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Optimal Leniency Programs*

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Abstract

Leniency programs reduce sanctions for law violators that self-report. We focus on their ability to deter cartels – and organized crime in general – by increasing incentives to "cheat" on partners. Moderate leniency programs that reduce/cancel sanctions for the reporting party cannot affect organized crime. Courageous leniency programs that reward self-reporting parties may completely and costlessly deter it. When fines/rewards are pure transfers, optimal leniency programs maximize rewards for self-reporting. When financing rewards is costly, optimal leniency programs are restricted to the first reporting party, and make this residual claimant for the fines paid by the others.

JEL Classification: K42, K21

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1 Introduction

Leniency programs are modifications of the law that reduce sanctions against a wrongdoer if this reports his or her behavior to the law enforcing agency. The social and legal value of lowering the sanctions for law violators who self-report has been already highlighted by Malik (1993), Kaplow and Shavell (1994), Innes (1999a,b), and others. Focusing on isolated wrongdoers committing isolated crimes, these studies showed that lowering sanctions for self-reporting agents increases welfare by lowering enforcement costs, reducing risk, and allowing early remediation of damages.

This paper focuses on a different, and at least as important aspect of leniency programs: their ability to deter *organized crime*.

Since Becker's (1968) seminal article, the new field of the economics of law enforcement has focused mainly on crimes committed by isolated agents.[1] Though, the most dangerous and far reaching forms of crime are typically organized: illegal activities that involve a number of agents acting together. Besides price-fixing conspiracies, which will be discussed extensively in the next sections, organized crime includes all Mafia's and gangs' activities, all forms of corruption (where at least two parties are involved, a briber and a bribee), all kinds of illegal trade (smuggling, drugs and arms dealing, etc., where again at least two parties, a buyer and a seller, are involved), large scale frauds, and any other form of crime exercised at too large a scale for an isolated individual.

Two fundamental and intertwined features of organized crime are not captured by standard economic models of law enforcement. The first one is that, because several agents are involved, free riding or "moral hazard in teams" issues become relevant. The second one, which is a direct consequence of the first, is that organized crime takes the form of ongoing criminal relations. Instead of the isolated criminal act with given benefit b and harm h usually considered in the literature, organized crime typically produces ongoing illegal activities delivering *flows* of present and expected future benefits and damages.

As noted by Polo (1995) and Gambetta and Reuter (1995), criminal organizations suffer of an intrinsic "enforcement problem," since to discipline internal behavior they obviously cannot rely on explicit contracts enforced by the legal system. This is why organized crime must be repeated in time: then implicit contracts between wrongdoers can be sustained by the "carrot" of expected future gains from the criminal activity,

[1] See the encompassing surveys by Polinsky and Shavell (1999); Kaplow and Shavell (1999); Garoupa (1997); and Mookherjee (1997).

together with the "stick" of the (often very harsh) punishments against cheaters.[2]

Since organized crime takes at least two parties, it is often proposed to fight it by playing one party against the other(s); that is, to structure the law so that agents involved in organized crime find themselves in a situation as close as possible to a Prisoner's Dilemma. This is the idea behind leniency programs. The Prisoner's Dilemma game itself is perhaps the best known example of leniency program, one that reduces the sanctions for a prisoner that unilaterally confesses his crime, allowing to prove guilty and punish heavily his former partner(s).

The Prisoner's Dilemma refers to a situation in which the joint law violators have already been detected and put under investigation, and the leniency program seeks to elicit the cooperation of at least one of them to facilitate prosecution of the crime.[3] However, leniency programs have been often advocated and implemented as a way to *deter* crime and reduce investigation costs by inducing *undetected* law violators to self-report. The idea, of course, is that leniency programs for law violators who are not under investigation may destabilize organized crime by undermining internal trust with the increased risk that one of the involved parties unilaterally reports to enjoy the benefits of the leniency program (which are typically restricted to the first reporting party only). This paper focuses on this kind of leniency programs, restricted to wrongdoers who spontaneously report their behavior when they are not under any sort of investigation.

Within a very stylized model we first focus on the "moderate" leniency programs common in reality, that only reduce or at best cancel sanctions for a self-reporting agent. We show that, in general, these programs can have little deterrence effect against long-term criminal relations. This is because if such relations were enforced before the introduction of the leniency program, it means that there where sufficient

[2]Consider, for example, corruption. Unless the exchange between briber and bribee is perfectly simultaneous, a rare case, to be enforceable corrupt transactions must be repeated frequently enough, so that the expected future gains from the corrupt relation outweight the short-run temptation to cheat (e.g., to cash the bribe and then not deliver the favor). Alternatively, parties may develop a reputation for being particularly "tough" against "cheaters " (Mafia's reputation is particularly well advertised), which also requires an ongoing criminal activity that enable to recoup through future illegal benefits the present investments in reputation. Analogous reasoning holds for cartels, gangs, illegal trade, etc., where credible threats are also usually needed to discipline individual behavior within the criminal organization. We wrote "usually" because sometimes the institutional framework is such that even infrequently repeated illegal deals can be enforced. See Buccirossi and Spagnolo (2000) for an example of how the legal system itself may provide an effective enforcement mechanism for otherwise unenforceable one-shot illegal deals.

[3]Motta and Polo (1999) analyze these kinds of programs in the enforcement of Antitrust law against cartels. Their model will be discussed at length in the next sections.

expected gains from the relation to both curb incentives to cheat and compensate for the probability of being caught and sanctioned. Then, self-reporting within a leniency program that reduces or cancels the sanctions for a reporting agent brings this agent only a loss of expected gains from the criminal relation.[4]

We then proceed by analyzing "courageous" leniency programs, programs that allow wrongdoers that report "hard" information on their criminal organization to be rewarded, and by characterizing optimal leniency programs under different assumptions about the costs of administering sanctions and rewards. We find that, at least in our model, optimally designed leniency programs for undetected wrongdoers can be very powerful. When political and moral constraints on their design are not too tight, optimal leniency programs can costlessly deter most illegal transactions enforced by reputational considerations. To have such pervasive effects, leniency programs must really be courageous. They should not only reduce sanctions, but also pay sufficiently high rewards to wrongdoers that spontaneously report, allowing to prove guilty their partners.

Of course, there may be drawbacks in rewarding law violators that self-report. Abstracting from moral and political considerations, the most commonly mentioned drawback is that rewards are incentives to distort or even "fabricate" information.[5] However, who raises this issue typically fails to acknowledge that exactly the same incentives are present in *any* trial where victims can receive damage payments. Should we forbid damage payments to victims just because they create incentives to distort information? Of course not. In private litigation the Court's task is exactly that of examining the information revealed by the parties, verifying its thruthfullness, and evaluating it. Courts are trained to do this, with the technical support of public investigation agencies.

The same argument applies to rewarding self-reporting agents. The "information fabrication" drawback can be taken care of directly, e.g. by substantially increasing sanctions for reporting false information within a leniency program. The denounced parties will then have all the opportunities and incentives to help the Court find out that the reported information was false.

[4]Real world "moderate" leniency programs have also been shown to be highly counterproductive (Buccirossi and Spagnolo, 2000; Spagnolo, 2000). This is because they provide an otherwise missing credible threat – reporting to the Law-enforcing agency – that enable agents to enforce even occasional illegal agreements, like collusion in one-shot auctions, which would not be enforceable otherwise (that is, in a lawless environment, or with different or no leniency programs).

[5]In this paper we focus on programs that require agents to report "hard" information, so this problem is absent. The problem emerges when agents reporting "soft" information, e.g. by witnessing, are also entitled to the program's benefits.

In the remainder of the paper we will focus on corporate leniency programs against price-fixing conspiracies in oligopoly, because the tool required for the analysis of ongoing relations, the theory of dynamic/repeated games, has been developed in that framework; and because the only previous analysis of leniency programs we are aware of, Motta and Polo (1999), focuses on that case. However, the reader should keep in mind that all our results directly apply to the other forms of organized crime discussed above. Although available strategies and payoff functions differ for different forms of organized crime, the problems of disciplining cooperation between gangs' or Mafia's affiliates and of enforcing compliance with corrupt agreements and other illegal deals are fully isomorphic to that of curbing unilateral deviations from collusive agreements in oligopolies.[6]

1.1 Corporate Leniency Programs and Cartel Deterrence

Leniency programs are being used more and more extensively around the world in the enforcement of antitrust law, in particular against cartels. In the US, a leniency program that cancels criminal sanctions against a colluding firm if this reports verifiable information when the cartel is not under investigation is present since 1978. In 1993, this program has been redesigned, and the new *Corporate Leniency Program* is now also open to firms that start cooperating with the Antitrust Authority (AA) after an investigation of the cartel has been opened, provided the AA has not yet been able to prove colluding firms guilty.

Closely following the American experience, the EU has also recently introduced a leniency program that gives fine discounts to firms that report sufficient information on a cartel in which they have been involved to prove firms guilty. These fine reductions are in the range 75-100% for firms revealing information before an investigation is opened, and in the range 50-75% for firms revealing information after an investigation is opened.

It is too obvious that the exact design of these programs is very important for their effectiveness in deterring cartels and facilitating their prosecution, and therefore that it should not be based only on the (still limited) practical experience. However,

[6] As collusive agreements, implicit contracts are normally modelled as equilibria of repeated games (MacLeod and Malcomson, 1989; Charmichael, 1989). To translate the results we obtain for cartels into correspondent results for other forms of organized crime, it is sufficient to reinterpret variables. For example, for corruption, the number of players N will typically be two, say a firm and a bureaucrat; profits at the collusive agreement π_i^A can be reinterpreted as a party's gains from one enforced collusive transaction; profits from a unilateral deviation from the collusive agreement $\widehat{\pi}_i^A$ can be reinterpreted as a party's gains from cheating in a collusive transaction; and so on.

although these programs have exactly the same features as an incentive scheme, so that one can use the tools of economic theory to work out the *optimal* design of leniency programs against cartels, one finds surprisingly little (that is, no) economic analysis on the subject. The only notable exception we are aware of, is the recent contribution by Motta and Polo (1999).

Motta and Polo develop a model of an AA that enforces competition law against collusion, and analyze the effects of leniency programs on cartel deterrence and prosecution. They focus mainly on leniency programs open to firms already under investigation, and among other things show that besides facilitating prosecution, they can have the adverse effect of reducing the overall deterrence power of Antitrust policy.[7] When comparing the relative effectiveness of leniency programs restricted to firms not under investigation with those open to firms under investigation, they conclude that only the second type of programs can be effective. In their words:

> "*Our analysis reveals that if leniency programs are to be effective in breaking down cartels, they should be extended to benefit firms which reveal after the industry is put under monitoring*" (p. 12).

Motta and Polo see an empirical proof of this superiority in the sharp increase in reporting firms under the US Corporate Leniency Program occurred after (1993), when the leniency program was extended to firms already under investigation.

Here we show that their conclusion may be premature. Motta and Polo's analysis focuses on an Antitrust Authority's (AA) optimal policy, not on the optimal design of the leniency program, and assumes fine discounts to be exogenously given and identical for the two types of program. Taking fine discounts for given may be sensible when one focuses on the AA's activity, since in reality AAs have little discretion on when to give fine discounts and how large. However, even within such a framework it is not sensible to assume identical fine discounts for reporting firms that are and are not under investigation, since in reality discounts are typically larger in the second case (for the precise reason discussed in the next paragraph).

More generally, without allowing parameters to be freely and optimally chosen, one cannot evaluate the relative efficacy of two alternative legislative instruments.[8]

[7] The possibility of getting reduced fines by reporting if they are caught, reduces firms expected sanctions for colluding and may make collusion more attractive.

[8] A Legislator who can choose whether a special legal treatment (the leniency program) should be introduced, and whether or not it should be open to wrongdoers in a certain situation (firms under inquiry), can also choose the details of the special treatment in different situations, including the size of the reduced sanctions in different cases (within the limits placed by political and historical factors).

This is particularly true for corporate leniency programs because, as we will show (Proposition 2), the most important characteristic of leniency programs restricted to undetected wrongdoers is that – contrary to those open to firms under investigation – they allow to increase fine discounts without negatively affecting cartel deterrence. This is well understood by practitioners and legislators, and is the reason why discounts are normally larger for reporting firms that are not under investigation.

Unfortunately, political and moral restrictions have until now kept discounted fines for reporting firms at suboptimally high levels, at which leniency programs for undetected firms are not effective. We show below (Proposition 1) that as long as these programs are "moderate," in the sense of only reducing or cancelling sanctions for a spontaneously self-reporting firm, they *cannot* affect collusive agreements. This is because if a collusive agreement was enforced before the introduction of the leniency program it means that net expected gains from collusion were positive. Then, self-reporting within a moderate leniency program can only bring a reporting firm a net loss of net expected gains from collusion. This is why the early US Corporate Leniency Program for Antitrust law violations, moderate and directed exclusively to reporting firms not yet under investigation, was ineffective in terms of number of reporting firms (Antitrust Division, 1994).

Of course, the effectiveness of the US Corporate Leniency Program – in terms of number of firms reporting – increased when in 1993 it was extended to firms already under investigation. The probability of being proven guilty and fined increases substantially when colluding firms are investigated, and collusion is hardly sustainable after that, so for these firms a fine discount corresponds to a net reward. But the increase in the number of firms revealing information may well have come at the cost of a reduction in the overall cartel deterrence effect of the US Antitrust policy, as shown by Motta and Polo (1999) (See the Appendix for a formal sketch of the argument along the lines of Motta and Polo's model).

According to this paper a better route, which would have increased both the effectiveness (in terms of number of firms reporting) and the deterrence effect of the program, would have been to let colluding firms who report "hard" information when they are not under investigation get a substantial reward (for example, the monetary fines eventually paid by other colluding firms). As we show below, once one lets discounted fines become negative, i.e. spontaneously self-reporting firms be rewarded, leniency programs reserved to undetected cartels become very powerful. When rewards are sufficiently large and fines and rewards are pure transfers, they can *costlessly* deter *all* collusive agreements.

2 Set up

2.1 A *very* simple model

Let there be an economy with a number of mature oligopolistic industries each of which can be represented by an oligopolistic supergame between risk neutral firms. Let there also be a Legislator who, having forbidden collusive behavior, can set the following parameters within some limits dependant on exogenous factors:

1. A monetary fine F, with $F \in [0, \overline{F}]$, that a colluding firm has to pay if detected and proved guilty (non-monetary and fit-the-crime sanctions for marginal deterrence can easily be accommodated by the model).

2. A reduced fine RF (or reward, when $RF < 0$), with $RF \leq F$ and $RF \in [\underline{RF}, \overline{RF}]$, that a colluding firm can pay (or cash) instead of F if – when it is not under investigation – it spontaneously reveals "hard" information sufficient to prove guilty and fine other members of the cartel.

3. A budget $B \geq 0$ for an Antitrust Authority whose task is to investigate and prosecute firms that collude.

To keep things simple we assume that the AA has a given technology that transforms its budget into a per-period probability $\alpha(B)$ that each industry is inspected, with $\alpha'(B) > 0$, and that if an industry is inspected the AA is able to ascertain and prove for sure whether firms are colluding or not.[9]

Consider a representative industry in which N symmetric firms interact repeatedly in the infinite, discrete time, and discount future through a common factor δ, with $0 < \delta < 1$. As usual, absent the Legislator these firms can sustain any stationary collusive agreement A in subgame perfect Nash equilibrium if, for each firm i, with $i = 1, 2, ..., N$, short-run gains from unilaterally deviating are smaller than expected losses from the punishment phase triggered by the deviation. The correspondent algebraic condition for a representative firm i is

$$\widehat{\pi}_i^A - \pi_i^A \leq \delta \frac{\pi_i^A - \underline{v}_i}{1 - \delta}, \tag{1}$$

or, perhaps more familiarly,

$$\pi_i^A \geq (1 - \delta)\widehat{\pi}_i^A + \delta \underline{v}_i,$$

[9] This basic framework can be complicated in many ways without affecting the results. For example, one could easily introduce uncertainty with regard to the AA's ability to prove guilty a detected cartel and leniency programs open to firms under investigation, *à la* Motta and Polo (1999).

where π_i^A denotes firm i's static payoff from sticking to the collusive agreement A, $\widehat{\pi}_i^A$ denotes its static payoff from unilaterally deviating from the agreement and following its static best response strategy, and $\underline{v}_i$ denotes the time average payoff a deviating firm earns from the period after the deviation on, depending on the punishment strategies used to discipline the cartel. Of course $\widehat{\pi}_i^A > \pi_i^A$, and $\underline{v}_i < \pi_i^A$ because a deviating firm is punished as hard as possible in a well organized cartel.

We assume that the Legislator is benevolent and maximizes a (unspecified) welfare function strictly decreasing in the amount of collusion in the economy and in the cost of law enforcement. Since the exercise of collusive market power generates deadweight welfare losses, and resources spent in law enforcement are real costs for society, the Legislator will set the policy parameters $\{F,\ RF,\ B\}$ optimally to maximize the social gains from Antitrust law enforcement.[10]

2.2 Benchmark: no leniency programs

Consider first the situation of a representative industry when no leniency program is present, that is, when the Legislator has set $B > 0$, $F > 0$, and $RF = F$. Assume that if a firm is caught colluding in a period it has to pay the fine the following period, and that once detected firms cannot start again colluding in the future (because, say, they are kept under constant observation by the AA), as in Motta and Polo (1999). Then sticking to the agreed collusive strategies each firm i expects the profit stream

$$\pi_i^A + \delta\left[(1-\alpha)\pi_i^A + \alpha(\frac{\pi_i^N}{1-\delta} - F)\right] + \delta^2(1-\alpha)\left[(1-\alpha)\pi_i^A + \alpha(\frac{\pi_i^N}{1-\delta} - F)\right] + ...,$$

$$= \frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - F)}{1-\delta(1-\alpha)},$$

where π_i^N denotes firm i's payoff at the static Nash equilibrium of the static oligopoly (stage) game. Therefore, firms can sustain a collusive agreement A in subgame perfect Nash equilibrium if, for each firm i, $i = 1, 2, ..., N$, it holds

$$\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - F)}{1-\delta(1-\alpha)} \geq \widehat{\pi}_i^A + \frac{\delta\underline{v}_i}{1-\delta}. \tag{2}$$

[10] In the standard model of optimal law enforcement optimal deterrence may be partial even if law enforcement is costless (see e.g. Polinsky and Shavell, 1999). This is because, it is argued, when the benefit from a crime exceeds the harm it causes, the crime should not be deterred. In the case of cartels, according to the standard doctrine, there are no gains, only welfare neutral transfers from consumers to firms, plus the classical deadweight losses from market power. It follows that if enforcing Antitrust law were costless, the social optimum would be to completely deter cartels.

It is easy to verify that condition (2) is more stringent the larger are F and α, and since raising $\alpha(B)$ is costly, we obtain the organized crime version of Becker's (1968) celebrated result that the Legislator should set fines at their maximum.[11]

From now on, we will assume that the Legislator has optimally set $F = \overline{F}$ (the optimality of this choice, in this simple model, is not affected by changes in RF).

3 Analysis

3.1 "Moderate" leniency programs

Suppose the Legislator unexpectedly introduces a leniency program that reduces fines down to $RF < \overline{F}$ for colluding firms that, when they are not under investigation, spontaneously report "hard" information sufficient to prove their cartel guilty to the AA. Consider the most common case of "moderate" leniency programs, those which – as the US's and EU's ones – only reduce or cancel the sanctions against firms that spontaneously self-report (so that $0 \leq RF < \overline{F}$). We can state our first result.

Proposition 1 *The introduction of "moderate" leniency programs with* $RF \geq 0$ *makes collusion more difficult to sustain only if* $\frac{\pi_i^N - v_i}{1-\delta} > RF$*; it does not affect firms' ability to collude otherwise.*[12]

Proof. The introduction of the leniency program affects condition (2) either if it leads a colluding firm to report, so that the LHS of (2) changes, or if it leads a deviating

[11] When the strength of the available punishment depends on the size of the fines, as in McCutcheon (1997), then Becker's (1968) result may not obtain. In that framework it is $v(F)$, with $v'(F) < 0$ for $0 \leq F < F'$, where $v(F')$ is firms' minimax, because expected fines curb incentives to renegotiate punishments in a repeated Bertrand oligopoly. Then, starting from $F = 0$, a small increase in fines has no deterrence effect on cartel formation but it has a deterrent effect on price-wars renegotiation sufficient to facilitate collusion by making harder punishments credible (renegotiation-proof). Above some $F'' > 0$, the deterrence effect on cartel formation dominates that on punishment renegotiation, and further increases in F make collusion harder. Therefore, in that framework Becker's (1968) result obtains only if the maximum fine is sufficiently large.

[12] In this paper we state and/or prove all results by focusing on of how stringent the incentive constraint (2) becomes under different leniency programs. However, condition (2) is linear in the discount factor δ, collusive profits π_i^A, and the oligopoly's payoff structure (parametrized here by $\hat{\pi}_i^A$). When condition (2) becomes less stringent, given the strength of the punishment and two of these parameters, the set of values of the third parameter that satisfy the relation increases in size. Therefore, all our results can be directly reformulated in terms of the minimum discount factor at which a given agreement is supportable in a given oligopoly; or, given the discount factor, in terms of the size of the equilibrium set of a given oligopoly; or else, given the discount factor, in terms of the set of oligopolies in which a given agreement is sustainable.

firm to report, so that the RHS of (2) changes, or if does both. Consider a deviating firm. Its discounted expected payoff from deviating and reporting is $\widehat{\pi}_i^A + \frac{\delta\pi_i^N}{1-\delta} - \delta RF$; if, instead, it deviates but does not reports it expects $\widehat{\pi}_i^A + \frac{\delta\underline{v}_i}{1-\delta}$.

When

$$\widehat{\pi}_i^A + \frac{\delta\pi_i^N}{1-\delta} - \delta RF > \widehat{\pi}_i^A + \frac{\delta\underline{v}_i}{1-\delta} \qquad \Leftrightarrow \qquad \frac{\pi_i^N - \underline{v}_i}{1-\delta} > RF,$$

deviating and reporting dominates deviating but not reporting, and the RHS of (2) increases becoming $\widehat{\pi}_i^A + \frac{\delta\pi_i^N}{1-\delta} - \delta RF$. Consider then a colluding firm. Its expected payoff from not reporting and sticking to the collusive strategies is $\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)}$, while colluding and reporting delivers $\pi_i^A + \frac{\delta\pi_i^N}{1-\delta} - \delta RF < \widehat{\pi}_i^A + \frac{\delta\pi_i^N}{1-\delta} - \delta RF$, therefore colluding and reporting is always dominated by deviating and reporting. It follows that the LHS of (2) does not change, and that (2) becomes more stringent because of the increase in its RHS. This proves the first part of the statement.

When

$$\widehat{\pi}_i^A + \frac{\delta\pi_i^N}{1-\delta} - \delta RF \leq \widehat{\pi}_i^A + \frac{\delta\underline{v}_i}{1-\delta} \Leftrightarrow \frac{\pi_i^N - \underline{v}_i}{1-\delta} \leq RF,$$

either deviating and reporting is strictly dominated by deviating but not reporting (when $RF > 0$), or deviating and not reporting is undominated (when $RF = 0$). In the first case the firm never reports, so the RHS of (2) does not change. In the second case, $RF = 0$ implies that the firm's choice of whether or not to report does not affect the RHS of (2). Consider then a colluding firm. Its expected payoff from not reporting and sticking to the collusive strategies is $\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)}$. By the assumption that after the cartel is detected by the AA collusion is not supportable anymore, the firm expects – if it reports without deviating – the discounted payoff stream $\pi_i^A - \delta RF + \frac{\delta\pi_i^N}{1-\delta}$. From $\pi_i^A < \widehat{\pi}_i^A$ follows $\pi_i^A - \delta RF + \frac{\delta\pi_i^N}{1-\delta} < \widehat{\pi}_i^A + \frac{\delta\underline{v}_i}{1-\delta}$, and since inequality (2) must be satisfied for the firm to be colluding in the first place, it must be

$$\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)} > \widehat{\pi}_i^A + \frac{\delta\underline{v}_i}{1-\delta} > \pi_i^A - \delta RF + \frac{\delta\pi_i^N}{1-\delta}.$$

This implies that for a colluding firm reporting is strictly dominated by not reporting, and that the LHS of (2) also does not change. The second part of the statement follows. ■

Whether moderate leniency programs have any effect at all in this model depends on the punishment strategies firms use. If the underlying oligopoly game is *à la* Cournot and firms use Abreu's (1986) optimal punishment strategies, then $\pi_i^N > \underline{v}_i$

and there may be a small deterrence effect. This effect, though, is subtle. It is due to the possibility the leniency program offers to a deviating firm to avoid the harsh punishment phase, by revealing information to the AA and transforming it into trigger strategy (a kind of "forced renegotiation" of the punishment phase). Revealing makes collusion impossible in the future, and therefore two-phase optimal punishments not sustainable (they are enforced by the carrot of future collusion), leading to discounted profits $\frac{\pi_i^N}{1-\delta} > \frac{\underline{v}_i}{1-\delta}$. Then, when $\frac{\pi_i^N - \underline{v}_i}{1-\delta} > RF$, the leniency program makes deviations more attractive and condition (2) more stringent.

If, on the other hand, firms discipline the collusive agreement using trigger strategies (Friedman, 1971), as assumed in Motta and Polo (1999); or if the oligopoly game is *à la* Bertrand, so that optimal punishments are payoff-equivalent to unrelenting trigger strategies; or if – more realistically – the strength of the punishment is limited by the finite cost of renegotiating it, as in Blume (1994) and McCutcheon (1997), then $\frac{\pi_i^N - \underline{v}_i}{1-\delta} \leq 0$ and moderate leniency programs cannot affect firms' ability to collude. We believe this second case to be the relevant one in reality, and therefore that moderate leniency programs directed to firms not under investigation, so common in reality, have not much sense.

Of course, one can soften this result by complicating the model, for example introducing trembles, asymmetric information, uncertainty, risk aversion, etc. However, its general flavor will not change.[13] Proposition 1 explains why the first US Corporate Leniency Program for Antitrust law violations, which was very moderate and restricted to reporting firms who are not yet under investigation, *could not* be effective in inducing colluding firms to report.

3.2 "Courageous" leniency programs

Suppose that, having moderate leniency programs proved ineffective, the Legislator (again unexpectedly) introduces more highly-powered incentives to self-report. Suppose it lets reduced fines become negative, that is, become rewards for colluding firms who are not under investigation and yet spontaneously self-report. We can then state the next result.

[13] With trembles, considerations of "risk dominance" may become relevant (see Harsanyi and Selten, 1988). Then, particularly when the number of would-be colluding firms is large, even moderate leniency programs might somewhat reduce firms' ability to collude. When gains from collusion are small and fines are large, firms may prefer to self-report just to avoid the risk to be fined because an other firm reports. We did not purse this argument in depth here because the formal theory of "risk dominance," to our knowledge, has not yet been extended to the case of dynamic games. Moreover, none of our results would be affected in its substance by introducing trembles and risk dominance considerations.

Proposition 2 *Suppose* $\underline{RF} < 0$, *and let* $RF' = \frac{\pi_i^N - \underline{v}_i}{1-\delta}$. *Then, whatever punishment strategies firms use to enforce collusion, for* $RF < RF'$ *the smaller is* RF *the more stringent is the incentive constraint for any collusive agreement to be supportable in subgame perfect Nash equilibrium in any oligopoly.*

Proof. Again the introduction of the leniency program affects condition (2), if its LHS, or its RHS, or both change. A deviating firm's discounted expected payoff from deviating and reporting is $\widehat{\pi}_i^A + \frac{\delta \pi_i^N}{1-\delta} - \delta RF$; if, instead, it deviates but does not reports, it expects $\widehat{\pi}_i^A + \frac{\delta \underline{v}_i}{1-\delta}$. Then, whatever $\underline{v}_i$ is, the inequality

$$\widehat{\pi}_i^A + \frac{\delta \pi_i^N}{1-\delta} - \delta RF > \widehat{\pi}_i^A + \frac{\delta \underline{v}_i}{1-\delta}$$

can be satisfied by a sufficiently low RF, such that

$$RF < RF' = \frac{\pi_i^N - \underline{v}_i}{1-\delta}.$$

Since $\widehat{\pi}_i^A + \frac{\delta \pi_i^N}{1-\delta} - \delta RF > \widehat{\pi}_i^A + \frac{\delta \underline{v}_i}{1-\delta}$, when $RF < RF'$ a firm that chooses to deviate also reveals information, so the RHS of the incentive constraint (2) increases to $\widehat{\pi}_i^A + \frac{\delta \pi_i^N}{1-\delta} - \delta RF$. Consider then a colluding firm. If it reports without deviating, it expects the discounted payoff stream $\pi_i^A - \delta RF + \frac{\delta \pi_i^N}{1-\delta}$, and since $\pi_i^A < \widehat{\pi}_i^A$ this choice is strictly dominated by that of deviating and revealing. It follows that a firm will either collude and not reveal or deviate and reveal, and that for $RF > RF'$ the incentive compatibility condition for a collusive agreement A being supportable is

$$\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1 - \delta(1-\alpha)} \geq \widehat{\pi}_i^A + \frac{\delta \pi_i^N}{1-\delta} - \delta RF,$$

which, by inspection, is more stringent the smaller RF is. ■

The intuition is, of course, that for $RF < RF' = \frac{\pi_i^N - \underline{v}_i}{1-\delta}$, the leniency program increases firms' short-run gains from unilaterally deviating (and reporting), while leaving unaffected their expected gains from collusion.

3.3 Optimal leniency programs when fines and rewards are pure transfers

We assumed that the Legislator's objective function is decreasing in the costs of antitrust law enforcement and in the deadweight losses from the exercise of collusive market power. As we wrote, in the law and economic literature monetary fines are

traditionally considered pure transfers, so that their level does not enter the evaluation of the welfare effects of a given policy. If we follow this tradition, the only real cost of antitrust policy in the model is the amount of resources B consumed by the AA. On the other hand, reducing RF below RF' (increasing the reward for revealing firms) costlessly increases the deterrence effect of the leniency program. This leads us to the next result.

Proposition 3 *Suppose (positive and negative) fines are pure transfers. Then, unless that there exist* $RF'' > \underline{RF}$ *such that all collusion is deterred at* $\alpha = 0$ *and* $RF = RF''$*, any optimal leniency program has* $RF = \underline{RF}$*.*

Proof. Suppose first that an optimal leniency program $LP^1 = \left\{RF^1, \alpha^1, \overline{F}\right\}$ has $\alpha^1(B^1) > 0$ and $RF^1 > \underline{RF}$. By Proposition 2 and the assumption that fines are welfare-neutral, decreasing RF below RF^1 costlessly increases collusion deterrence. Then, by marginally decreasing both α and RF the legislator can obtain the same policy result (the same amount of deadweight losses from collusion) at a smaller social cost $B < B^1$, which contradicts the initial hypothesis.

Suppose now that an optimal leniency program $LP^2 = \left\{RF^2, \alpha^2, \overline{F}\right\}$ has $\alpha^2(B^2) = 0$ and $RF^2 > \underline{RF}$. By Proposition 2, the assumptions that fines are welfare-neutral, and the assumptions that there exist no $RF' > \underline{RF}$ such that all collusion is deterred at $\alpha = 0$ and $RF = RF'$, decreasing RF below RF^2 the Legislator can costlessly reduce deadweight losses from collusion, which again contradicts the hypothesis. ■

In other words, the optimal policy is to set rewards for self-reporting firms maximal. This result for leniency programs against organized crime corresponds to Becker's (1968) result that fines should be set maximal in normal law enforcement.

Now let the superscript j indicate the industry in which collusion is easier to sustain among those where collusion was sustainable in the absence of a leniency program. Let X solve

$$\delta X = \left[\frac{\pi_i^{A^* j}}{1-\delta} - \widehat{\pi}_i^{A^* j} - \frac{\delta \pi_i^{Nj}}{1-\delta}\right],$$

where A^{*j} is the more easily enforced collusive agreement in industry j. Then we can state a straightforward but noteworthy corollary.

Corollary 1 *When* $\underline{RF} \leq X$ *optimal leniency programs completely and costlessly deter collusion.*

Proof. Follows straightforwardly from Proposition 2.

By setting RF so that $\underline{RF} \leq RF \leq X$, no cartel is sustainable, as every firm in any cartel would prefer to immediately deviate, turn in its partners and cash the reward. Then optimally designed leniency programs make the public enforcement of Antitrust law against cartel redundant (and suboptimal).

4 Optimal leniency programs with costly collection of fines and public funds

When administering sanctions is costly, Becker's result that these should be set maximal to save on investigation costs changes only if the cost of administering sanctions increases with their size, so that the marginal cost of increasing the sanction is positive (Kaplow, 1990). When this is the case F and α should be optimally set to equate the marginal cost of crime deterrence by raising the fines, the marginal cost of crime deterrence by increasing investigation activity, and the marginal social gain from increasing crime deterrence. If, instead, the cost of administering sanctions is fixed (or decreasing), as is perhaps more reasonable to assume for monetary fines, then these should again be set maximal. For simplicity from now on we will focus only on the case of a fixed cost of administering fines.

An analogous argument applies to fine discounts and rewards within a leniency program, and we can state it as a proposition without proof.

Proposition 4 *Suppose the cost of administering rewards is fixed but not prohibitive, and that there exist no $RF'' > \underline{RF}$ such that all collusion is deterred at $\alpha = 0$ and $RF = RF''$. Then any optimal leniency program has $RF = \underline{RF}$.*

Suppose the marginal cost of administering rewards is positive. Then optimal leniency programs equate the marginal costs of increasing deterrence respectively by lowering RF and by raising α, and the marginal social gain from increasing collusion deterrence.

Compared to fines, rewards are normally more costly policy instruments because of the additional frictions and distortions present in the process of collecting the funds necessary to finance them (e.g. when taxation is not neutral, or tax compliance is not automatic). Also, because these costs increase with the size of the rewards, the most reasonable assumption is that the marginal cost of reducing RL below 0 (of raising the reward $-RL$) is increasing in $-RL$.

4.1 Only the first comer should be entitled to fine reductions

Motta and Polo note that the counterproductive effect on deterrence typical of leniency programs opened to firms under investigation is reduced if eligibility to the program is restricted to the first firm that reports about a cartel, as in the EU's leniency program.

It turns out that also in leniency programs for undetected firms it is optimal to restrict eligibility to the first firm that reports hard information on its cartel, even though these programs have no counterproductive effect on deterrence. This is because the overall deterrence effect of leniency programs for undetected firms (as that of leniency programs for firms under investigation) depends only on the increased incentives for (at least) one firm revealing, and is independent of the number of firms that effectively report. Given that high rewards are costly to administer, restricting eligibility to a courageous leniency programs for undetected firms to one colluding firm only allows to minimize the costs of antitrust policy (only one reward per cartel that brakes up is paid) while achieving the same policy result (the same amount of deterrence). Let us state this conclusion more formally.

Proposition 5 *Suppose fines* $(RF, F > 0)$ *are less costly to administer than rewards* $(RF < 0)$*. Then, if the cost of administering rewards is not prohibitive and* $\underline{RF} < 0$*, any optimal leniency program is restricted to the first firm that reports information about a cartel.*

Proof. Both when only the first reporting firm and when all a cartel's firms that report information are entitled to the reward RF, the leniency program, a representative collusive agreement A is supportable in any given industry if, for each firm i,

$$\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)} \geq \max\left\{\widehat{\pi}_i^A + \frac{\delta\underline{v}_i}{1-\delta};\ \widehat{\pi}_i^A - \delta RF + \frac{\delta\pi_i^N}{1-\delta}\right\}.$$

Therefore, the collusion deterrence effect is identical in the two cases. Consider a representative cartel A' which breaks down for the introduction of the leniency program, i.e. such that

$$\widehat{\pi}_i^{A'} + \frac{\delta\underline{v}_i}{1-\delta} \leq \frac{\pi_i^{A'} + \delta\alpha(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)} < \widehat{\pi}_i^{A'} - \delta RF + \frac{\delta\pi_i^N}{1-\delta}.$$

When only the first reporting firm is entitled to the reward, each firm's expected profits the period after the introduction of the leniency program is $\overline{F} - \frac{\overline{F}-RF}{N} + \frac{\pi_i^N}{1-\delta}$ (each firm has a $1/N$ chance of being the first to report), and $N-1$ fines $\overline{F}$ and one reward RF is paid.

When all a cartel's firms that report are entitled to the fine reduction of the leniency program, each firm's expected profits the period after the introduction of the leniency program is $RF + \frac{\pi_i^N}{1-\delta}$ (each firm has a probability $1/N$ of being the first to report), and N rewards RF are paid.

Since the cost of administering the reward, denoted by $c^P(RF\,|_{RF<0})$, is larger than the cost of administering a normal fine, denoted by $c^{\overline{F}}$, the cost of a leniency program open to all reporting firms, $Nc^P(RF)$, is strictly larger than the cost $(N-1)c^{\overline{F}} + c^P(RF)$ of a leniency program restricted to the first reporting firm only. And because the deterrence effect of the two programs is identical, it is always optimal to introduce the restriction. ■

4.2 The optimal allocation of revenue from fines

We wrote above that rewards (negative fines $RL < 0$) are usually more costly policy instruments than fines because of the additional frictions in the process of collecting the funds necessary to finance them; and that since these frictions increase with the size of the rewards (with the amount of funds to collect), the marginal cost of increasing rewards is positive. Then the Legislator can economize on the cost of raising revenue to pay rewards by allocating the revenue he obtains from fines directly to the reward to pay to the revealing firm. We can state this formally.

Proposition 6 *Suppose that the cost of collecting fines is fixed, while the cost of collecting public funds is increasing in the amount of funds collected. Then any optimal leniency program allocates to the first firm that self-reports all revenue from monetary fines $\overline{F}$ when $\sum_{-i}\overline{F} \leq -\underline{RF}$, and an amount $-\underline{RF}$ of that revenue when $\sum_{-i}\overline{F} > -\underline{RF}$.*

Proof. Suppose an optimal leniency program allocates a fraction $k < 1$ of the revenue from fines $(N-1)\overline{F}$ to the reward for the revealing firm, and that $k(N-1)\overline{F} < -RF \leq -\underline{RF}$. Then, for each cartel that breaks down, the leniency program costs $(N-1)c^{\overline{F}} + c^P(RF - k\overline{F})$. Moreover, if the marginal cost of deterring corruption by reducing RF at $RF = \underline{RF}$ is larger than the marginal welfare gain from increased deterrence, then $RF > \underline{RF}$ by Proposition 5. Consider now an increase in k. Since $c^P(RF - k\overline{F})$ is an increasing function, for given RF increasing k reduces the cost of the leniency program, and when $RF > \underline{RF}$ because of Proposition 5, it also increases the optimal level of collusion deterrence. This contradicts the hypothesis that the initial allocation was optimal. ■

In reality administrative and political constraints may make it hard to collect public funds for financing rewards for colluding firms that self-report. Then, when high

rewards can in principle be paid (when $\underline{RF}$ is sufficiently low), an optimal corporate leniency program make the first firm that spontaneously reports hard information on a cartel full residual claimant for the monetary fines eventually paid by other firms of the cartel; that is, it sets the reward $-RF$ for the revealing firm i equal to the sum of the fines paid by the other firms $\sum_{-i} \overline{F}$.

4.3 Targeting a pre-specified firm is counterproductive

Motta and Polo (1999) argue that the adverse effects of leniency programs for firms under investigation on collusion deterrence can be further reduced with respect to the first comer rule by a rule that determines ex ante which reporting firm is the only one entitled to a reduced fine if it reveals information (e.g. the first in alphabetical order, or the one located more north). In contrast, here we show that for leniency programs for undetected firms this rule is strongly counterproductive.[14] We can state the following result.

Proposition 7 *As long as the leniency program is effective, i.e. for any RF such that* $RF < \frac{\underline{v}_i - \pi_i^N}{1-\delta}$*, a rule that pre-determines the firm eligible to the leniency program strictly reduces the deterrence effect of the program with respect to the first comer rule.*

Proof. When the leniency program is effective, so that

$$\widehat{\pi}_i^A - \delta RF + \frac{\delta \pi_i^N}{1-\delta} > \widehat{\pi}_i^A + \frac{\delta \underline{v}_i}{1-\delta},$$

a representative collusive agreement A is supportable in any given industry if, for each firm i, it holds

$$\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)} \geq \widehat{\pi}_i^A - \delta RF + \frac{\delta \pi_i^N}{1-\delta}.$$

The pooled incentive constraint across firms is then

$$\sum_{i \in N} \left[\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)} \geq \widehat{\pi}_i^A - \delta RF + \frac{\delta \pi_i^N}{1-\delta} \right]$$

and, by symmetry, the pooled incentive constrain is satisfied if each individual constraint is, and *vice versa*.

[14] In the Appendix we argue that their conclusion is problematic also in their framework. Under less restrictive assumptions than theirs on the allocation of the collusive rent firms, in leniency programs open to firms under investigation the pre-determined firm rule is fully equivalent to the first comer rule.

Consider now a rule that determines ex ante which reporting firm is the only one entitled to the benefits of the leniency program. If firm j is the one entitled to the program, a representative collusive agreement A is supportable in any given industry if

$$\frac{\pi_j^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)} \geq \widehat{\pi}_j^A - \delta RF + \frac{\delta\pi_j^N}{1-\delta},$$

and, for $i \in N$, with $i \neq j$,

$$\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)} \geq \widehat{\pi}_i^A + \frac{\delta\underline{v}_i}{1-\delta}.$$

Now the pooled incentive constrain across firms is

$$\sum_{i\in N}\left[\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)}\right] \geq \sum_{i\in N,\ i\neq j}\left[\widehat{\pi}_i^A + \frac{\delta\underline{v}_i}{1-\delta}\right] + \widehat{\pi}_i^A - \delta RF + \frac{\delta\pi_i^N}{1-\delta},$$

which, by inspection, is strictly less stringent than the pooled incentive constraint with the first comer rule. As long as firms are free to reallocate the collusive rent (market shares) as they wish, a collusive agreement A is sustainable as long as the pooled incentive constraint is satisfied. It follows that collusion is easier with a rule that determines ex ante the entitled firm than with the first comer rule. ■

Under the first comer rule, any firm can get the fine reduction as long as it is the first one to report, therefore the increase in gains from a unilateral deviation linked to the possibility to also reveal and get $-RF$ must be deterred for all the firms. A rule that identifies ex ante the firm eligible to the leniency program limit to one firm only the increase in gains from a unilateral deviation, allowing other firms to offset this increase by increasing the collusive market share of that firm.

5 Extensions

5.1 Treble damages

When a cartel is successfully prosecuted, *all* former cartel members, including firms that self-reported and cooperated with the Antitrust Authority, are exposed to suits for damages from their customers. How does this feature of reality affects our analysis?

It is easy to realize that taking damages into account reinforces all our conclusions. Let $E[D]$, with $E[D] > 0$, denote the damages a firm expects to pay if caught colluding by the Antirust Authority, and $E[RD]$, with $E[RD] \geq 0$, the damages a firm that

spontaneously self-reports expects to pay, with $E[RD] \leq E[D]$ (at present, both in the EU and in the US it is $RD = D$, but in the light of our previous results it is not hard to see why one may wish to protect reporting firms by setting $E[RD] < E[D]$.). Now let us redefine variables in the previous sections so that $F = MF + E[D]$ and $RF = RMF + E[RD]$, where MF and RMF stand for "monetary fines" and "reduced monetary fines" respectively. Then, it is immediate to verify that *all our propositions continue to hold*, and that *the minimum reward for self-reporting firms necessary for the leniency program to have any deterrence effect increases.*

Moreover, if we allow $E[RD]$ and $E[D]$ to differ, it becomes clear that as long as increasing rewards for self-reporting firms is more costly than modifying the law to protect them from damage suits, the Legislator's optimal policy is to set $E[RD] = 0$.

5.2 Uncertain benefits

The EU's Antitrust law establishes that only after the firm has reported its information and this has been evaluated, the AA will judge whether the firm is eligible to the benefits of the leniency program and set the actual fine discount. Analogously, in the US only amnesty from criminal prosecution is automatic for firms that spontaneously self-report. The reduction in fines is decided case by case, after firms have reported information. This means that at the time a firm decides to report, it only has an expectation $E[RF]$ over the reduced fines it will eventually face. As in the case of damages, we can simply substitute RF with $[RF]$ in the previous sections and verify that *all previous results continue to hold* when the benefits from the leniency program are uncertain.

5.3 Restitution

In the US, to obtain leniency self-reporting firms are required to pay back collusive profits to customers "if they can," that is, if this do not drive them bankrupt (see Spratling, 1998). It is easy to verify that when self-reporting firms must pay back realized collusive profits to customers, again *all previous results continue to hold* and *the minimum reward for self-reporting firms necessary for the leniency program to have any deterrence effect increases.* The logic behind this conclusion is straightforward. With the restitution requirement, a firm that spontaneously self-reports not only loses expected future collusive rents, as in our simplified setting, it even loses (at least part of) *past* collusive profits! Then, higher rewards are needed to compensate for these additional losses if one wish to deter cartels by inducing firms to spontaneously self-report.

5.4 Violence

A very similar argument applies when colluding firms arrange for credible, violent sanctions against cartel members that turn them down. In many countries this is not such an improbable hypothesis. For example, Gambetta and Reuter (1995) argue that, in Sicily, Mafia has met the enforcement demand of oligopolistic firms with a (compulsory) supply of coordination and enforcement services, particularly in procurement auction markets. In these situations, firms (or executives) that self report risk a lot. To be effective, leniency programs must compensate for this risk by providing protection and, when protection becomes too costly at the margin, by increasing rewards. Again, *all our previous results continue to hold* and *the minimum reward for self-reporting firms necessary for the leniency program to have any deterrence effect increases.*

6 Appendix. "Moderate" leniency programs for firms under investigation

As we wrote, the effectiveness of the US Corporate Leniency Program increased, in terms of number of firms reporting, when it was opened to firms already under investigation. This happened because a firm under investigation has a very high probability of being fined and little hopes to collude in the future, which turns a fine reduction into a reward. Motta and Polo (1999) showed that this increase may have came at the cost of a reduction in the deterrence effect of the Antitrust law against cartels. To see how this can happen, we can follow their model and assume the probability that a colluding firm is caught and fined to be the product of the probability of being investigated $\alpha(B) < 1$ and the probability of investigated firms being proven guilty $p(B) < 1$, and that if an industry is investigated but firms are not proven guilty the industry is never investigated again. Then, in the absence of a leniency program or with a moderate leniency program restricted to firms not under investigation, from sticking to the agreed collusive strategies each firm i expects the profit stream

$$\pi_i^A + \delta(1-\alpha)\pi_i^A + \delta\alpha\left[(1-p)\frac{\pi_i^A}{1-\delta} + p(\frac{\pi_i^N}{1-\delta} - \overline{F})\right] + \delta^2(1-\alpha)^2\pi_i^A +$$
$$+\delta^2\alpha(1-\alpha)\left[(1-p)\frac{\pi_i^A}{1-\delta} + p(\frac{\pi_i^N}{1-\delta} - \overline{F})\right] + ...,$$

or

$$\frac{\pi_i^A\left(1+\frac{\delta\alpha(1-p)}{1-\delta}\right) + \delta\alpha p(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)},$$

so that the incentive compatibility condition for collusion to be supported by the representative firm in a representative industry is

$$\frac{\pi_i^A\left(1+\frac{\delta\alpha(1-p)}{1-\delta}\right) + \delta\alpha p(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)} \geq \widehat{\pi}_i^A + \frac{\delta\underline{v}_i}{1-\delta}.$$

6.1 Fine reductions for all reporting firms

Suppose that, having proved ineffective when restricted to firms not yet under investigation, the moderate leniency program is (again unexpectedly) extended to firms under investigation with all reporting firms are entitled to the fine reduction. That is, firms already under investigation can now choose between not reporting and paying the full fine $\overline{F}$ with probability p, and reporting and paying a reduced fine $0 \leq RF < \overline{F}$.

Firms under investigation that decide to report would also like to deviate unilaterally from the collusive agreement, since after a cartel is detected firms cannot collude anymore in the future, the hardest punishment cannot be worse than playing the static Nash equilibrium forever. However, by symmetry, this holds for all firms simultaneously. Therefore when an investigation starts that make deviating and revealing information profitable, it becomes common knowledge that all firms will abandon the collusive agreement and play according their best response strategies, so that the static Nash equilibrium of the oligopoly stage game emerges.

Therefore, firms report when

$$(1-p)\frac{\pi_i^A}{1-\delta} + p(\pi_i^A + \delta\frac{\pi_i^N}{1-\delta} - \overline{F}) \leq \widehat{\pi}_i^A + \delta\frac{\pi_i^N}{1-\delta} - RF, \tag{3}$$

but their expected payoff when revealing is only

$$\frac{\pi_i^N}{1-\delta} - RF.$$

Suppose now that p is sufficiently large, so that condition (3) is satisfied by our moderate leniency program with $0 \leq RF < \overline{F}$. Then, sticking to the agreed collusive strategies each firm i expects the profit stream

$$\pi_i^A + \delta(1-\alpha)\pi_i^A + \delta\alpha\left[\frac{\pi_i^N}{1-\delta} - RF\right] + \delta^2(1-\alpha)^2\pi_i^A + \delta^2\alpha(1-\alpha)\left[\frac{\pi_i^N}{1-\delta} - RF\right] + ...,$$

or

$$\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - RF)}{1-\delta(1-\alpha)},$$

and by (3)

$$\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - RF)}{1-\delta(1-\alpha)} > \frac{\pi_i^A\left(1 + \frac{\delta\alpha(1-p)}{1-\delta}\right) + \delta\alpha p(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)}.$$

Therefore, after the moderate leniency program is extended to firm under investigation, the incentive compatibility condition for collusion to be supportable

$$\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - RF)}{1-\delta(1-\alpha)} \geq \widehat{\pi}_i^A + \frac{\delta\underline{v}_i}{1-\delta},$$

becomes strictly less stringent. In other words, the extension of the leniency program to firms under investigation facilitates collusion.

6.2 Reduced fines only for one reporting firm

Motta and Polo show that this counterproductive effect of leniency programs open to firms under investigation is reduced, although non necessarily eliminated, if eligibility to the leniency program's benefits is restricted to the first firm that reports. Then, a firm has only a probability $\frac{1}{N}$ of getting the fine reduction if an investigation is opened, and although it still reveals if (3) is satisfied, its expected gains from colluding are reduced to

$$\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - (\overline{F} - \frac{\overline{F}-RF}{N}))}{1-\delta(1-\alpha)},$$

strictly smaller than when eligibility is not restricted,

$$\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - RF)}{1-\delta(1-\alpha)},$$

although still possibly larger than without leniency program,

$$\frac{\pi_i^A \left(1 + \frac{\delta\alpha(1-p)}{1-\delta}\right) + \delta\alpha p(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)},$$

depending on $\overline{F} - RF$ and N.

Motta and Polo also argue that the adverse effect can be further reduced with respect to the first comer rule by an alternative rule that determines ex ante which reporting firm is entitled to a fine reduction. This should be the case because while for the firm entitled to the leniency program the condition to support collusion is as when all revealing firms are entitled to the fine reduction,

$$\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - RF)}{1-\delta(1-\alpha)} \geq \widehat{\pi}_i^A + \frac{\delta\underline{v}_i}{1-\delta},$$

which is laxer than under the first comer rule, for firms not entitled to fine reductions the incentive compatibility condition would be

$$\frac{\pi_i^A + \delta\alpha(\frac{\pi_i^N}{1-\delta} - \overline{F})}{1-\delta(1-\alpha)} \geq \widehat{\pi}_i^A + \frac{\delta\underline{v}_i}{1-\delta},$$

which is more stringent than under the first comer rule. Since also these more stringent conditions must be satisfied, the pre-determined firm rule would eliminate the adverse effect of the leniency program on collusion deterrence.

This argument is problematic because it hinges on the unpalatable implicit assumption that even though firms are asymmetric with respect to the leniency program,

the allocation of the collusive rent (of collusive market shares) must still be symmetric. Instead, one would imagine that the firm entitled to the leniency program, whose incentive constraint is laxer, would be happy to optimally restrict its stake of collusive profits (its market share) in favor of the other firms', if this allow their incentive constraints to be also satisfied and collusion to be supported. It is straightforward to check that if we allow firms to endogenously and optimally choose the allocation of collusive profits, they would choose an asymmetric allocation that compensates for the asymmetry introduced by the leniency program making the incentive constraints for collusion equally stringent for all firms. Then the pre-determined firm rule is fully equivalent to the first comer rule, because the pooled incentive constraints for all firms in the cartel is the same under the two rules: under the first comer eligibility rule the pooled incentive constraint is

$$\sum_{i\in N}\left[\frac{\pi_i^A+\delta\alpha(\frac{\pi_i^N}{1-\delta}-(\overline{F}-\frac{\overline{F}-RF}{N}))}{1-\delta(1-\alpha)}\right]\geq\sum_{i\in N}\left[\widehat{\pi}_i^A+\frac{\delta\underline{v}_i}{1-\delta}\right]$$

$$\Rightarrow\frac{N\pi_i^A+\delta\alpha(N\frac{\pi_i^N}{1-\delta}-(N-1)\overline{F}-RF)}{1-\delta(1-\alpha)}\geq N\left[\widehat{\pi}_i^A+\frac{\delta\underline{v}_i}{1-\delta}\right];$$

while under the pre-determined firm eligibility rule, the pooled incentive constraint is

$$\frac{\pi_i^A+\delta\alpha(\frac{\pi_i^N}{1-\delta}-RF)}{1-\delta(1-\alpha)}+(N-1)\frac{\pi_i^A+\delta\alpha(\frac{\pi_i^N}{1-\delta}-\overline{F})}{1-\delta(1-\alpha)}\geq N\left[\widehat{\pi}_i^A+\frac{\delta\underline{v}_i}{1-\delta}\right],$$

which also implies

$$\frac{N\pi_i^A+\delta\alpha(N\frac{\pi_i^N}{1-\delta}-(N-1)\overline{F}-RF)}{1-\delta(1-\alpha)}\geq N\left[\widehat{\pi}_i^A+\frac{\delta\underline{v}_i}{1-\delta}\right].$$

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Non-Technical Summary

Leniency programs are modifications of the law that reduce sanctions against a wrongdoer if this reports his or her behavior to the law enforcing agency. The paper focuses on the optimal design of leniency programs when the aim of the legislator is deterring *organized crime*: price-fixing cartels, Mafia's and gangs' activities, corruption, illegal trade (smuggling, drugs and arms dealing), and any other form of crime exercised at too large a scale for an isolated individual.

The "moderate" leniency programs used in reality, that only reduce or at best cancel sanctions for a self-reporting agent, are shown to have little/no deterrence effect against long-term criminal relations. This is because, if such relations were enforced before the introduction of the leniency program, it means that there where sufficient expected gains from the relation to both curb incentives to cheat and compensate for the probability of being caught and sanctioned. Then, self-reporting within a leniency program that reduces or cancels the sanctions for a reporting agent brings this agent only a loss of expected gains from the relation.

"Courageous" leniency programs are then considered – that allow wrongdoers that self-report to be rewarded – and "optimal" leniency programs are characterized under different assumptions about the costs of administering sanctions and rewards.

Optimally designed leniency programs for undetected wrongdoers are shown able – in principle – to costlessly and completely deter cartels and other illegal transactions enforced by reputational considerations.