk averse, the optimal fine may be well below the maximal fine.[88] This is because when an individual is risk averse, a higher fine imposes substantial risk-bearing costs which are not translated into extra revenue for the enforcement agency (or the state). Since violators dislike risk, the expected fine falls by an amount reflecting the risk premium (the disutility caused by imposing greater risk on risk-averse individuals). Importantly, the real social cost of fines increases

the avoidance effect. The deterrence effect emerges because an increase in the punishment increases the marginal cost of crime, and, thus, reduces crime. The avoidance effect emerges because an increase in the punishment implies a higher benefit from avoidance, and, thus, increases investment in avoidance. However, there is another indirect effect between crime and avoidance. A greater investment in avoidance reduces the marginal expected punishment, thereby inducing more crime. Similarly, a lower level of crime reduces the expected punishment, thereby decreasing the marginal benefit of avoidance. The complementarity between crime and avoidance is explored by Nussim and Tabbach [2009]. The authors show that increasing the punishment may result in more crime, contrary to Malik [1990].

[88] In the extreme case where the cost of investigation is sufficiently small, the optimal probability of detection converges to one. This is because the decrease in utility due to the risk of a fine is higher than the potential benefit from a lower probability of detection. In this case, the optimal level of the fine is equal to the benefit of wrongdoers from the law violation.

for risk-averse criminals as the fine increases.

Becker's remark that a higher fine implies a lower expected net utility to a potential offender is valid for single-act framework where each individual makes a binary decision, namely, whether to commit an illegal act or not. In a more realistic multi-act framework, where illegal activities can take on different graduations, higher fines may induce wrongdoers to switch to more harmful acts. The argument is that if the fine is unrelated to the severity of the crime, the marginal deterrence for more serious crimes could be very small or even negative. Therefore, a violator who is threatened with a uniform fine, regardless of the severity of the violation he commits, would have more incentives to substitute that crime for a more serious one, from which he obtains a higher benefit.[89] The marginal deterrence of less serious crimes is also distorted from higher fines. For instance, over-enforcement could emerge with the risk of judicial errors (e.g. prosecution of innocent individuals).[90] Taking into consideration the distortion to marginal deterrence, Stigler [1970] shows it is optimal to impose only moderate fines on less serious violations to maintain sufficient marginal incentives to deter more serious offenses. The condition for optimal marginal deterrence advocated by Stigler states that the marginal benefit of an illegal activity should be equal to the marginal expected fine to deter such an activity.

4 Enforcement of Antitrust Law

Building on the insights of Becker [1968] and Stigler [1970] that penalties should be sufficient to induce offenders to internalize the full social cost of their illegal actions, Landes [1983] lays the foundations for the economic analysis of antitrust enforcement. In particular, Landes develops the economic theory of the optimal antitrust penalties.

In a simple setting where detection of violations and enforcement of the law are perfect and costless, the optimally deterring penalty equals the net harm to persons other than the violator. In more realistic settings wherein the probabilities of detection and conviction are less than perfect, and enforcement costs are non-trivial, the optimal penalty equals the net harm (which includes the enforcement costs per case) multiplied by the inverse of the probability of a fine being effectively imposed (i.e., the product between the probability of detection and the probability of conviction).

[89] For instance, if robbery is punished as severely as murder, the robber might as well kill his victim to eliminate a witness.

[90] The costs of defense of innocent individuals, whether borne by themselves or the government, are part of the social costs of enforcement.

Notably, this rule allows for possible benefits that accrue form the offenses to third parties. More precisely, the net harm rule makes the offender internalize all costs and benefits of the violation. Accordingly, this rule implies that the offender commits only the '*efficient violations*', i.e., violations whose total benefits exceed the total costs.

Applied to the case of cartels, the benefits consist of the additional collusive profits, plus any cost saving and quality advancement as a result of the coordinated practice, net of any cost of enforcement. On the other hand, the harm consists of the consumer surplus transferred to firms in the form of overcharges plus the utility of the foregone consumption due to the higher price and the induced misallocation of scarce social resources, i.e., the deadweight loss.[91]

The theory of optimal penalties developed by Landes [1983] does not explore the effects of antitrust enforcement on firms' behavior (e.g. pricing decisions). The first systematic effort to study the impact of antitrust enforcement on cartels' pricing decisions is by Block et al. [1981]. The authors consider a static model of collusion where the antitrust policy instruments are endogenous. In particular, a higher price cost-margin raises more suspicions by customers or antitrust authorities, thus implying a higher probability of detection and conviction.[92] In addition, the penalty (fine plus damages) is also influenced by firms' pricing decisions since it is a multiple of collusive profits.[93] In this context, firms want to increase prices in order to achieve higher profits but avoid detection and conviction by an antitrust authority.

The analysis of the paper shows that the optimal cartel price is below the monopoly price and is decreasing in the penalty multiple and the intensity of antitrust enforcement.

The authors conduct an empirical test of the implications of the model in the market of white pan bread. The empirical results reveal that raising the Department of Justice's (DOJ) enforcement capacity or indicting a DOJ price-fixing complaint had the deterrent effect of contracting markups in the industry.

An implicit assumption made by Block et al. [1981] is that firms' price-

[91] The net harm rule fits the Chicago School view that the primary goal of antitrust laws is to maximize the total economic welfare, i.e., the sum of the economic welfare of both consumers and producers. Clearly, this rule gives equal weight to the welfare of antitrust violators and that of their victims.

[92] The authors find empirical support of this evidence in their study of the bread industry.

[93] This mainly reflects the US legal system wherein a price fixing conspiracy is subject to both criminal and civil sanctions. Civil sanctions such as treble damages are a multiple of markups.

cost margins are publicly known. This requires that the antitrust authority (or, in general, the enforcement agency) observes the collusive firms' cost functions. Besanko and Spulber [1989] relax this assumption and explore the optimal monitoring policy of an antitrust authority when firms' production costs are private information. In particular, the authors assume that cartels can be of two types: high marginal cost and low marginal cost.[94]

In this context, neither the antitrust authority nor the buyers (who lodge complaints to the antitrust authority) observe the cartel. Instead, they draw inferences from the observed price (and expected price-cost margins) and decide whether or not to pursue a case. What makes the problem interesting is that with incomplete information it is difficult to distinguish situations with high price due to high marginal costs from situations with high price due to collusion.

A crucial assumption of the paper is that the antitrust authority credibly commits to a set of instruments, i.e., fines and probability of investigation, that make the expected fine contingent on some observed signal, as for instance the market output. Given that the litigation procedure is costly, the antitrust authority may not wish to carry out its threat to prosecute cartels. Anticipating that they are not going to be prosecuted, firms would not change their behavior. Thus, the antitrust policy would not have any deterrence effects unless the antitrust authority credibly commits to prosecute cartels.

Besanko and Spulber [1989] show that, under full information, the fully competitive equilibrium can be costlessly achieved. Similar to Becker's logic, the optimal fine is the maximum feasible and the probability of detection is such that the expected fine equals the supra-normal profits accrued to a cartel. However, with asymmetric information the antitrust authority will always tolerate some collusion by low-cost firms (i.e., adopt a *laissez-faire* policy for slightly harmful price agreements) to economize on the costs of enforcement. Since the enforcement costs are decreasing in firms' production levels, the authority can allow '*little*' collusion to go unpunished. This would enable the antitrust authority to deter more serious cartels at a lower expected enforcement cost. Prominently, this result holds regardless of the level of enforcement costs. Finally, the authors show that the cartel's equilibrium price is decreasing in the fines, a result which is consistent with Block et al. [1981].

A common characteristic of the papers by Block et al. [1981] and Besanko

[94] Pénard and Souam [1996] generalize this approach to the case of where the cost of production take a continuum of values. The results of the analysis are qualitatively consistent with the original paper.

and Spulber [1989] is that they explore the impact of antitrust enforcement on firms' pricing decisions in static settings. Several papers consider dynamic settings where the parameter time influences firms' pricing behaviour. The first attempt to integrate the probability of detection and fines into a repeated game of collusion is put forward by Cyrenne [1999]. The author considers an antitrust enforcement policy which focuses on significant price changes in an industry as a sorting mechanism for the allocation of resources devoted to monitoring collusion. In particular, the enforcement agency monitors the market price, and if it significantly falls for a number of periods and then reverts back to a higher price, it intervenes and investigates all firms for price fixing. To determine the effect of this enforcement strategy, the author considers the Green and Porter [1984] model where firms use a (finite reversion) trigger strategy as a punishment mechanism to sustain collusion. According to this strategy, firms initiate a price war if the price is below an agreed threshold – the trigger price - for a finite number of periods and then revert to the initially agreed price.[95]

In this context, prices can change even if antitrust enforcement is not included in the analysis, contrary to Block et al. [1981] where prices adjust only in responds to changes in the enforcement policy parameters (fine and probability of detection).

The author considers two versions of the Green and Porter [1984] model, i) quantity competition with homogeneous goods and ii) price competition with differentiated goods.

While the enforcement policy typically reduces the expected gains from collusion, it has no effect on the frequency of collusion unless fines are sufficiently large.[96] Importantly, undesirable effects may emerge if firms anticipate that the fines will not be sufficiently high.

In the first scenario, where firms produce homogeneous goods and compete in quantities, the enforcement policy may have a negative impact on the length of the punishment period. A defection from the agreement (increase in output) increases the probability of a price war, and, thus detection is more likely. This implies a higher punishment for a defection from the collusive agreement, since firms pay a fine in the case of detection, which allows firms to reduce the costs of their own punishment mechanism by limiting the length of the reversion period.

[95] However, in Cyrenne [1999] firms observe the market price and can monitor rivals' sales. Unlike Green and Porter [1984], the market price is determined by industry output and an additive stochastic component.

[96] When fines are not sufficiently high, the choice of collusive output or price is unaffected since the antitrust policy does not influence the probability that an unexpected price fall is realized.

In the second scenario, where firms produce differentiated goods and compete in prices, the analysis shows that, for given trigger quantity and length of the reversion period, the enforcement policy allows firms to charge a higher collusive price than would be sustainable otherwise.

Another crucial assumption of the paper by Block et al. [1981] is that the probability of detection and the penalty depend on the price levels. In a dynamic setting, this assumption leads to a counterfactual result, namely, that there is a radical price increase when the cartel forms and then the price declines. Intuitively, a higher price in the current period increases current profits, but lowers the future payoff by both increasing the probability of detection and the penalty. Since the probability of detection and the penalty are both increasing in price, colluding firms steadily lower their prices over time to make detection less likely.

The impact of antitrust enforcement on a cartel's pricing dynamics is explored by Harrington [2005]. The author assumes that the probability of detection depends on price changes, rather than on price levels. In particular, large price movements raise more concerns to buyers and antitrust authorities about collusion, implying a higher probability of detection.

In this context, the cartel gradually raises its price to the steady-state level which is less than the monopoly price. The steady-state price is set to equate the incremental profit with the expected present value of the marginal rise in damages due to a higher price.[97] Notably, the steady-state price is decreasing in the damage multiple and the probability of detection while it is independent of the level of fixed fines. The latter implies that if fines are the only penalty, so that the penalty is independent of the price path, the steady-state price equals the monopoly price. In this case, antitrust enforcement does not influence firms' pricing decisions.[98] Finally, the author shows that when the damage multiple increases, the steady state price is reduced. This is because an increase in the damage multiple increases the cost of detection for the cartel, and, thus, firms lower their prices to decrease the probability of detection.

An implicit assumption in Harrington [2005] is that firms' incentive com-

[97] Harrington [2005] assumes that the punishment in case of detection comprises of a (fixed) fine and a multiple of the damages instigated by the cartel (historical and current). The latter depend on the cartel's price path contrary to Block et al. [1981] where damages depend only on the price level. This difference is due to the static nature of the model by Block et al. [1981]. A similar assumption is made by Harrington [2004].

[98] This result is known in the literature as the 'neutrality' of antitrust enforcement. A similar result has been shown by Block et al. [1981] when the probability of detection is insensitive to price.

patibility constraints are not binding. In another paper, Harrington [2004] investigates the role of antitrust policy in destabilizing the internal stability of cartels. The analysis shows that two qualitatively different cartel price paths may develop depending on the parameter values. One is qualitatively the same as in Harrington [2005] - the cartel gradually increases its price converging in the long-run to a steady-state level. The second type of price path has the cartel gradually increase its price, but then the price declines down to the steady-state. Even though reducing the collusive price shrink profits, and cannot make detection less likely (since the probability of detection depends on price changes), a price decline is essential to discourage defections from the collusive agreement. Moreover, the author shows that the risk of detection and penalties may deter a firm from defecting, anticipating that a price war may spark suspicions about collusion. Thus, antitrust enforcement can loosen firms' incentive compatibility constraints and have preserve effects on cartels' pricing.

Motchenkova and Kort [2006] explore the deterrence power of two distinct penalty structures for antitrust law violations: fixed and proportional. The latter penalty scheme takes into account all accumulated illegal gains to the violating firm(s). An implicit assumption of the study is that the antitrust authority can perfectly observe the accumulated rents from the antitrust law violation. The authors focus their attention to illegal price-fixing agreements. Using a dynamic optimal control model wherein a cartel maximizes its discounted expected payoff in the presence of antitrust enforcement, the paper shows that the proportional penalty scheme is more effective in achieving complete deterrence. Although complete deterrence is feasible with fixed fines, the level of the fixed penalty that attains complete deterrence is too high and leads to bankruptcy of the fines participating in the cartel. The proportional penalty scheme is more appropriate than the fixed penalty since it ensures complete deterrence of cartels in the long-run, even when the penalty is moderate. Moreover, the analysis reveals that cartel deterrence is achieved sooner with a combination of high probability of detection and more severe penalty. Finally, when the penalty is already high, then a further increase in the severity of the punishment is less efficient than the policy that increases the probability of detection.

5 Self-Reporting Schemes

The literature on self-reporting schemes for generic crimes is divided into two ramifications. One studies the effects of self-reporting schemes offered to

single individuals who commit a single illegal act. The other one, studies the effects of self-reporting schemes offered to a group of individuals who jointly commit a crime (organized crime). We survey the two subdivisions of the literature below.

5.1 Crimes committed by individuals

Kaplow and Shavell [1994] and Malik [1993] are the first to investigate the effects of self-reporting schemes on the optimal design of law enforcement.

Kaplow and Shavell [1994] show that if self-reporting individuals pay lower fines, then the social costs of law enforcement diminish. . The crux of their argument is that if the fine for those who self-report is infinitesimally smaller than the expected fine without self-reporting, while the fine for those detected is the maximum feasible, then all (risk-neutral) violators will self-report. Although deterrence is unaffected, given that the fine for self-reporting is slightly lower than the one without self-reporting, the enforcement costs are lower. This is because only those individuals who have not reported must be monitored. The authors maintain that the optimum enforcement policy is such that all individuals who commit an illegal act self-report. Nevertheless, the *first best* (complete and costless deterrence of illegal acts) is infeasible as the enforcement agency has to credibly commit itself to costly monitoring. Otherwise, no individual will have any incentives to self-report.[99]

Kaplow and Shavell [1994] develop various extensions to their basic model. Specifically, they show that if there is an administrative cost associated with fines, then self-reporting is beneficial only if that cost is sufficiently higher than the monitoring cost. The reason is that in a self-reporting regime administrative costs are borne with certainty, while in a regime without self-reporting these costs are borne only with the probability of apprehension. Furthermore, the authors show that if the monitoring technology is imperfect, that is, if there is a positive probability of *Type I* or *Type II errors*[100] transpiring, then the cost savings from self-reporting are greater than those estimated in the basic model. The underlying reasoning is that in the presence of imperfect monitoring technology, the frequency of violations is, *ceteris*

[99] Spagnolo [2004] is the first to show that the *first best*, that is complete and costless deterrence, is feasible. However, the framework of his study is different from that of Kaplow and Shavell [1994]. The latter authors examine individual violations, while Spagnolo [2004] studies violations by a group of individuals.

[100] Type I errors occur when the enforcement agency fails to punish/convict a guilty party (also known as '*false positives*'). Type II errors occur when the enforcement agency punish/convicts an innocent party (also known as '*false negatives*').

paribus, higher (as with some probability complying with the law is pointless).[101]

Another beneficial effect that derives from a self-reporting scheme is the provision of insurance to risk-averse individuals. Thus, in a self-reporting regime, risk cost is reduced since (risk-averse) individuals who self-report pay a certain amount rather than uncertain (expected) fines.

In another extension to their basic model, Kaplow and Shavell [1994] investigate the effects of imprisonment as a punishment for those individuals who do not self-report. Although imprisonment is costly (as suggested by Becker [1968]), Kaplow and Shavell [1994] show that the benefits stemming from a self-reporting regime are extensive. This is because all violators self-report at the equilibrium, and thus the imposition of imprisonment obviates. However, this result holds as long as the enforcement agency credibly commits to put in jail those violators who do not self-report. This conclusion is relevant whenever imprisonment is an optimal punishment when a self-reporting scheme is not available. Nevertheless, as Becker [1968] argues, even if imprisonment is not an optimal punishment, the threat of imprisonment, as an ex-post sanction for those who fail to self-report their illegal acts, always augments the advantages of self-reporting schemes. The intuition is that a given level of deterrence (i.e., a given level of *ex-ante* sanction) can be attained at a lower cost with a lower probability of detection. Only the violators that falsely report face a greater ex-post sanction. Importantly, since the ex-post sanctions are never actually imposed, the social costs of imprisonment are evaded.

In a similar vein, Malik [1993] explores the effects of self-reporting when fines are subject to administrative control. This implies that fines, contrary to Becker [1968], are not costless transfers.[102] In particular, the author analyzes the effects of self-reporting in a context of regulation of stochastic environmental pollution where the privately known effort level of a firm affects the probability of an environmental standard violation. Within this context, the goal of the regulatory authority is to design a policy that elicits

[101] For a discussion of the effects of Type I and Type II errors on the enforcement of competition law see Schinkel and Tuinstra [2006]. The authors conclude that an increase in the enforcement errors exacerbate antitrust law violations. The reasoning is twofold. Firstly, the probability of detection drops, leading to lower expected fines for firms. Secondly, the risk of being fined increases (because of the probability of an unjust punishment), inducing firms to collude as a '*precautionary*' measure.

[102] The analogy between environmental pollution and cartels is limited and vague, if it exists at all. Nevetheless, Malik's [1993] assumption that fines are not costless seems to be more realistic for the analysis of antitrust policy. This is because antitrust authorities' decisions are also subject to costly judicial review.

a truthful self-reporting of firms' pollution levels. The portfolio of policy tools of the regulatory authority comprises of: i) random audits in order to verify each firm's report, ii) penalties for generating pollution and iii) fines for submitting dishonest reports.

The main result of the study is that self-reporting does not necessarily reduce regulatory costs. Therefore, a policy that does not require firms to self-report may be preferred to one that does. This is because with a self-reporting scheme available, firms need to be audited less often and punished more often than without self-reporting. Whether self-reporting reduces or not the regulatory and social costs depends on the relative magnitude of the costs pertinent to auditing and fining. Malik concludes that self-reporting is more likely to reduce (increase) the regulatory and social costs when a) the audit costs are high (low), b) the maximum feasible fine is low (high), c) the accuracy of the monitoring technology is low (high) and, d) the desired effort level by the firm is high (low). Finally, he argues that an improvement in the accuracy of the regulator's monitoring technology is socially less valuable when a self-reporting scheme is available to polluting firms.

Innes [1999] identifies additional benefits that emanate from self-reporting schemes, namely, introducing and allowing the possibility of the early prevention of damages. Motivated by environmental law, the author develops a model wherein firms engage in activities that may cause socially costly accidents. In this context, each firm exerts some accident prevention effort to reduce the accident rate. Accidents do not cause fixed and immutable harm, but rather harm that can be reduced ex-post if firms engage in costly post-accident remediation activities. Innes assumes that a firm is eligible for leniency provided that it engages in remediation activities that (partially) remedy the damage caused by the accident.[103]

The author shows that by increasing the frequency of remediation rate, a self-reporting scheme enhances the ex-post benefits of remediation. While non-reporting firms engage in costly remediation activities only when they are caught by the enforcement agency, self-reporting firms always engage in efficient remediation (before or after the accident occurs). Another result of the paper is that a self-reporting scheme allows the enforcement agency to costlessly impose stiffer fines to non-reporters. Thus, a lower effort is required

[103]It is worth noting that there is no such a requirement for obtaining leniency for antitrust law violations. A colluding firm is eligible for obtaining leniency as long as it terminates its participation to the cartel, at the latest at the time it lodges a leniency application, and actively cooperates with the antitrust authority. Moreover, leniency programmes in antitrust do not require ex-post remediation actions by self-reporting firms. However, firms can be held liable to private damage claims.

by the enforcement agency to achieve a target level of deterrence. Innes' analysis shows that in a regime without self-reporting the optimal fine for an accident may be set below the maximum feasible level, contrary to Becker's argument. If remediation is possible, then an increase in the probability of detection not only increases the frequency of accident detection, but it also mitigates the harm caused by the accident through a socially valuable remediation. This implies that the probability of detection and the fine are no longer substitute policy instruments.

By comparing the two regimes, with and without self-reporting, Innes [1999] infers that the optimal fine in the setting where self-reporting is feasible is lower than the one without self-reporting. The rationale is that self-reporting firms must be incentivise to undertake precautionary measures (effort) to prevent the accident.

One common prediction of the papers discussed above is that at the equilibrium all violators self-report. Nonetheless, this theoretical result is inconsistent with empirical observations. The discrepancy between theory predictions and empirical facts is the primary motivation for a new study by Innes [2000]. By segregating all other advantages of self-reporting schemes (as indicated by Kaplow and Shavell [1994], Malik [1993] and Innes [1999]), Innes [2000] suggests that one possible explanation for the fact that law enforcement agencies sometimes detect non-reporters is the existence of heterogeneity in violators' likelihood of apprehension. The study shows that at the optimum enforcement policy only those violators with high probability of apprehension, who would be over-penalized under a regime without self-reporting, self-report. Those individuals pay a fine equal to the harm they cause by their illegal acts. However, Innes shows that those violators who do not self-report continue to be under-penalized. Thus, he concludes that self-reporting can provide a screening mechanism that enables the enforcement agency to tailor the fines based on individuals' heterogeneity. The introduction of a self-reporting scheme may thus foster the efficacy of the enforcement policy.

Building on Malik [1993], Innes [2001] explores the impact of self-reporting schemes on detection avoidance activities. In this study, Innes identifies two advantages of self-reporting, those being the savings achieved both in avoidance and, enforcement costs. The main result of the analysis is that with self-reporting there is no need to engage in socially inefficient investments in avoidance activities. By setting the fine for self-reporting equal to the average fine that the violators would otherwise face, including the optimal avoidance cost, the enforcement agency can induce self-reporting without

dampening individuals' incentives to avoid engaging in illegal acts. The additional benefit from self-reporting is that those individuals who self-report do not engage in avoidance activities and, therefore, the costs related to these activities are economized. Moreover, by deterring avoidance, self-reporting allows the enforcement agency to thwart violations with a lower enforcement effort. This is achieved by raising the non-reporting fines to the maximum feasible level. Therefore, Innes [2001] concludes that at the optimal policy, the same benefits identified by Becker [1968] without the additional costs identified by Malik [1990] could be attained.

The introduction of *ex-ante* asymmetric information, as studied by Innes [2001], was criticized by Feess and Heesen [2002]. These authors suggest that, although *ex-ante* asymmetric information allows explaining partial self-reporting, it does not account for the main drawback of self-reporting schemes, which is that they, *ceteris paribus*, sharpen the incentives to violate the law.

The authors consider a scenario wherein each violator receives a private signal about the individual probability of apprehension, after the violation is committed. Technically, this implies that the decisions related to the violation and self-reporting are made on different information sets, contrary to Innes [2001] who assumes that individuals' probabilities of apprehension are ex-ante heterogeneous. The distinguishing feature of ex-post asymmetric information is that it creates an *option value* for individuals which bolsters their incentives to violate the law. Nevertheless, Feess and Heesen [2002] show that the advantages of self-reporting dominate this undesirable effect.

More specifically, the authors show that when there is ex-post asymmetric information, the opportunity to self-report may provide those individuals that receive an unfavorable signal (i.e., those with high probability of detection) with an option value. If the enforcement agency's effort remains the same, as in the setting without self-reporting, then the option to self-report tends to increase the frequency of law violations. However, self-reporting violators need not be investigated, and, therefore, the enforcement agency may achieve a target level of deterrence at a lower cost. Thus, by taking into consideration this feature of self-reporting, the enforcement agency may coin a second best optimal enforcement policy. As a result, social welfare increases, even with the restriction that the violation rate must not exceed the one without a self-reporting scheme.[104]

[104]This *second best* solution entails 1) a higher monitoring effort because of value of the option to self-report and 2) a fine for self-reporting that is slightly below the expected fine for the violator with the highest detection probability.

5.2 Crimes committed by groups of individuals

The observation by Feess and Heesen [2002] that the introduction of self-reporting schemes sharpens, *ceteris paribus*, the ex-ante incentives of individuals to violate the law has stimulated the research on self-reporting schemes for groups of violators. A distinguishing feature of this stream of the literature is that the enforcement agency can exploit the strategic interdependence between violators in order to increase the expected fine for each violator. This is despite of the fact that the probability of apprehension diminishes. This contrasts to the single violator scenario where the expected fine with self-reporting cannot exceed the expected fine without self-reporting, since otherwise no individual would self-report.

One paper that investigates the deterrence effects of self-reporting schemes to groups of individuals that jointly act to commit an illegal act is by Feess and Walzl [2004]. Their analysis suggests that the adoption of self-reporting schemes improves the efficacy of the enforcement policy, in spite of the fact that violators behave cooperatively at the self-reporting stage. In particular, the authors show that if violators behave non-cooperatively at the self-reporting stage, the enforcement agency may induce them into a Prisoners' Dilemma situation. The agency can achieve this by setting the maximum feasible fine if all violators self-report and by granting full amnesty (i.e., the reduced fine is equal to zero) only to a single self-reporter. Although all group members can be better-off if they credibly commit that none of them will self-report, each of them has an incentive to unilaterally run to the court first and benefit from amnesty.[105] While not all crime is deterred, all violators self-report with the least enforcement cost given that the optimal probability of apprehension is (almost) zero. If, on the other hand, violators behave cooperatively at the self-reporting stage to minimize their joint expected fines[106], then, as in Kaplow and Shavell [1994], the optimal fine for each violator is equal to the expected fine that individuals are liable to pay in the setting without self-reporting. In this case, even if all violators self-report, the probability of apprehension is weakly higher than the one with non-cooperative behavior. This implies that the enforcement cost is higher with cooperative behavior.

In addition, Feess and Walzl [2004] explore the optimal enforcement policy when the enforcement agency has imperfect information about violators'

[105] This effect of self-reporting schemes is known in the literature as '*race to the courthouse*'.

[106] This is also the case in the paper by Motta and Polo [2003] discussed in the next section.

actions at the self-reporting stage, i.e., it is ignorant whether violators act cooperatively or non-cooperatively. The authors show that if individuals' cooperation probability is exogenous, the optimal self-reporting scheme is independent of the cooperative behavior rate. The optimal policy calls for a fine against a single self-reporter equal to the expected fine without self-reporting. Moreover, if all violators self-report, then the optimal policy calls for the maximal feasible fine, so that to induce violators into a Prisoners' Dilemma situation. The threat of being driven to a Prisoners' dilemma situation may, however, motivate accomplices to search for credible commitment devices to provoke cooperation. Thus, when the probability of cooperation is endogenously determined, the optimal policy offers fine reductions to all violators that non-cooperatively self-report. Given that the expected fine is increasing in the probability of conviction, and that higher fines induce a higher degree of cooperation, a non-cooperative self-reporter may pay a fine which is below the maximum feasible level. The rationale is to limit the cooperation rate of individuals at the self-reporting stage. Therefore, an endogenous rate of cooperation, as maintained by the authors, may explain the partial reduction to fines for all violators in case of simultaneous self-reporting.

A supplementary explanation of why all members of the group should be offered a fine discount is the existence of imperfect self-reporting technology. For instance, if self-reporting by a single violator does not necessarily imply the conviction of other group members. Thus, if violators retain evidence of different quality ex-post, i.e., after they commit the illegal act, then it will be optimal to induce full self-reporting by all group members and impose the maximum fines. This would force violators into a Prisoners' dilemma situation. The optimal fine in this case is lower than the maximum feasible fine. Furthermore, the fine is higher for the violator who has been more often convicted on the basis of his accomplices self-reporting. Finally, the authors show that the fine for each violator depends on how informative the evidence submitted by other group members is to the enforcement agency.

6 Leniency programmes in Antitrust

The literature reviewed in the previous section addresses the optimal level of enforcement in generic law. In this section, we survey the literature that explores the implications of self-reporting in antitrust law enforcement, where the centre of interest is firms rather than individuals. This ramification of the literature has proliferated over the last decade, after the pioneering papers of Motta and Polo [2003], and Spagnolo [2004]. It has to be emphasized, at the

outset, that at the heart of this literature is the exploration of the impact of leniency programmes on cartel desistance and cartel deterrence.

Motta and Polo [2003] are the first to study the impact of leniency programmes in antitrust policy.[107] The main research question of their paper is whether firms already under investigation should be eligible for leniency. Their study shows that a leniency programme has two effects on law enforcement. On the one hand, it may lower proceedings costs and lead to a temporary cessation of cartels (anti-collusive effect). On the other hand, it may exacerbate cartel activity as the expected cost of collusion decreases (*ex-ante* pro-collusive effect). The latter effect was also identified by Feess and Heesen [2002].

The main assumptions of the paper by Motta and Polo [2003] are the following: i) the antitrust authority has an exogenous fixed budget constraint that can be used either to detect or to convict cartel members; ii) the same lenient treatment is offered to all self-reporting firms regardless of the reporting order[108]; iii) a deviating firm can neither be convicted for taking part in a cartel nor can report its former partners; and iv) firms sustain collusive agreements by adopting grim trigger strategies. Assumptions ii and iii are less intuitive and are in odds with the leniency programmes implemented in various jurisdictions. In fact, antitrust authorities discriminate self-reporters depending on the self-reporting sequence, as well as on the quality of information that self-reporting firms reveal to the antitrust authority. Theoretically, the assumption of '*no fine differential*' among self-reporting firms relaxes firms' incentive compatibility constraints, and thus enhances cartel sustainability. In addition, an antitrust authority can in practice convict a deviating firm for taking part in a collapsed cartel. More importantly, a deviating firm has strong incentives to self-report its illegal conduct to the antitrust authority so as to pay a lower fine. Essentially, assumptions ii-iv of the paper, drain firms' incentives to spontaneously and non-cooperatively run to the antitrust authority to self-report. As we will see later, this is the main motivation of the paper by Spagnolo [2004].

The two major results of the paper are the following: i) leniency programmes are not unambiguously optimal and ii) it may be optimal to grant leniency to firms already under investigation if the antitrust authority has not yet obtained actionable evidence. With respect to the first result, the authors show that, in principle, it may not be optimal to introduce a leniency

[107] For an exellent survey of the literature (theoretical, empirical and experimental) on leniency and whistleblowers in antitrust, see Spagnolo [2008].

[108] For a convenient way to model asymmetric treatments to self-reporting firms, which depends on the sequence of self-reporting, see Houba et al. [2011].

programme if the antitrust authority's budget is sufficiently high, so that cartels could be deterred with a sufficiently high probability of detection without leniency. If, however, the antitrust authority has limited resources, a leniency programme may be an optimal ancillary policy instrument from a second best perspective. In this case, the introduction of a leniency programme may generate a Prisoners' dilemma situation at the conviction stage, which induces firms to (collectively) self-report. Taking into consideration the collective application for leniency and the fact that a leniency programme reduces the expected costs of the cartel, the authors demonstrate that the optimal enforcement policy should provide full amnesty (as in Feess and Walzl [2004]) to all self-reporting firms so as to increase the probability of conviction. The second result of the paper is rationalized on the basis that the probability of conviction radically increases once the antitrust authority prosecutes the cartel. Thus, the prospect of reduced fines becomes more appealing for a firm under investigation. Therefore, leniency programmes that are open to firms after the commencement of an investigation by the antitrust authority might play a pivotal role in the prosecution of cartels.

It is worth noting that the paper by Motta and Polo [2003] is a close mirror of Kaplow and Shavell [1994]. Both papers highlight two benefits of leniency programmes (or self-reporting schemes). On the one hand, help economize enforcement resources and, on the other hand, provide insurance to risk-averse individuals or firms (a leniency programme essentially provides a riskless alternative to a probabilistic conviction).

The paper by Spagnolo [2004] can be viewed as a complement to Motta and Polo [2003]. However, the two approaches crucially differ in their focus and results. The study by Spagnolo [2004] focuses on whether a leniency programme can induce spontaneous self-reporting by firms, contrary to Motta and Polo [2003] who focus their analysis on whether firms already under investigation should be eligible for leniency. Moreover, although Motta and Polo [2003] highlight the indirect effect of leniency programmes on deterrence by facilitating post-detection prosecution, Spagnolo [2004] emphasizes the direct effect on deterrence caused by the undermined trust among cartel members.

Another difference between the two papers is that in Motta and Polo [2003] the cost of enforcement is exogenous, while in Spagnolo [2004], it is a choice variable. Moreover, in Motta and Polo [2003] detection leads to conviction only with some probability, while in Spagnolo [2004] detection and conviction are identified with a single probability, as in Becker [1968]. A fundamental difference is that Motta and Polo [2003] do not address risk dominance issues in their model (they assume in contrary that the equilib-

rium selection criterion is Pareto dominance), and as a result a leniency programme cannot induce firms to spontaneously self-report. Conversely, Spagnolo [2004] introduces risk dominance considerations, which are captured in the spirit of Harsanyi and Selten [1988].[109] The idea is that a leniency programme increases the risk of unilateral self-reporting, and thus undermines the trust among collusive firms. An additional difference is that in Motta and Polo [2003] firms sustain collusive agreements with grim trigger strategies, while in Spagnolo [2004] collusive agreements are sustained via optimal penal codes à la Abreu [1986, 1988]. Contrary to Motta and Polo [2003], Spagnolo [2004] considers the possibility that a defecting firm cannot be convicted for having taken part to a cartel, nor is it able to report information on its former partners. Finally, in Spagnolo [2004] leniency programmes take into consideration recidivism, contrary to Motta and Polo [2003].

A first observation by Spagnolo [2004] is that when a leniency programme is not available, the optimal enforcement policy requires the antitrust authority to commit not to target the firms that unilaterally defect from the collusive agreement. Prominently, this policy must be publicly known. Intuitively, a firm is more prone to defect from the collusive agreement if it knows that it will not be fined for its past illegal conduct. Spagnolo calls this effect '*protection from punishment*'[110]. In principle, this effect mitigates the costs associated with a deviation from the collusive agreement, and thereby makes collusion harder to sustain.[111]

The main result of the study by Spagnolo [2004] is that the first best, of complete and costless deterrence, is feasible.[112] To attain the first best,

[109] Technically, an equilibrium is *risk dominant* if the Nash Product (product of surpluses) of that equilibrium is greater than the Nash Product of every other potential equilibrium. Such equilibrium is called risk dominant because players try to mitigate the risks associated with their choices by minimizing the risks for every player. The concept of '*risk dominance*' was introduced by Harsanyi and Selten [1988]. Risk dominance should be contrasted to Pareto dominance where players select the Nash equilibrium that Pareto dominates all other Nash equilibria. For a meticulous discussion on equilibrium selection criteria, see Fudenberg and Tirole [1991].

[110] Harrington [2008] rename this effect to '*deviator effect*'.

[111] Effectively, this assumption of protecting a defecting firm from the risk of punishment for participating in a collusive agreement in the past allows to overcome the '*irrelevance result*' in Motta and Polo [2003].

[112] This result is based on a rather strong assumption, namely, that the antitrust authority can offer positive rewards to self-reporting firms. This has been criticized in the literature as politically infeasible. It is worth noting that the UK, South Korea, and Hungary have in place rewards programs for reporting information on cartels. In 2002 the (South) Korean Fair Trade Commission introduced a cartel informant reward scheme. This program was modified in 2002 and 2005 to increase the amount of maximum reward from 20 million won (approximately 18,789 USD) to 1 billion won (approximately 1 billion

the antitrust authority must impose the maximum feasible fine on all cartel members except the first to self-report (known in the literature as the '*first informant rule*').[113] At the optimal policy, the first self-reporting firm is rewarded with the fines imposed on all other cartel members. This finding is in stark contrast to Becker [1968], who argues that the optimal probability of detection and the investigation costs that generate such a probability are a dead-weight loss that keeps society away from the first best. It is also distinguished from the paper by Motta and Polo [2003], according to which the leniency programme can, in the best case scenario, result in a second best solution. This is attributed to the fact that some resources need to be invested in detection activities in order for the enforcement policy to have teeth.

Spagnolo [2004] shows that when the leniency programme is sufficiently generous, then two conflicting effects on cartel deterrence may emerge. On the one hand, the value of the collusive agreement increases since the leniency programme may be exploited; firms can collude and self-report in every period. Thus, a very generous leniency programme can rein cartel deterrence. This effect is, however, mitigated when the antitrust authority restricts eligibility for leniency only to the first self-reporting firm. This is because if more than one firm is eligible for leniency, fewer firms will have to pay the fine, and thereby a lower amount will be available to reward self-reporting firms. On the other hand, the value of deviation from the illegal agreement increases. A firm that defects from the collusive agreement is protected both from the antitrust fines ('*protection from fines effect*'[114]) and from the (temporary) punishment by the other cartel members ('*protection from punishment effect*'[115]). Thus, a very generous leniency programme can enhance deterrence. It is important to underline that the *protection from punishment effect* exists when the collusive agreement is sustained with two-phase Stick and Carrot punishment strategies à la Abreu [1986] and the punishment for repeat offenders is stricter. The intuition is the following: with

USD). A similar informant reward program was adopted by the Office of Fair Trading in UK. The program provides a reward rising to 100,000 GBP. In 2010 Hungary also introduced an informant rewards program. The program provides a reward of at least 1% of the fine levied against the cartel's members with an upper bound of 50 million forints (approximately 238,000 USD). Remarkably, parallel application to the leniency program and the information reward program is prohibited.

[113] In Becker [1968] the first best of complete and costless deterrence could not be attained even with infinite fines. This is because when no resources are invested in the enforcement of law, the probability of detection is zero. Thus, even infinite fines have no impact on crime deterrence.

[114] In Harrington [2008] this effect is called the '*cartel amnesty effect*'.

[115] Harrington [2008] calls this the '*deviator effect*'.

two-phase stick-and-carrot punishment strategies, firms suffer a cost when participating to the '*stick*' phase, and are willing to do so because it allows them to return back to the collusive ('*carrot*') phase the following period. Furthermore, if repeat offenders are punished more severely than first time offenders, then a report today by one firm raises future fines. This diminishes the expected value of further collusion. As a result, the amount that firms are willing to bear in punishing defections in the first place is limited (i.e., the carrot tightens the incentive compatibility constraint for the punishment phase). Effectively, this drains the strongest credible '*stick*' that can be used to discourage defections in the first place.

In this context, Spagnolo [2004] proves that if positive rewards are feasible, the optimal policy is to impose the maximum possible fine to all firms but the first to self-report.[116] Restricting eligibility (only to the first self-reporting firm) makes the leniency programme less exploitable as it triggers a '*race to the courtroom*' caused by the '*fear to arrive second*'. Thus, the author infers that a combination of sufficiently high fines and high powered leniency programmes (courageous leniency programmes) makes law enforcement redundant. Nevertheless, when the maximum fines are sufficiently small to achieve the first best, it may be optimal to couple rewards with active investigations, given that investigations and rewards are substitute enforcement instruments.

Moreover, Spagnolo [2004] shows that when positive rewards are infeasible, there is another effect of leniency programmes on cartel stability and deterrence. In addition to the protection from fines and protection from punishment effects, a leniency programme influences the riskiness of the cartel agreement by undermining the trust among its members. Collusive agreements are strictly riskier when the eligibility to the leniency programme is restricted only to the first self-reporting firm. A leniency programme that does not restrict eligibility only to the first self-reporting firm makes the illegal agreement less risky as firms can exploit such programs and enjoy fine discounts. Therefore, contrary to Motta and Polo [2003], Spagnolo [2004] concludes that it is always optimal to have a leniency programme (even if moderate).

An additional reason why colluding firms spontaneously apply for leniency, before an investigation is launched in the market, is offered by Ellis and Wislon [2003]. Their study explores the impact of a leniency programme on firms' behavior under Bertrand price competition with differentiated prod-

[116] High fines are now crucial not only because they reduce the expected value of the illegal cartel, as in Becker [1968], but because they allow the enforcement agency (e.g., the antitrust authority) to offer higher rewards to the first self-reporting firm.

ucts. Similar to Motta and Polo [2003], the authors assume that the collusive equilibrium is sustained by grim trigger strategies. The novelty of the paper is that fines are not fixed, but proportional to revenues.[117] This implies that a change in marginal revenue can impact on firms' behavior in the market, and, ultimately, on their incentives to collude.

In this context, Ellis and Wislon [2003] show that firms can exploit the leniency programme by defecting in the market and denouncing the cartel. Thus, a leniency programme may destabilize cartels. In particular, a defecting firm can gain market advantage by raising its rivals' costs through fines and compliance measures. The authors highlight that firms' incentives to defect and apply for leniency are sharper when the fine is higher and the market less concentrated.

However, forward looking firms anticipate this opportunistic behavior and, thus, strategically use the leniency programme as a mechanism to thwart defections from their illegal agreement. If a firm defects from the agreement but does not self-report, then the other firms may punish the defector by self-reporting the cartel to the antitrust authority. In this case, a leniency programme can strengthen the stability of the cartel.

Contrary to Motta and Polo [2003] and Spagnolo [2004] who assume constant (time independent) probabilities of detection and conviction, Hinloopen [2003] studies the effects of leniency programmes when the probability of detection is time dependent. In particular, the author assumes that the probability of detection increases with a cartel's record. This may, for example, correspond to a scenario where the efficiency of an antitrust authority's prosecution activities constantly improves over time. A novelty of the paper by Hinloopen [2003] is that the antitrust authority is assumed to continue its investigation for a finite number of periods after the collapse of the cartel due to a market defection by one of its members. This allows the author to examine the effects of the duration of the limitation period that comes with antitrust law violation.[118]

By distinguishing two manners whereby a cartel may collapse, either by a deviation in the market or a deviation in the self-reporting stage, the author concludes that the effectiveness of leniency programmes increase with the generosity of the fine reduction. The reasoning is that a larger fine reduction for self-reporting reinforces firms' incentives to deviate from the collusive

[117] This is a realistic assumption. Importantly, it is consistent with the fine policies in the US and EU.

[118] Acording to Article 25 of the EC Council Regulation 1/2003, the limitation period is (a) 3 years in the case of infringements of provisions concerning requests for information or the conduct of inspections; (b) 4 years in the case of all other infringements.

agreement by self-reporting, as opposed to deviating in the market. Furthermore, the rate of reduction of fines does not impinge on firms' incentives to deviate in the market, while it affects their incentives to self-report, as the cost of self-reporting diminishes. Thus, an additional reduction in the fine for self-reporting increases the probability of leniency application. A necessary condition for this result to hold is the existence of a sufficiently transparent leniency programme so that cartel members can accurately estimate the benefits accruing from self-reporting. However, this does not mean that the antitrust authority should publicly disclose information about the firms that apply for leniency. Such practice may allow firms to simultaneously apply for leniency, and thus exploit the leniency programme by paying lower fines.[119] Moreover, it may increase the risk for private claims, the costs of which is potentially greater that the fine imposed by the antitrust authority.[120]

Hinloopen [2003] argues that if the antitrust authority consistently improves the effectiveness of its detection activities so that the probability of detection in future periods increases, then the expected fine, and hence the cost of collusion rises. This implies sharper incentives to deviate from the cartel and self-report to the antitrust authority. The author also argues that an increase in the fine has two conflicting effects on firms' incentives. On the one hand, a higher fine implies a higher cost for collusion. This strengthens firms' incentives to defect, either in the market or by self-reporting to the antitrust authority. On the other hand, a higher fine implies a higher absolute value of the fine, net of the reduction for self-reporting, which mitigates firms' incentives to self-report. The net product of these two opposite forces depends on the fine reduction relative to the sequence of per-period probabilities. If the percentage of the fine reduction is relatively high, compared to the increase in future probabilities of detection, then an increase in the level of the fine is more likely to improve the effectiveness of the leniency programme. Finally, Hinloopen [2003] argues that an extension to the limitation period makes self-reporting more likely to be preferred to deviation from the market, given that with self-reporting the cartel would be convicted immediately. In the case of deviation from the market, there is a possibility of being convicted in the future for past violations of the law. The length of the limitation period does not have any impact on the decision to self-report the cartel. Thus, the effectiveness of the leniency would not be affected by the duration of the limitation period.

It has to be remarked that, unlike Motta and Polo [2003], the study

[119] It is precisely for this reason that Motchenkova [2004] argues in favor of confidential leniency programmes.

[120] On the other hand, the cost for private damages increases the total fine for a cartel member, and therefore enhances cartel deterrence.

by Hinloopen [2003] cannot predict self-reporting when an investigation is underway. This is because the probability of cartel detection once an investigation is launched in the market is intact, contrary to Motta and Polo [2003].

Most studies in the literature on leniency programmes analyze the effects of such programmes under fixed fines, that are independent of the accumulated illegal collusive gains. However, fines may also be proportional to the accumulated illegal collusive profits. This is also an assumption that is closer to realism and the actual fining policies adopted by antitrust authorities in various jurisdictions. A paper that acknowledges and incorporates the distinction between fixed and proportional fines is by Motchenkova [2004].

Motchenkova [2004] explores the effects of leniency programmes under two distinct fine regimes, fixed and proportional, and two distinct application procedures, confidential and non-confidential. With a non-confidential procedure, firms can simultaneously apply for leniency.[121] Although this is not a very realistic assumption, it allows to highlight the role of confidentiality of leniency applications. Based on the approach of Reiganum-Fudenberg-Tirole[122], Motchenkova [2004] analyzes whether the treatment of collusive firms by the antitrust authority should depend on the timing of their applications for leniency. The main conclusion of the paper is that the driving force for the effectiveness of leniency programmes in deterring cartels is the strength of firms' incentives to stop colluding and apply for leniency before preempted by some other firm (*preemption mechanism*).[123] A well designed leniency programme may reduce the duration of cartel agreements; however this result is ambiguous. Only strict leniency programmes unambiguously erode cartel stability, and thus enhance the efficacy of antitrust law enforcement. Similar to Spagnolo [2004], Motchenkova [2004] also shows that programs that do not restrict the eligibility for leniency only to the first self-reporting firm may restrain deterrence because of the reduced expected fines.

Motchenkova [2004] demonstrates that when fines are proportional to the accumulated collusive gains and the application procedure for obtaining leniency is confidential, then complete cartel deterrence can be achieved,

[121] For instance, if a firm applies for leniency, then this becomes publicly known, and, therefore, the other firms can instantaneously react and lodge a leniency application too.

[122] See Reinganum [1981] and Fudenberg and Tirole [1985]. The authors study the decision of whether and when to build a new plant or adopt a new innovation when the market can accommodate only one such addition.

[123] In effect, this mechanism induces firms in a race to the antitrust authority in order to be the first to self-report and benefit from a lenient treatment.

provided that the fine is sufficiently high. At any rate, the introduction of a leniency programme (with these specifications) does not facilitate cartel formation or increase cartel duration. When the application procedure is not confidential, the leniency programme may reduce the duration of cartel agreements, but not deter cartel formation. This result is again ambiguous. When the fines and the probability of detection are sufficiently low, the introduction of a leniency programme may, on the contrary, foster collusion. Motchenkova [2004] also shows that under fixed fines and confidential leniency application procedures, the introduction of a leniency programme does not affect the effectiveness of the enforcement policy at all. In this situation, cartel duration depends on the size of the fine, while cartel deterrence is not influenced by the leniency programme. Only a sufficiently high fine can guarantee the success of the leniency programme. A policy recommendation that derives from the paper is that leniency programmes must be confidential, which seems to be the procedure adopted in most jurisdictions.

A typical assumption in the literature (including the studies by Motta and Polo [2003], Hinloopen [2003], Spagnolo [2004], Motchenkova [2004] and Harrington [2008]), is that the incriminating evidence retained by firms, and which can be used to apply for leniency, is symmetric. Although this symmetry assumption simplifies the analysis, it is not very realistic. For instance, firms may retain different pieces of evidence. The amount of evidence revealed to the antitrust authority critically affects the magnitude of the fine reduction and the probability of successful conviction of the cartel. One of the few papers that explores the relevance of the amount of reported evidence in the determination of the fine reductions and the number of firms that should be eligible to receive leniency is by Feess and Markus [2005].[124]

More formally, Feess and Markus [2005] develop a (static) model with two self-reporting stages, one before the investigation and one after the investigation, to explore the different amount of revealed evidence that is required to obtain leniency. A key result of the paper is that the strategic interaction between cartel members is different at the two stages. Self-reporting before detection leads collusive firms to a race to the courthouse, whereas after detection, it leads them to a Prisoners' Dilemma situation.

Feess and Markus [2005] conclude that the optimal fine hinges on the degree the evidence provided to the antitrust authority. The team specific characteristics, which affect the probability of cartel detection, also play a pivotal role in the determination of the optimal fine. Specifically, the authors demonstrate that granting full amnesty at the pre-detection stage is

[124] A more recent paper that sheds some light on similar research questions is by Silbye [2010].

never optimal for the low evidence provider. Nonetheless, depending on the distribution of team specific characteristics, it may be optimal for the high evidence provider. The authors also show that the optimal fines are increasing in the amount of additional information delivered by other members of the cartel. A crucial assumption of the paper is that each firm is perfectly informed about the evidence retained by others. Furthermore, the evidence retained by an individual does not influence the level of the fine, a result driven by the Prisoners' Dilemma structure at the conviction stage. However, high evidence providers should pay a lower fine if they self-report at the pre-detection stage. Another significant result of the paper is that it is optimal to offer leniency to the low evidence provider if the high evidence provider self-reports. This provokes self-reporting by another cartel member, and thus save investigation costs (as in Motta and Polo [2003]). Finally, the paper concludes that the fine for the firm providing less evidence should be the same in both self-reporting stages (pre-detection and conviction), while the fine for the high evidence provider should be higher in the pre-detection stage. The rationale is that the antitrust authority has more to economize if self-reporting occurs at an earlier stage of the antitrust proceedings, while the cartel has more to lose given that the cartel is dissolved sooner. The authors remark that the theoretical predictions of the paper are consistent with the EU leniency programme, which may provide leniency to more than one firm. However, the predictions are in dissonance with the US corporate leniency programme - which provides leniency only to the first self-reporting firm.

A critical assumption of the papers discussed above is that the hard evidence that is generated by cartel members lasts only for one period and thereafter evaporates.[125] This is not always a realistic assumption. Evidently, evidence can be durable, and as such it can play the role of a '*hostage*' to discourage defections from the collusive agreement. One paper that factors in this assumption is by Buccirossi and Spagnolo [2006]. The authors study the effects of leniency programmes in occasional sequential bilateral illegal agreements (or other corruptive activities) wherein reputation plays no role. Crucially, these types of transactions are exposed to serious '*governance*' or '*hold up*' problems because of the lack of an enforcement mechanism (i.e., a contract) that can constrain the development of opportunistic behavior by the party delivering last in the transaction.

The authors demonstrate that if the enforcement agency grants a fine reduction, or at best amnesty, without paying a positive reward to the first

[125] In the paper by Motta and Polo [2003] evidence is produced only if no defection occurs. Thus, a defecting firm cannot apply for leniency.

firm that self-reports, the commitment to cooperate with the enforcement agency may facilitate the punishment of a defecting party at a relatively low cost. As a result, a poorly designed leniency programme, for which the fine paid by the self-reporting party is lower than the expected fine without self-reporting, may provide an effective governance mechanism or credible threat to any party that attempts to deviate from the agreed strategy. The transacting parties can collect hard evidence to discourage opportunistic behaviour. In case of a defection, the mislead party can report the evidence to the enforcement agency. This counter-productive effect can be mitigated by offering a sufficiently high reward (above the expected gain from the illegal transaction) only to the first self-reporting party. To this effect, the paper by Buccirossi and Spagnolo [2006] is in line with Spagnolo [2004]. Both papers conclude that collusion can be completely deterred if the enforcement agency sufficiently rewards the first self-reporting firm.

The main shortcoming of the papers assuming a fixed probability of detection (and conviction) over time is that they produce the counterfactual result that a cartel will never use the leniency programme. Nevertheless, this theoretical prediction contradicts the empirical evidence that many cartels established after the introduction of leniency programmes and eventually applied for, and obtained, fine reductions afterwards. Harrington [2008] argues that a logical explanation for this empirical observation is that the probabilities of successful prosecution stochastically change over time.

The study by Harrington distinguishes three effects of leniency programmes on firms' incentives to self-report. These effects are referred as the '*deviator effect*', the '*cartel amnesty effect*' and the '*race to the courthouse effect*'. The deviator effect operates through the payoff of defecting in the market. It captures the reduction of fines when a defecting firm applies for leniency. Clearly, this effect makes collusion more difficult to sustain as it increases the payoff from cheating. The cartel amnesty effect operates through the expected payoff of collusion. It captures the reduction in the size of the fine when a firm self-reports. This effect makes collusion easier to sustain when a firm obtains leniency. Similar to the cartel amnesty effect, the race to the courthouse effect operates through the payoff of collusion. This effect transpires when only the first self-reporting firm is eligible to receive a lenient treatment. The race to the courthouse effect makes collusion harder to sustain. Harrington [2008] allows for these three effects to simultaneously interact, thus permitting a richer analysis of the design of optimal leniency programmes.

The paper shows that the overall effect of leniency programmes on firms' incentives hinges on the size of the fine reduction. With an extremely lenient

program that offers leniency only to the first self-reporting firm only the deviator effect and the cartel amnesty effect would be at play. In general, the deviator effect dominates the cartel amnesty effect. This implies that a more generous fine reduction to self-reporting firms makes the cartel agreement more unstable. The underlying reasoning is that the benefit for a firm that applies for leniency and self-reports today is greater than the expected benefit from using the leniency programme in the future. If those were the only two effects in operation, then collusion would be made more difficult to sustain under a more generous leniency programme. In this case, a policy of maximal leniency would be optimal. If, however, the fine reduction is sufficiently mild, only the cartel amnesty effect and the race to the courthouse effect would be at operation. A deviating firm cannot apply for leniency because the fine reduction is too small, while a cartel would be detected with certainty if a firm self-reports to the antitrust authority. In other words, a firm prefers to pay a lower expected fine than a higher certain fine. In this case, the fine reduction affects only the future expected collusive payoff. If the *cartel amnesty effect* were the only force at work, then a more lenient program would raise the collusive payoff, and thus facilitate collusion. A more lenient policy would then revive cartel stability contrary to the objective of the antitrust policy. The picture is less clear-cut once the race to the courthouse effect and the cartel amnesty effect are both in force. In this case, a more generous fine reduction may increase or decrease the stability of the cartel depending on which of the two effects dominates. Cartel stability erodes when the race to the courthouse effect dominates.

Harrington [2008] proves that under some plausible conditions[126], it is best to offer full amnesty only to the first self-reporting firm; otherwise, partial leniency is optimal. Intuitively, when more than one firm is eligible to receive lenient treatment, the expected fine with self-reporting decreases (i.e., the cartel amnesty effect strengthens). On the other hand, the deviation profits remain intact (i.e., the deviator effect is intact). It is important to note that this result is in line with Spagnolo [2004], Motchenkova [2004] and Buccirossi and Spagnolo [2006]. The author also shows that it is not always optimal to offer unrestricted amnesty to the first self-reporting firm. Amnesty should be offered only when the probability of conviction without self-reporting is sufficiently small and a firm delivers evidence that substantially reinforces the antitrust authority's case. In particular, the author shows that it is always optimal ex-ante (not ex-post) to offer leniency only if the probability that the antitrust authority wins the case, without self-reporting,

[126] Technically, the Cumulative Distribution Function (CDF) of the probability of detection must be weakly concave.

is less than 50%.

Finally, it is worth noting that, contrary to Spagnolo [2004], the paper by Harrington [2008] have no implications for spontaneous self-reports.

The papers discussed above consider symmetric firms. The effects of a leniency programme on cartels' stability when firms are asymmetric is explored by Motchenkova and Leliefeld [2010]. In particular, the authors consider two firms which for historical reasons have asymmetric market shares (one has a large market share while the other has a low market share). The asymmetry in the size of firms implies different collusive profits for cartel members, and, thus, asymmetric punishment threats in case of defection from the collusive agreement. In effect, the larger firm has less to fear from a retaliation than the smaller firm. In this context, the authors explore the impact of a leniency programme on a cartel's stability, by means of its effect on the severity of the threat of retaliation.

In a setting where the small firm decides whether to self-report or not and subsequently the large firm decides whether to retaliate or not, the authors show that the leniency programme may foster cartel stability. The underlying reasoning lies in the ability of the large firm to use the leniency programme as a mean to enhance its trust to the small firm not to report the cartel to the antitrust authority. In other words, the leniency programme facilitates the large firm to '*coerce*' the small firm not to report with the threat of a severe punishment. Thus, firms may exploit the leniency programme to enhance cartel stability. It is worth noting that this adverse effect on cartels stability crops up even if the leniency programme restricts complete amnesty only to the first self-reporting firm. The authors show that increasing the fine or the probability of detection helps to alleviate this adverse effect of leniency programmes.

A policy recommendation that derives from the paper is that self-reporting firms should be protected from possible retaliation measures by other cartel members. For instance, the antitrust authority may closely monitor the market after a firm self-reports so that to discourage retaliatory measures, which may manifest with abuse of dominant positions (e.g. predatory pricing). Moreover, the antitrust authority may focus its investigations in markets with intermediate degrees of asymmetry wherein the adverse effects of leniency programmes are more likely to evolve. Finally, the antitrust policy should put greater emphasis on aggravating factors, such as coercion, when calculating the fines for illegal cartels.

A common limitation of the papers discussed above is that the collusive price and profits are fixed. In addition, the pricing behaviour of collusive

firms does not influence the probability of cartel detection. These two assumptions imply that a leniency programme does not influence the price charged by a defecting firm, nor does it affect its profits.

The impact of a leniency programme on the cartel price path and cartel stability is explored by Chen and Harrington [2007]. The authors extend Harrington [2004, 2005], where the probability of detection and fines are endogenous to colluding firms' prices[127], by considering a leniency programme as an additional tool for the enforcement of antitrust law. In this context, the cartel chooses a price path that ensures compliance by all firms (i.e., it is incentive compatible) without raising suspicions to buyers or the antitrust authority about the cartel.

A distinctive assumption of the paper is that detection can occur in the period after the collapse of the cartel (i.e., the period after which a firm defects from the illegal agreement). This assumption implies that the expected penalties can be higher when partial leniency is offered, compared to the policy of no leniency. As a result, a defecting firm can lodge a leniency application even if the ensuing payoff is lower than without a leniency programme to preempt others to self-report in the following period.

The authors show that a leniency programme providing full amnesty only to the first firm to self-report the cartel makes collusion more difficult to sustain. Moreover, their analysis shows that offering partial leniency can facilitate collusion (compared to offering no leniency), nonetheless, this result is ambiguous. When the probability of detection is weak, a defecting firm would prefer not to self-report to the antitrust authority. However, anticipating that the other firms will self-report in the next period and considering that only the first self-reporting firm receives a generous treatment, the firm chooses to defect in the market and simultaneously self-report. This strategy reduces the payoff to cheating which allows the cartel to sustain a higher price path. On the other hand, as the fine discount rate increases, firms have more incentives to defect in the market and simultaneously self-report to the antitrust authority. This tightens the incentive compatibility constraint which induces the cartel to price lower. Hence, even if a leniency programme is unsuccessful in deterring cartel formation, it may still achieve to impel the cartel to price lower in order to preserve the stability of the cartel.

The papers by Motta and Polo [2003], Hinloopen [2003], Spagnolo [2004], Motchenkova [2004], Feess and Markus [2005], Buccirossi and Spagnolo [2006], Harrington [2008], Motchenkova and Leliefeld [2010] and Chen and Harring-

[127] In particular, the probability of detection is increasing in price changes while the magnitude of the penalty, in case of conviction, is increasing in prices (current period and historical prices). See Section 4, pp. 29.

ton [2007] investigate the effects of leniency programmes on firms' incentives to self-report. However, as discussed in Section 2, an antitrust authority has also other investigative tools to detect cartels and achieve compliance with antitrust law. One tool is individual leniency programmes. Such programmes may provide a new source of information for antitrust authorities. Indeed, if individuals are provided with sufficient incentives, then the firms that breach antitrust law would not only be in a race for leniency with their competitors but also with their own employees.

In addition, a typical assumption of the literature on leniency programmes is that collusion always generates hard evidence.[128] The hard evidence may last only for one period (as in Motta and Polo [2003]), and then evaporate, or it may be indelible (as in Ellis and Wislon [2003] and Buccirossi and Spagnolo [2006]). The role of evidence retention has not been given sufficient attention in the literature. A notable exception is Aubert et al. [2006] who consider several explanations, in a rather informal way, for the puzzling fact of evidence retention. Evidence is crucial both for an antitrust authority and colluding firms. To credibly build a case against cartels, an antitrust authority needs to find cogent incriminating evidence. For instance, documents proving that firms have agreed to coordinate their conduct (e.g., fix prices). Thus, an essential assumption of the literature is that firms axiomatically keep hard evidence.[129] Moreover, to be eligible for leniency a firm must provide hard evidence to the antitrust authority, which is a realistic assumption to be made. However, the interesting question is not whether a cartel produces hard evidence or not but, given that hard evidence is produced, whether firms consciously decide to retain or destroy the incriminating evidence. This suggests that it may be indispensable to make the decision to retain or destroy the hard evidence endogenous, so that to analyze and comprehend the dynamics of the potential trade-offs involved. Considering these remarks, the conclusions derived by Aubert et al. [2006] are the following.

Firstly, courageous leniency programmes offering positive rewards to individuals have a greater deterrence effect than moderate leniency programmes offering at best amnesty (as in Spagnolo [2004]). Secondly, rewards to in-

[128] An exception is Motta and Polo [2003] who assume that evidence is produced, provided that defection occurs in the market. For instance, the evidence comprises of *scoresheets* tracking the compliance of colluding firms to the illegal agreement. Essentially, this assumption implies that a colluding firm cannot defect in the market and simultaneously self-report to the antitrust authority.

[129] Certainly, a more realistic assumption is that colluding firms can be convicted based on indirect evidence, e.g. circumstantial evidence, however, with a lower probability than the one associated with hard evidence. For example, this may be justified on the fact that it is easier and less costly to prosecute and successfully convict a cartel based on hard evidence rather than on circumstantial evidence.

dividuals can be more effective than rewards to firms. Thirdly, sufficiently low rewards may instigate adverse effects on the benign cooperation among firms, as well as on firms' organizational structure. Finally, the probability of retaining hard incriminating evidence by firms, or individuals, increases with the magnitude of the reward.

In particular, the authors contend that positive rewards may exacerbate the agency problems within firms by encouraging individuals to self-report. Given that firms must pay higher bonuses to their employees, in order to '*bribe their silence*', collusion becomes less lucrative, and thus less alluring. The higher the reward, the higher the compensation a firm must pay to its employees to discourage them from running to the antitrust authority. In addition, a high reward may provide sufficient compensation to the employees for their anticipated reduction in future earnings, in case of dismissal. It is for this reason that positive rewards have a stronger deterrence effect than reduced fines.

Nonetheless, a poorly designed individual leniency programme may give rise to unfavorable effects, such as, the chilling of valuable cooperation between firms or the restriction of beneficial information flows within the firm. For instance, the exchange of information regarding the future prospects of market demand or costs which, in effect, may allow firms to adopt better informed decisions.[130] Moreover, they can cause rigidities in the job market or the internal structure of firms. For instance, colluding firms may increase the duration of their informed employees' contracts, rather than hiring new, and probably more productive, employees. This will be the case if the bribe that has to be paid to new employees is significantly higher than the productivity differential between new and current employees. Moreover, positive rewards to individuals may also induce firms to inefficiently adopt '*innocent attitudes*' in order to avoid raising suspicions to their employees. In particular, firms may strive to prevent their employees from '*sensing trouble*' so as to discourage them from investing their working time into non-productive activities (e.g. sneaking about and acquiring convicting evidence).[131] In addition, employees may strategically exploit the leniency programme by self-reporting even if they do not keep valid evidence. Rewards may also result in deterrence of valuable inter-firm or intra-firm cooperation. This could be the case if prosecution is costly for firms and the antitrust authority erroneously con-

[130] See, for instance, Athey and Bagwell [2001].

[131] A more recent study by Avramovich [2011] shows that the hunt for bounties by individuals may generate intra-firm productive inefficiencies. For instance, employees' attention may be destructed from production towards activities related to gathering evidence on firms' miconduct. The author shows that by rewarding whistleblowers, the antitrust authority may enhance deterrence at the expense of compromising productive efficiency.

sider a legal conduct as illegal (a type I error). An antitrust authority may, however, mitigate these inefficiencies by introducing fines for information fabrication or coloring.

The authors also investigate plausible explanations for the puzzling fact that firms or individuals keep hard evidence that can be discovered by an antitrust authority. However, the explanations offered cannot justify why firms keep hard evidence in the absence of leniency programmes, or why firms that keep evidence, nevertheless fail to report it to the antitrust authority.

Aubert et al. [2006] contend that firms or individuals may decide to keep hard evidence, running the risk of a higher probability of detection and conviction, to prevent deviations from the collusive agreement, or to mitigate the agency problems within the firm. In particular, the authors argue that firms may want to keep hard evidence so as to decrease the expected fine they have to pay in case of detection by the antitrust authority. The retained evidence can also be used by firms as a disciplining device to threaten to denounce their partners in case of a deviation from the collusive agreement, as in Ellis and Wislon [2003] and Buccirossi and Spagnolo [2006]. Another plausible explanation is that individuals retain evidence to take advantage of the agency problems within firms. For instance, an individual may keep evidence pertaining to the negotiations to form a cartel in order to increase his bargaining power *vis-à-vis* the manager or the shareholders of the firm. An individual may also keep hard evidence that proves his conformity to the orders of his superiors in order to evade conviction by the antitrust authority, or to threaten to report it in case of deprivation of his bonus, or promotion, or even his employment to the firm.

7 Empirical Literature on Leniency Programmes

From the papers discussed above, it is clear that the theoretical literature on leniency programmes is inconclusive with regard to the effectiveness of such incentive schemes in deterring cartels. Some dynamics work in favour of cartel deterrence after the introduction of a leniency programme while others work against it. For example, reducing the fines for self-reporting firms makes collusion less costly ex-ante which fosters collusion.[132] Moreover, when the probability of cartel detection exogenously increases, as a result of a policy change, the option to self-report becomes more valuable to firms.[133] On the other hand, a cartel which is otherwise stable may become unstable

[132] Motta and Polo [2003].

[133] Chen and Harrington [2007] and Harrington [2008].

after the introduction of a leniency programme. In particular, a leniency programme may reduce the expected fine in case of conviction[134], or increase rivals' costs through revenue based fines and other compliance measures[135], or make the collusive agreement more risky in the sense of Harsanyi and Selten [1988]. Finally, the deterrence effect of leniency programmes hinges on i) the punishment strategies that firms adopt to align their incentives and conform with the illegal agreement[136], ii) the confidentiality of the leniency application procedure[137], iii) the transparency of the leniency programme[138], iv) the fine policy (fixed or proportional to the illegal gains)[139], v) whether the probabilities of detection are endogenous[140] and, vi) the heterogeneity of colluding firms[141].

Because of the inherently clandestine nature of cartels, the empirical analysis of the efficacy of leniency programmes in deterring cartels is difficult. The major challenge involved is the lack of information regarding undetected cartels. The sample selection problem due to observing only the detected cartels may lead to biased estimates and misleading conclusions with regard to the impact of leniency programmes on cartel deterrence.[142]

There are several empirical studies that attempt to measure the impact of leniency programmes on cartel deterrence. The success of such programmes can be measured by their impact on the duration and profitability of cartels.

With regard to the duration of cartels, it is worth noting that the theoretical literature on collusion (see Section 2) does not directly consider cartel durations. It rather focuses on the conditions under which collusion can be sustained after a change in market characteristics or a policy innovation (e.g. introduction of a leniency programme). An exception to the literature is Chang and Harrington [2010]. The authors develop a theoretical framework

[134] Spagnolo [2004] and Harrington [2008].
[135] Ellis and Wislon [2003].
[136] Ellis and Wislon [2003] and Spagnolo [2004].
[137] Motchenkova [2004].
[138] Hinloopen [2003].
[139] Motchenkova [2004].
[140] Chen and Harrington [2007].
[141] Motchenkova and Laan [2011].
[142] For instance, an increasing number of detected cartels or detection of cartels with shorter duration, after a change in the antitrust policy (e.g. introduction of a leniency programme) may be attributed to an increase in the probability of detection (e.g. increase in the antitrust authority's budget which allows more market investigations) or an increase in the propensity to collude (Ellis and Wislon [2003], Buccirossi and Spagnolo [2006] and Aubert et al. [2006]). Failing to take these concerns into account may lead to misleading conclusions regarding the effectiveness of a change in antitrust policy (Posner [1970]).

for the evaluation of the impact of a critical policy change, which affects the magnitude of the fines on the duration of cartels (e.g. introduction of a leniency programme). The model predicts that if the policy change is effective, then the average duration of detected cartels should rise in the short-run and fall (below the initial levels) in the long-run. Intuitively, after a policy change (e.g. introduction of a leniency programme) the short-run benefit from defecting exceeds the long-run gains from colluding. Thus, the policy change shifts the '*marginal*' cartel (indifferent between competing and colluding) from the population of sustainable and longer-lived cartels, to the population of unstable and shorter-lived cartels. As a result, the ensuing cartel detection comes from a population of longer-lasting cartels. This implies that the average duration of cartels increases in the short-run. In the long-run, the duration decreases (below pre-leniency levels) due to the enhanced overall deterrence. It is important to note that no information regarding undetected cartels is necessary to assess the impact of a change in antitrust policy. The implications of this model are empirically tested by Brenner [2009] and Zhou [2012].

An alternative model, which infers the deterrence effects of leniency programmes from the rate of cartel detection, is suggested by Miller [2009]. Similar to Chang and Harrington [2010], the model developed by Miller [2009] predicts that the number of cartel discoveries increases immediately after the introduction of a leniency programme and subsequently decreases below the initial levels.

With regard to the impact on the profitability of cartels (price-cost margins), the situation is more clear-cut. An effective leniency programme should enhance competition and thus squeeze firms profit margins. Therefore, the hypothesis to be tested empirically is whether the price-cost margins contract after the introduction of a leniency programme.[143] This proposition is empirically tested by Klein [2010] and Cloutier [2011].

Below we survey the most influential contributions to the empirical literature on leniency programmes.

Brenner [2009] empirically investigates the efficacy of the first EU Leniency programme of 1996 for the period 1990-2003. In particular, the author addresses two questions. The first is whether the information revealed

[143]However, to get reliable and unbiased results the empirical analysis should take into account the potential problems due to endogeneity and omitted variables. A reduction in price-cost margins may be due to other policies that concurrently change with the leniency policies. See Klein [2010] and Cloutier [2011].

under leniency applications i) induces higher fines per-case, compared to traditional prosecution methods, and ii) accelerates the prosecution procedure (as advocated by Motta and Polo [2003]). The second is whether the leniency programme destabilizes existing cartels and deters future cartel activity (as shown by Spagnolo [2004] and Ellis and Wislon [2003]).

The econometric analysis shows that the leniency programme induces a higher level of per-firm fines, controlling for a number of factors that influence the level of the fines. To the extent that the level of the fines is influenced by the strength of the case against the cartel, this confirms that additional and value-added information is revealed to the European Commission which would not have access to without self-reporting. Moreover, the analysis of the data reveals that after the introduction of the leniency programme in 1996, the average duration of a cartel investigation decreased by almost 1.5 years, which hints at the economized investigation and prosecution costs.

The change in cartels' stability is measured by cartels' duration prior and after the introduction of the leniency programme. The author shows that although there is a sharp increase in the number of prosecuted and convicted cartels after adopting the leniency programme, this cannot be interpreted as ample evidence of the deterrence effects of leniency programmes. The reasoning is twofold. On the one hand, the particular temporal pattern of detections is not consistent with sufficient conditions on the deterrence effects of leniency programmes as established by Miller [2009]. On the other hand, the empirical results of the paper do not corroborate Chang and Harrington [2010] who show that an effective leniency programme increases the average duration of detected cartels in the short-run.

Zhou [2012] criticizes Brenner [2009] because the econometric specification of his paper does not allow the impact of a leniency programme on cartel durations to change over time. As a result, the short-run and long-run effects of leniency programmes, pointed out by Miller [2009] and Chang and Harrington [2010], are confounded, leading to biased estimates.

The paper by Zhou [2012] adapts a dynamic model of cartel formation developed by Chang and Harrington [2010] which predicts that the impact of a more efficacious policy on the duration of discovered cartels is time-dependent. In particular, following an increase in the detection capabilities of an antitrust authority the marginal cartel (indifferent between colluding and competing) immediately collapse and the ensuing cartel detection comes from a population of longer-lasting cartels. Because of such a sample selection effect, the average duration of discovered cartels increases in the short-run; in the long run, the duration decreases due to the enhanced overall deterrence.

The adapted model is then used to evaluate the efficacy of the new EC

leniency programme of 2002 for the period 1990-2010. In particular, the author examines whether cartel durations increase immediately following the introduction of the new leniency programme in 2002[144], and whether it falls below the pre-leniency levels, immediately after the change in the leniency policy.

The econometric results of the paper are consistent with the theoretical predictions of Chang and Harrington [2010] that following the introduction of a more efficacious leniency programme, the average duration of discovered cartels increases in the short-run and falls in the long-run below pre-leniency levels.

Miller [2009] develops a dynamic model of cartel behavior that provides predictions and moment conditions regarding the temporal distribution of the number of convicted cartels. The theoretical model predicts that the number of detected cartels increases immediately after the adoption of the leniency programme (because of a higher rate of detection) and decreases in the long-run (because of a lower rate of cartel formation). These effects, which depend on the time horizon, are subsequently used to empirically identify the impact of the amended US corporate leniency programme of 1993, on detection and deterrence capabilities.[145] In particular, the author applies the model to the set of convicted cartels by the DOJ over the period 1985-2005.

The econometric results are consistent with the theoretical predictions suggesting that the number of cartels detected increases immediately following leniency introduction and then falls below the initial levels. Thus, the author concludes that the amended US corporate leniency programme of 1993 enhances both deterrence and detection of cartels.

As Miller [2009] remarks, the results must be interpreted with caution. The predictions of the theoretical model which the author tests empirically is based on the assumption that the probability of detection is equal for all cartels. This remains valid as long as the detected cartels are representative (for the total pool of cartels – detected and undetected) in some fashion. However, a more realistic assumption is that the probability of detection may depend on the level of the cartel overcharges.[146] Moreover, the empirical results of the paper may be biased. This is because the identification of the

[144]The change in the leniency policy in 2002 essentially provides an exogenous shock which identifies the impact of the leniency programme on the duration of detected cartels.

[145]The major innovation of the amended corporate leniency programme of 1993 is that the first self-reporting firm is automatically guaranteed full amnesty, provided that an investigation is not underway. Moreover, amnesty was still available even if an investigation was underway.

[146]See Block et al. [1981], Harrington [2004, 2005] and Houba et al. [2010].

impact of the leniency programme on detection and deterrence is based on a single time series with only one exogenous policy change.

A common characteristic of the papers discussed above is that they indirectly measure the effectiveness of leniency programmes via the change in the probability of detection or the duration of detected cartels. Below we discuss two papers, by Klein [2010] and Cloutier [2011], that follow a different identification approach. In particular, the effectiveness of leniency programmes is directly measured by their impact on the intensity of competition at the industry level. Since the ultimate goal of leniency programmes is to enhance the desistance and deterrence of cartels, which are harmful for society, a successful leniency policy should have a negative impact on the profitability of firms.

The paper by Klein [2010] studies the effectiveness of leniency policies over a 20 years period from a population of 23 OECD countries. Rather than focusing on cartel detection, the author measures the effect of leniency policies on price-cost margins at industry levels. In particular, the author considers whether a country's specific leniency policy has an impact on the price cost margin of its industries. To avoid potential endogeneity problems and measurement problems from omitted variables, since a change in price-cost margins can be due to other factors than the introduction or amendment of a leniency policy, the author employs the instrumental variables approach. The author uses two instruments: 1) the implementation of leniency programmes in other OECD countries and 2) indicators for the political environment.[147]

The results of the empirical analysis suggest that the national leniency programmes, as well as the EU leniency programmes of 1996 and 2002, have a positive impact on industries' competition intensity, with an approximate decrease in the price-cost margins of 3-5%. Moreover, the instrumental variable estimation reveals that these results do not suffer from significant endogeneity and omitted variable bias. Thus, the author concludes that leniency programmes are efficient in detecting and deterring cartels. Robustness checks indicate that a leniency programme takes on average 1 year after its implementation to become effective, and that its effectiveness proliferates over time. Finally, the legal system wherein the underlying leniency programme is implemented seems to have an important impact on its effectiveness.[148]

[147] A good instrument must be correlated with a country's leniency policy, but uncorrelated with any other policy or shock that affects the profitability of the firms operating in the country.

[148] On average, profits are lower in countries that embrace the English and Scandinavian legal systems, and, especially, in countries with the German legal system.

Cloutier [2011] criticizes the instrumental variables approach implemented by Klein [2010] arguing that this method may lead to biased estimates because of endogeneity. In particular, the author argues that the EU is a considerably integrated region where many large firms operate at an EU-wide or supranational level; thus they are affected by the leniency policies of other countries. Therefore, other countries leniency policies could be directly related to home country's cartels and their profitability. A similar problem exists with the second instrument used, the policy position of political parties of a country, which is influencing several other policies and not only the leniency policy of a country.

To overcome the potential endogeneity problems, Cloutier [2011]uses the industry concentration as a proxy of the inherent competitiveness of an industry. To the extend that highly concentrated industries are more prone to collusion, Cloutier [2011] suggests that leniency programmes should potentially be more effective in highly concentrated industries.

Thus, he assumes that the leniency policy should be potentially more effective in highly concentrated industries since those industries are more prone to collusion. The implicit assumption is that changes in other policies, but the leniency policy influence all industries regardless of their concentration levels. The author uses the difference-in-differences approach, where the low concentration industries is the control group and the high concentration industries is the treatment group.

The author uses annual firm-level data of all publicly traded firms in the US over the period 1991 to 1997. The econometric results show that the amendment of the US corporate leniency programme in 1993 had no significant effect on price-cost margins in the short-run while a persistent effect is present after 1-2 years. The results are consistent with Klein [2010].

To conclude this section, the main findings of the existing empirical literature on the effectiveness of leniency programmes are synopsized below:

i) leniency programmes seem to strengthen the case of the antitrust authority against the cartel - reflected in the higher per-firm fines when a leniency programme is available (Brenner [2009]);

ii) leniency programmes accelerate the judicial procedure, thus economizing investigation and prosecution costs (Brenner [2009]);

iii) more transparent leniency programmes (the amendment of the US corporate leniency programme in 1993) seem to have a positive impact in deterrence (Miller [2009]);

iv) offering full amnesty to the first self-reporting firm enhances the deterrence effect of the leniency programme (compare Brenner [2009] and

Miller [2009]);

v) leniency programmes enhance both desistance and deterrence of cartels (Miller [2009], Zhou [2012] and Klein [2010]).

8 Conclusions

Cartels are a symptom of free markets. Because of their inimical effects to consumers, and the economy as a whole, cartels are considered as per-se illegal. Antitrust authorities encounter two key challenges in the war against cartels. The first is the budget stringency which restricts the frequency and success of their investigations. The second is the asymmetry of information which is due to the inherently secret nature of cartels: firms know whether they participate in a cartel while antitrust authorities have only an indication about the existence of the cartel.

A powerful policy instrument to combat illegal cartels is leniency programmes. Leniency programmes are information revelation mechanisms incentivising the instability of cartels. The rationale for using such incentive schemes is twofold: facilitate the detection and/or prosecution of existing cartels and deter the formation of new cartels.

The economic literature on leniency programmes has thrived in the last decade. This survey paper reviews a selective subset of the most influential contributions to the relevant literature. To comprehend the operational mechanism of leniency programmes, and their effects on firms' incentives to collude, this paper reviews the literature on collusion in Industrial Economics. Moreover, it surveys the literature on generic law enforcement, with a focus on self-reporting schemes, both for individuals and groups of individuals.

The main conclusions derived from the literature on leniency programmes in antitrust, in the light of the research articles reviewed in this paper, are the following:

1. Post-investigation leniency may provide colluding firms with incentives to reveal evidence of significant added value to the antitrust authority. As a result, the judicial procedure accelerates and the investigation costs diminish. These beneficial effects of leniency programmes are more pronounced when an antitrust authority's investigations are not fruitful in detecting incriminating evidence of good quality.

2. The deterrence effects of a leniency programme may be indirectly amplified to the extent that the economized resources for the antitrust authority are used to conduct further market investigations.

3. The punishment strategy (grim trigger v. stick and carrot) adopted by colluding firms in order to enforce their illegal agreement influence the deterrence effects of leniency programmes.

4. Restricting eligibility to the first self-reporting firm (*first informant rule*) curbs colluding firms' ability to exploit the leniency programme - firms can collude and report in each period, however, all but one has to pay the full fine.

5. Offering a positive reward to the first self-reporting firm, financed by the fines imposed on all other cartel members, provides high-powered incentives to firms in order to self-report (*courageous* leniency programmes). In this case, the leniency programme generates a Prisoners' dilemma situation where all firms run to the antitrust authority to confess their illegal act and benefit from leniency.

6. Extending eligibility to receive leniency to more than one firm when colluding firms retain asymmetric evidence facilitates the prosecutorial procedure of cartels.

7. A more transparent leniency programme allows firms to accurately estimate the benefits accruing from a leniency application.

8. More severe punishment for repeat offenders enhance the efficacy of a leniency programme.

9. A confidential application procedure restricts firms' ability and scope to exploit the leniency programme.

10. A leniency programme for individuals is more effective than a corporate leniency programme.

11. Reduced fines (because of a lenient treatment) make collusion less costly ex-ante (pro-collusive effect).

12. Wrongly designed leniency programmes may provide firms a credible mechanism to curb the opportunism which is inherent to illegal cartel agreements. Thus, contrary to the policy objectives, a poor leniency programme may exacerbate cartel formation and/or make existing cartels more robust.

13. A poorly designed leniency programme for individuals may have adverse effects on intra-firm hiring strategies and inter-firm benign cooperation.

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