The Leniency Policy’s Deterrent Effects on Failing Cartels

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Abstract

Much of the recent success of antitrust authorities in detecting and prosecuting cartels has been attributed to the introduction of leniency programs. However, critics claim that leniency programs only capture failing cartels. This raises concerns since leniency applications could suck up antitrust authorities’ resources without necessarily enhancing deterrence. In this paper, we present a model where only firms participating in failing cartels would apply for leniency. Contrary to the critics, we show that leniency programs can actually enhance deterrence by placing firms into a Prisoner’s Dilemma situation.

JEL Codes: K21; K42; L41

Keywords: Leniency Program, Failing Cartels, Anti-trust Law Enforcement, Collusion

1 Introduction

The fight against cartels has long been at the forefront of competition authorities’ concern in both sides of the Atlantic.1 Commissioner Neelie Kroes2 stated that cartel enforcement "is at the very top of the priorities of the Commission". Besides, the strong EC commitment against cartels can be seen through the huge increase in the number of detected cartel cases and in the average size of fines imposed on firms in connection to cartel activity (see Appendix 1).

Leniency policy is a program that grants a reduction in the fine imposed to the colluding firm(s) that reports the cartel activity to the antitrust authorities. This can destabilise the cartel by putting the firms against each other since only the first one to report the anticompetitive practice will benefit from full

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1European Competition Law Annual (2006), introduction p.i
2In the opening speech at the 11th Competition Law and Policy Workshop, EUI, 2006.
immunity from the fine. An effective leniency program will lead cartel members to confess their conduct to the authorities (desistance) but also will discourage firms from joining a cartel agreement in the first place (deterrence). The introduction of leniency programs is viewed as the biggest success for cartel detection and deterrence leading to a dramatic increase in the number of cases brought to the attention of the antitrust authorities. Hammond (2000) views the Amnesty program in the US as "unquestionably the most important investigative tool available for detecting and cracking cartel activity". The greatest advantage of a leniency program is that it brings crucial evidence to the antitrust authorities. In cartel cases the establishment of guilt can become very difficult without the discovery of an explicit agreement and therefore leniency can greatly facilitate this information gathering. Much attention has been attracted in leniency after the revision of the leniency program in the US in 1993. Since then, leniency programs have been introduced in more than 30 countries and in the European Commission. The figure in appendix 2 demonstrates the crucial role of the leniency program in practice. It shows that the great majority of cases prosecuted by the EC since 2000 involve firms that received immunity from fines, due to the leniency program.

Nevertheless, despite this apparent success in practice, there are some more skeptical views arguing that leniency applications might not be as effective. First, the main problem with cartels is that we cannot know how many of them exist in our economy. Therefore, it is empirically very hard (if not impossible) to estimate whether the introduction of the leniency program has increased deterrence. The higher number of prosecuted cases could simply be the result of an increase in cartel activity. Furthermore, leniency inherently lowers the expected fine for the firms and therefore reduces the expected cost of entering into cartels. An important trade off arises (see Motta and Polo (2003), Chen and Rey (2007)): while leniency programs induce firms to report their information and evidence to the antitrust authorities (the procompetitive effect), they also reduce the expected penalty that firms will face when they enter such an agreement (the anticompetitive effect). Moreover, there are concerns that the EC leniency program is not effective in itself but it benefits from the effectiveness of the US leniency program (see Stephan (2005)).

Finally, and most relevant for our paper, some practitioners and academics have argued that leniency programs (only) attract failing cartels and would therefore not improve ex ante deterrence. More specifically, Stephan (2005) finds that many cartels discovered through leniency applications "had failed or ceased to operate because of market conditions (...), before being revealed to the Commission by a cartel member". For example, the Carbonless Paper cartel (2001)
faded because the market for self copying paper was in decline in the face of new technology. In the case with the highest fine at the time, the Vitamins cartel (2001), the colluding agreement had ceased in most market segments, due to the emergence of new Chinese products. The Sodium Gluconate cartel (2002) suffered from falling profits due to escalating production costs throughout the 1990s. Therefore, Stephan (2005) considers that leniency applications are a consequence of "leaving the sinking ship" with firms looking at their interest. Further, concerning deterrence he suggests that "the leniency notice may have benefited collusion by taming the endgame for one of the players". In a similar spirit, Guersent (2006) suggests that "firms usually do not rush to report young and well functioning cartels; they only come in and apply for leniency policy when things become more problematic". Also Grout (2006), commenting on the results obtained by Langus and Motta (2007) on the effect of an antitrust investigation to the stock market valuation of a firm, argues that financial markets must predict that the "detected cartels must not have much life left in them". Cartel agreements might fail either because of market conditions, or even because of an exogenous change in the antitrust authority enforcement parameters. More specifically, Motta and Polo (2003) suggest that the leniency policy can lead to desistance in a situation where the probability of detection of the cartel activity rises. Similarly one can imagine that a cartel fails because the fine that the antitrust authorities impose on the colluding firms increases.

This paper aims to investigate the argument that leniency programs only attract failing cartels. This would enable us to examine whether the introduction of leniency programs enhances deterrence and would guide us to provide some policy conclusions. In a context of no uncertainty about market conditions and about enforcement parameters, we show that firms would internalise the presence of leniency programs into their ex ante decision to collude. Therefore, we would observe no leniency applications at equilibrium since firms would be able to predict that the cartel they enter is unstable. In order to model a framework where firms only apply for leniency when the cartel is fading we introduce some uncertainty on the sustainability of the cartel agreement. In a setting where there are possible profitability shocks or enforcement parameter changes, firms will take the decision on whether to enter cartel agreements by taking an expectation over the possible states of nature. However, at some point the uncertainty over the state of the economy would dissolve and firms would have to decide whether they still want to be part of this collusive agreement. In the presence of a leniency program, we shall show that firms might prefer to report the illegal activity when the "bad" state of nature materialises. The important question that arises is whether these leniency applications are a worthy target

\(^6\) Taking the conservative estimates of Langus and Motta (2007) this effect can be as low as 2%. Grout (2006) argues that the future loss of the benefit of cartel induced supra competitive prices seems to be of relatively little importance. This is based on the perception that the share prices are often very responsive even to minor events.

\(^7\) As a result, only the introduction of a leniency program might lead to applications. However, in practice one can observe leniency applications that go beyond the period of the introduction of the leniency programs.
for the antitrust authorities given that these cartels will collapse in any case.

The contribution of the paper is twofold. First, we offer an additional explanation on why cartel members might resort to the antitrust authorities applying for leniency. Firms are shown to apply for leniency when there is uncertainty concerning the precise collusive conditions. At the same time, the model is more general since it encompasses different situations leading to desistance already identified in the literature. Secondly, the paper stresses the importance of the race to the courthouse effect and sheds light on the deterrence effect of the leniency program when the cartel is fading.

2 Literature review

Our paper adds to the literature on the effectiveness of the leniency schemes initiated by Motta and Polo (2003). Much of the literature focuses on the issue of deterrence and therefore in most models there is no reporting arising at equilibrium. We, instead, are interested in analysing the effects of desistance on ex ante deterrence in the context of failing cartels. Therefore, we advocate a model where there are leniency applications at equilibrium.

A first reason for applying for leniency that has been identified in the literature is a change in the probability of detection. Motta and Polo (2003) show that firms apply for leniency if an investigation has opened in the industry where the cartel activity takes place. This induces an increase in the probability of detection and therefore following the opening of an investigation firms will have a greater incentive to report. Contrary to Motta and Polo (2003) we assume that leniency is only granted to the first informant which gives rise to a "race to the courthouse effect", as termed by Harrington (2005). Harrington (2005) allows the probability of detection to vary, in a continuous setting, and shows that leniency programs can lead to desistance when discovery becomes more likely. A second reason to apply for leniency arises when the fines depend on the duration of the cartel activity. In such a setting firms might prefer to collude and then reveal in order to avoid paying the accumulated fine (see Motchenkova (2004)). Another possibility is that a change in the management might trigger the leniency application. Or, the management was not aware of the illegal activity and upon discovery it runs to the antitrust authorities. The change of management was indeed responsible for the leniency application of Monochloroacetic Acid cartel (2005) when Hoechst chemicals discovered that the newly acquired Clariant business management had engaged in collusive activities. Last, Siragusa (2006) suggests that there might be strategic motives behind a leniency application i.e. firms exploit leniency programs for competitive or exclusionary reasons. However, in the theoretical models that incorporate strategic behavior (Ellis and Wilson (2003), Leliefeld and Motchenkova (2007)) no leniency applications arise at equilibrium since firms internalise the strategic considerations in their ex ante decision.

Concerning the optimal structure of leniency programs, it is well established in the literature (see Harrington (2005), Chen and Rey (2007)) that providing
leniency only to the first informer would make the cartel less sustainable and would create a race to the courthouse effect. Introducing the risk dominance concept, Spagnolo (2004) argues that such a program risk dominates a scheme with multiple fine reductions, which instead reduce the deterring effect of the leniency programs. He also finds, contrary to our model, that courageous leniency programs in which the reporting party is granted rewards are the first best solution. However, moderate leniency systems as currently employed by the EC and US can be helpful. On the other hand, leniency programs can be exploited by firms and this should determine a maximal level of leniency. Building on this framework, Chen and Rey (2007) propose a normative framework to study the effects of the leniency policy by introducing heterogeneity in the stakes of collusion across industries. This allows them to "characterise the objective of the antitrust authority, that is, deterring as many as possible cartels by an upper bound of collusive benefits".

3 The model

3.1 The market setup

We consider a simple game where there are two firms that are symmetric and they compete in prices in the market of a homogeneous good in an infinitely repeated game. The discount rate is identical for both firms and is denoted by $\delta \in (0,1)$. We assume that the profit per firm from colluding in the first period is $\pi$ and the profits from deviating from the colluding agreement when the other firm colludes is $2\pi$, in which case the other firm earns 0. We also assume that firms attempt to sustain collusion by employing standard trigger strategies, threatening with reversion to the one period Nash outcome of no collusion when one firm deviates.

3.2 The Antitrust Authority and the Leniency Program

The antitrust authority in our model has the legal power to investigate all the sectors of the economy and (has limited resources and) can detect an infringement of competition law relying on audits with a probability $\rho \in [0,1]$ in each period. When an antitrust authority finds a cartel it sets to the parties involved in the illegal activity a fine equal to $F$. Further, we assume that the evidence of collusion lasts for only one year which implies that firms cannot be fined for past activity. The antitrust authority can impose a maximal fine $F$ that is not enough to deter collusion given the probability of detection $\rho$ i.e. we assume that $\pi - \rho F > 0$. Moreover, the investigations that we consider are "secret" in the sense that firms do not have the opportunity to apply for leniency after the antitrust authority has opened an investigation.

The antitrust authorities also have in place a leniency program. Firms can report to the antitrust authorities the existence of a collusive agreement. When one firm reports, then it benefits from a reduction $q \geq 0$ on the fine normally
levied on it. We assume that a fine reduction is only available to the first informant and therefore when both firms decide to report simultaneously, they each have a chance of one half to be the first to report. Following reporting, trust is broken and no further collusion could arise. From the next period onwards the firms revert to the static Nash equilibrium. We make this assumption in order to rule out the rather unrealistic possibility that firms collude and report in every period.\textsuperscript{8} Aubert et al (2006), among others, argue that it is very unlikely that antitrust authorities would not spot this kind of collusive behavior, and therefore they also exclude it from consideration.

Finally, the antitrust policy parameters are exogenously set.

3.3 The timing of the game

In the first period of the game the timing is as follows:

Stage 1. The two firms simultaneously decide whether they want to enter into a collusive agreement or not. Only if both firms decide to collude then the cartel is formed, otherwise, competition takes place. In this latter case each firm gets zero profits and the game ends for this period.

Stage 2. If a cartel is formed in stage 1, each firm decides whether it wants to stick to the colluding agreement or to deviate in the product market and earn a payoff of $2\pi$. If at least one firm deviates, collusion can not arise anymore; otherwise, each firm gets the collusive profits. Then market realisation occurs.

Stage 3. Nature draws the state of the world. With probability $\alpha$ there would be no shock in the expected collusive profits and the cartel activity would be sustainable whereas with probability $1 - \alpha$ the cartel agreement will collapse from the second period onwards.

Stage 4. Firms after observing the state of nature, they decide whether they want to report the infringement to the antitrust authorities. The antitrust authority detects cartels with probability $\rho$ (a collusive agreement that has not survived stage 2 cannot be detected). When the cartel is detected, or reported, firms are charged with the corresponding fine. Firms still earn the collusive payoffs for this period. However, from the next period they return to the one stage Nash equilibrium.\textsuperscript{9}

From period 2 onwards the game is repeated with no uncertainty on the expected collusive profits.

Note that in our model, we assume that firms obtain the collusive outcome even if they decide to report in the same period. More specifically, following Chen and Rey (2007), the market realisation takes place before the antitrust authorities intervene in the market. This assumption to some extent reflects the requirement of the European Commission for leniency applicants not to report once, collude and never report afterwards in a setting where no leniency for repeated offenders is offered, see Chen and Rey (2007).

\textsuperscript{8}This can be modeled explicitly by assuming for example perfect monitoring in the markets where an infringement has been detected, or immense fines for repeat offenders. Note that the EC new Guidelines on fines (2006) have a tougher stance against repeat offenders.

\textsuperscript{9}
terminate their role in the illegal activity immediately (so as to be able to make dawn raids in the conspirators’ premises that would yield some evidence).

We solve the game using the Subgame Perfect Nash Equilibrium solution concept. We shall assume throughout the paper, as in Motta and Polo (2003), that when there is a Pareto Dominating equilibrium firms would be able to coordinate on it.

4 No uncertainty

We first consider the scenario of no uncertainty i.e. the subgames that start
from period 2 onwards.

Since the environment does not change in each period, if a firm finds optimal
to report in the second period of the game it would also be optimal to report in
the first period. Therefore, similar to Motta and Polo (2003)\(^{10}\), we shall focus
on two relevant collusive strategies: one is to collude and report in the first
period (CR) and the second is to collude and never reveal (CNR).

The present discounted value of colluding and not reporting, \(V^{cnr}\), is:
\[
V^{cnr} = \pi - \rho F + (1-\rho)\delta(\pi - \rho F) + \cdots = (\pi - \rho F)(1 + (1-\rho)\delta + \cdots) = \frac{(\pi - \rho F)}{1-(1-\rho)\delta}
\]
whereas the present discount value of colluding and then reporting, \(V^{cr}\), is:
\[
V^{cr} = \pi - (1 - \frac{q}{2})F
\]
Proceeding with backward induction we need to consider two subgames:

4.1 The revelation subgame

First, we consider the reporting decision. When firms have entered into a collu-
sive agreement one can depict the game in the following reduced\(^ {11}\) normal form
game

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<td>(\frac{(\pi - \rho F)}{1-(1-\rho)\delta}, \frac{(\pi - \rho F)}{1-(1-\rho)\delta})</td>
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The pair (report, report), in which the firms decide to reveal their illegal ac-
tivity to the antitrust authorities is always a Nash Equilibrium. When leniency
is relatively small, with \(\pi \leq (1 - q)F\), the pair (no report, no report) also always
constitutes a Nash equilibrium. When \(\pi > (1 - q)F\) the pair (no report, no
report) is also a Nash Equilibrium if:
\[
\frac{(\pi - \rho F)}{1-(1-\rho)\delta} \geq \pi - (1 - q)F
\]

\(^{10}\)The only difference is that in Motta and Polo (2003) the relevant strategy Collude and Report implies that firms Collude and they Report whenever the antitrust authority opens
an investigation, whereas in our setting of no uncertainty the relevant strategy is to Collude and Report in the first period.

\(^{11}\)We assume that the continuation game of (no report, no report) is to collude and never
report forever and therefore we introduce the present discounted value of collude and never
report in the (no report, no report) outcome.
One notes that the higher the leniency rate offered the more fragile the cartel agreement is made since firms would have stronger incentives to report.\textsuperscript{12}

When the pair (no report, no report) constitutes an equilibrium then it is also Pareto dominant, i.e. both firms will prefer to remain silent than to run into the antitrust authorities' leniency program.

\subsection*{4.2 The Cartel Formation subgame}

Moving backwards we have to examine the Cartel Formation subgame, i.e. whether the firms have an incentive to deviate from the collusive agreement in the product market.

\textbf{When }$\delta \geq \delta_1$. \textit{In this case the firms prefer not to report.}\textsuperscript{13} The present discounted value of colluding (and not reporting) is $V^{cnr}$, and the relevant product market deviation is that firms undercut each other and obtain the whole market: $V^d = 2\pi$.

The incentive compatibility constraint for the firms to join the collusive agreement is that:

\begin{align*}
V^{cnr} &\geq V^d = 2\pi \\
\implies \delta &\geq \frac{\pi + \rho F}{2\pi(1-\rho)} \equiv \delta_2 \quad (2)
\end{align*}

Therefore, a necessary condition for firms colluding and never reporting is that $\delta \geq \max(\delta_1, \delta_2)$ since both conditions (1) and (2) need to be satisfied.

\textbf{When }$\delta < \delta_1$. \textit{In this case firms prefer to report in the revelation subgame.} In the Cartel Formation subgame firms prefer to collude when the present discount value of colluding and then reporting, $V^{cr}$, is greater than the product market deviation, $V^d$.

\begin{align*}
V^{cr} &= \pi - (1 - \frac{q}{2})F \geq 2\pi = V^d \\
\implies q &\geq \frac{2(\pi + F)}{F} = 2 + \frac{2\pi}{F} \equiv q_1
\end{align*}

For firms to have an incentive to enter a collusive agreement and then report, the leniency that the antitrust authority offers should be much greater than 1 i.e. when it offers rewards. This is the case of "exploitative" leniency policy: the leniency policy is so attractive that it induces firms to collude in order to take advantage of its rewards. Also, note that this condition does not depend on the discount rate since once reporting takes place firms cannot collude any longer and all the future payoffs are zero.

\textbf{Lemma 1} \textit{The introduction of a leniency policy under no uncertainty and when no rewards are allowed is completely ineffective i.e. it does not affect the rate}

\textsuperscript{12}More specifically, the first derivative of $\delta_1$ with respect to $q$ can be shown to be always positive and therefore for a higher level of leniency the threshold of the discount factor for sustaining collusion increases.

\textsuperscript{13}As long as $\pi > (1 - q)F$. Otherwise for any discount rate the firms would prefer not to report in the revelation subgame.
of cartel formation nor the cartel desistance. Firms will prefer to collude when $\delta \geq \delta_2$.

**Proof:** To assess the effectiveness of the leniency program we have to compare the case where $q = 0$ with the case where $q \in (0, 1]$. When no leniency program is adopted, i.e. $q = 0$, firms have no benefit from reporting. On the other hand, reporting brings costs to the firms since they would have to pay the fine with certainty and not only the expected fine. As we have shown above even when $q \in (0, 1]$, as long as no rewards are offered, reporting cannot arise as an equilibrium outcome. Therefore, leniency does not enhance desistance.

Further, when no rewards are allowed $\delta_1 < \delta_2$. Suppose the contrary:

$$\delta_2 = \frac{(\pi + \rho F)}{2\pi(1 - \rho)} < \frac{F(\mu - (1 - \rho))}{(1 - \rho)(\pi - (1 - \rho)\bar{F})} = \delta_1 \implies q > 1 + \frac{\pi(\pi + \rho F)}{F(\pi - \rho F)} - \frac{2\pi F}{F(\pi - \rho F)}$$

This is a contradiction since it requires that

$$\frac{\pi(\pi + \rho F)}{F(\pi - \rho F)} < \frac{2\pi F}{F(\pi - \rho F)} \implies 0 > \pi - \rho F$$

i.e. that each period’s expected profits when colluding are negative, which by assumption cannot occur.

This implies that introducing leniency is irrelevant in the ex ante decision of the firms to enter a collusive agreement and has no deterrent effect. We still require that $\delta \geq \delta_2$.

We have analysed the subgames that start in the second period of the game: since uncertainty is dissolved, the conditions we obtained under no uncertainty hold. The interesting result is that under no uncertainty at the equilibrium there would be no applications for leniency. This result arises because firms have exactly the same information before reporting as in the cartel formation subgame (see also Motta and Polo (2003) Proposition 4). This seems to contradict what actually happens in practice. This is precisely the puzzle that we are trying to understand and analyse. We shall show that in the general model the collapse of collusion would provide the incentive to the firms to report their illegal activity.

In what follows we shall assume that there are no rewards to leniency applicants, as is currently the case in the vast majority of antitrust policies in the world.

5 **Introducing uncertainty**

Now we move backwards to the first period. We have introduces uncertainty by allowing for the sequence of expected collusive profits in the market to become known only at stage 3 of the first period. We assume that with probability $1 - \alpha$ a negative shock will hit the expected collusive profits, either in the form of a market shock or of an antitrust enforcement parameter change, that would result in the breakdown of collusion from the second period onwards. Remember that from period 2 onwards there is no uncertainty on the profit realisation. We also make the assumption that firms cannot have strategies of the type "wait and see". Firms have to decide today whether they want to take part in the
illegal activity; they would not have this possibility tomorrow unless they decide
to collude today.

5.1 The revelation subgame

We first analyse the two Revelation Subgames in the first period assuming firms
have joined the collusive agreement:

**When the "good" state occurs and the cartel activity persists:** The
normal form game would be written exactly as in the no uncertainty game since
the continuation value of all actions is unaltered. Therefore the pair (no report,
no report) is the Pareto dominating equilibrium.

**When the "bad" state occurs and the cartel activity fails:** Since firms
from period 2 onwards will prefer to compete rather than collude, the reduced
normal form of the reporting game is:

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As long as:
\[\pi - \rho F < \pi - (1 - q)F \Rightarrow \rho > 1 - q\]
the only equilibrium is for both firms to report; otherwise, when \(\rho \leq 1 - q\),
the pair (no report, no report) is the Pareto dominating equilibrium.

Therefore, we have shown that reporting can be triggered when the "bad"
state occurs. For example, if there is immunity, \(q = 1\), then firms prefer to report
unless the probability of detection is zero. Also, as the reduction in the fine
becomes more generous, it becomes more likely that firms would prefer to report.
Essentially, firms compare the probability of detection and the proportion of
fine they still have to pay if they apply for leniency. Recall that the cartel
activity is going to collapse from \(t = 2\) onwards in any case. When \(\rho > 1 - q\)
the outcome (no report, no report) cannot be an equilibrium since firms can
increase their profits by deviating and reporting. In such a case the leniency
program offers protection from fines since otherwise the firms would have to
pay a higher expected fine. Instead, when \(\rho \leq 1 - q\) firms find it optimal not
to report. The probability of detection is relatively small with respect to the
post leniency fine and therefore the leniency program does not offer effective
protection from fines.

**Lemma 2 (The ex post effect of leniency)** When there is no leniency pro-
gram there is no desistance. The introduction of a leniency policy when there
is uncertainty about the future expected collusive profits can lead to desistance
when the bad state occurs, as long as \(\rho > 1 - q\).
Proof: As shown above a necessary condition for reporting to arise in equilibrium is that $\rho > 1 - q$. However, when $q = 0$ this inequality cannot be satisfied. When no leniency program is available, once again the revelation subgame is trivial. Firms would never have an incentive to report since this would imply they have to pay the fine with certainty.

5.2 The cartel formation subgame

The question that follows is whether collusion arises ex ante. We therefore focus on the Cartel Formation subgame. We distinguish between two subcases, following Lemma 2.

When $\rho \leq 1 - q$ firms prefer not to report in the revelation subgame.

In this scenario the firms prefer to collude when:

\begin{equation}
V_{\text{CNR}}^\text{unc} = \alpha \frac{(\pi - \rho F)}{1 - (1 - \rho)^\delta} + (1 - \alpha)(\pi - \rho F) \geq 2\pi = V^d
\end{equation}

\begin{equation}
\delta \geq \left(\frac{\pi + \rho F}{\pi + F(a \rho + (1 - a) (1 - \frac{q}{2}))}\right) (1 - \frac{q}{2}) = \delta_{\text{crr}}
\end{equation}

One notes that the critical discount rate is always greater than under the case of no uncertainty i.e. $\delta_{\text{crr}} \geq \delta_2$. This implies that under this scenario collusion is less likely, which is not surprising given that with probability $1 - \alpha$ collusion would not be an optimal choice from the second period onwards. Also, when $\alpha = 1$, i.e. when the high state occurs with certainty, $\delta_{\text{crr}} = \delta_2$.

Furthermore, as shown in Lemma 2, when there is no leniency program firms do not report. Therefore, equation (3) is the Incentive Constraint (IC) of firms joining collusive agreements in such a case.

Naturally, for the leniency policy to possibly have a (positive) effect on deterrence the leniency should be sufficiently high to make the incentives to report worthwhile, which leads us to the second subcase.

When $\rho > 1 - q$ firms prefer to report in the revelation subgame.

Firms would prefer to collude if:

\begin{equation}
V_{\text{CNR}}^\text{unc} = \alpha \frac{(\pi - \rho F)}{1 - (1 - \rho)^\delta} + (1 - \alpha)(\pi - (1 - \frac{q}{2})F) \geq 2\pi = V^d
\end{equation}

\begin{equation}
\Rightarrow \delta \geq \left(\frac{\pi + \rho F}{\pi + F(a \rho + (1 - a) (1 - \frac{q}{2}))}\right) (1 - \frac{q}{2}) = \delta_{\text{crr}}(\alpha, F, q, \pi, \rho)
\end{equation}

Proposition 3 (The ex ante effects of leniency) The introduction of a leniency policy when there is uncertainty about future profitability affects the ex ante decision of firms to engage in collusion when $\rho > 1 - q$. Greater deterrence is achieved when $1 - q < \rho < 1 - \frac{q}{2}$.

Proof: One should compare the case where there is leniency policy to the case where there is no leniency program. Remember that when $q = 0$ equation (3) represents the relevant IC. Condition (4) is less likely to be satisfied when

\begin{equation}
\frac{\pi + \rho F}{(\pi + F(a \rho + (1 - a) (1 - \frac{q}{2}))} \geq \frac{\pi + \rho F}{2\pi (1 - \rho)} \Rightarrow (1 - \alpha)(\pi - \rho F) \geq 0 \text{ which always holds.}
\end{equation}
\[
V_{CR\text{unc}} = \frac{(\pi - \rho F)}{1 - (1 - \rho)^{\frac{1}{2}}} + (\pi - \rho F) > \frac{(\pi - \rho F)}{1 - (1 - \rho)^{\frac{1}{2}}} + (1 - \alpha)(\pi - (1 - \frac{q}{2})F) \geq 2\pi \Rightarrow \\
\rho < 1 - \frac{q}{2}.
\] (5)

From Lemma 2 we know that reporting can arise only when \( \rho > 1 - q \). Therefore deterrence is enhanced when \( 1 - q < \rho < 1 - \frac{q}{2} \).

In this range of values for \( \rho \) the goal of the leniency program to place firms at a Prisoner’s dilemma situation is achieved. More precisely, even if the firms would collectively prefer the outcome of (no report, no report), the possibility, offered by the leniency program, to report makes deviations from this outcome profitable. Given that \( \rho > 1 - q \), the only Nash Equilibrium of the game is to (report, report). However, at equilibrium firms share the reduction in the fine and when \( \rho < 1 - \frac{q}{2} \) they become worse off. Anticipating this, firms will be less willing to enter illegal activities than in the case where there was no leniency policy. When the leniency program protects "adequately" the firms that report from fines (i.e. offer them lower expected fines but not rewards) then leniency can destabilise the cartel by putting firms at a race to the courthouse that ultimately makes them worse off.

**Lemma 4** The introduction of a leniency policy can not decrease deterrence.

**Proof:** We observe that condition (3) is stricter than condition (4) and therefore ex ante deterrence decreases as long as:
\[
V_{CR\text{unc}} > V_{CNR\text{unc}} > 2\pi \Rightarrow \rho > 1 - \frac{q}{2}.
\] (6)

Note here that this is a static condition since from period two onwards collusion would break down in any case. Condition (6) implies that firms become better off when they report. As a result, firms would be more likely to enter collusive activities than in the case of no leniency program. We need to show that (6) cannot be satisfied.

Recall, from Lemma 1, that we require, for collusion to be sustainable under no uncertainty, that \( \delta \geq \frac{(\pi + \rho F)}{2\pi(1 - \rho)} \equiv \delta_2 \). If this condition is not satisfied then collusion would never arise in the first place. Also \( \delta < 1 \) and therefore we require that the lower bound on \( \delta \) is lower than 1.

\[
\frac{(\pi + \rho F)}{2\pi(1 - \rho)} < 1 \Rightarrow \rho < \frac{\pi}{2\pi + F} \equiv \overline{\rho}.
\] (7)

Therefore, only for small detection rates firms will be able to sustain collusion. The upper bound of \( \rho \) where collusion can be sustained is obtained for \( F = 0 \), when \( \overline{\rho} = \frac{1}{2} \). However, condition (6) can never be satisfied for such a \( \overline{\rho} \), unless rewards are offered, i.e. for \( q > 1 \).

This result is different from the result obtained in Motta and Polo (2003) as well as in Chen and Rey (2007) and underlines the positive effect of the leniency program in our setup. In most papers on leniency there is a trade off between higher desistance (leniency makes reporting more attractive) and lower

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\(^{15}\) It is trivial to note that when \( \rho = 1 - q \) then the introduction of leniency makes no difference on the ex ante incentive to engage in the collusive activity.
deterrence (a decrease in the expected fine makes collusion more attractive ex ante). However, in Chen and Rey (2007) this trade off arises since they permit rewards to be given to the leniency applicants. At the same time, they allow firms to employ a strategy of colluding and then reporting indefinitely i.e. they assume that firms’ trust is not broken when reporting occurs. In Motta and Polo (2003) firms are not put into the Prisoner’s Dilemma situation since every firm applying for leniency, and not simply the first informant, can receive a lower fine. In our setup, instead, the race to the courthouse effect constitutes a driving force that leads to the Prisoner’s Dilemma situation. As a result, firms are less willing to enter collusion ex ante. The introduction of the leniency program cannot lead to a procollusive effect since this would require firms to be better off in the presence of the program. This in turn, would require the post leniency fine, $(1 - \frac{\delta}{2})F$, to be higher than in the case of no reporting, $\rho F$. However, this cannot occur since the probability of detection must be higher than one half; a level at which collusion would not be sustainable even in the absence of a leniency program (see condition (7)). This happens because in our setup firms compete strongly in a Bertrand way. Remember that the profitable deviation in the Bertrand scenario is much stronger than in Cournot since firms in the former case could serve the whole market.

Figure 1 illustrates the Incentive Compatibility Constraints for the firms to participate in the cartel activity in the plane $(q, \rho)$ for given values of $\pi, F, \alpha$, and $\delta$ (such that it satisfies $\delta \geq \delta_2$). The line $IC_{cnr}$ represents the incentive constraint for the case where there is no reporting at equilibrium. This is the case if there is no leniency program. Also in the presence of a leniency program, as long as $\rho \leq 1 - q$, we have shown that it is the optimal response of the firms. Unsurprisingly, this line does not depend on the leniency offered and is represented as a line parallel to the $q$–axis. Above the line firms prefer to not collude whereas below the line they prefer to collude (and not report).

The thick black lines, $IC_{cr}$ represents the IC in the case where there is a leniency program. As we showed above this coincides with line $IC_{cnr}$ for $\rho \leq 1 - q$. When $\rho > 1 - q$ the $IC_{cr}$ is an upwards sloping curve which indicates that firms are more willing to collude and report as leniency increases. In the area above the thick black lines ($IC_{cr}$) firms prefer not to engage in the collusive activity whereas in the area that lies between the upwards sloping part of $IC_{cr}$ and the $\rho = 1 - q$ line they prefer to collude and report if the "bad" state occurs.
The role of leniency can be understood from the figure. We detect two areas where the leniency policy changes the optimal response of the firms. In the presence of a leniency policy, in area (2) firms report their activity to the antitrust authorities when the "bad" state materialises. This area does not represent per se a positive effect since these cartels would fail in any case from period 2 onwards. Furthermore, the market realisation for this period has already occurred, given the timing of the game, and therefore consumers have already paid the collusive prices. However, one notes that firms would collectively prefer to not report in this area. The leniency program puts the firms into a Prisoner’s Dilemma situation by offering protection from fines. Anticipating this, firms would be less likely to collude ex ante. This gives rise to the procompetitive effect of the leniency policy: area (1). In area (1) firms would find it optimal not to collude in the presence of a leniency program whereas in its absence they would collude. Therefore, greater deterrence is achieved.

**Comparative statics**

We proceed with comparative statics analysis. We first consider a decrease in the probability of the "good" state, $\alpha$. In this case the value of collusion decreases and therefore firms are less willing to engage in collusive activities in the first place. This is also illustrated in the graph in Appendix 3.1 where now $\alpha = 0.3$ instead of $\alpha = 0.5$. This result is intuitive since when $\alpha$ is lower there is a greater probability that the "bad" state will occur. Also note that when we set $\alpha = 1$ then the $IC_{cnr}$ and $IC_{cr}$ coincide. One notes that the difference
between the vertical intercept of the two lines increases as $\alpha$ decreases.

The second scenario we consider is a change in the fine, $F$. As expected, collusion becomes less likely when the fine increases, since the expected collusive profits decrease. We observe a downward jump of the ICs. At the same time, the slope of the $IC_{cr}$ when reporting is the optimal choice (slightly) increases. Given that the fine is relatively larger the impact of an increase in $q$ is greater.

An increase in the discount factor, $\delta$, makes collusion more likely since the future collusive payoffs are relatively more important today. One notes that both ICs move upwards as expected.

Finally, increasing the collusive profits shifts the ICs upwards. Trebling the profits increases the incentives to enter collusive agreements. Note that the new $IC_{cr}$ is closer to the $IC_{cnr}$ line and its slope is flatter. This occurs since an increase in the leniency rate would have a smaller effect on the incentive to collude when the collusive profits are greater.

5.3 Allowing for "wait and see" strategy

Now we relax the assumption that firms need to collude in period 1 if they wish to have the possibility to collude at a later period. Therefore, we want to investigate whether firms prefer not to engage in the illegal activity until they know with certainty the state of the expected collusive payoff. In this case firms might employ a strategy of the type not collude in the first period and only collude (and not report) from time 2 onwards, as long as the good state materialises. Remember that since the uncertainty is resolved after the end of the first period, this strategy dominates the strategies of entering at a collusive agreement, if the good state occurs, at a later period.

The present discounted value of this strategy would be $V_{ws} = \alpha \delta \frac{\pi - \rho F}{1 - \delta (1 - \rho)}$.

We shall consider the firm’s decision in the first period. We analyse whether the equilibrium strategies that we identified above are preferred to the "wait and see strategy" in the cartel formation stage of the game.

When $\rho \leq 1 - q$, the firms decide not to report. The strategy collude and not report would still be optimal when

$$V_{CNR}^{unc} = \alpha \left( \frac{\pi - \rho F}{1 - (1 - \rho)\alpha} + (1 - \alpha)(\pi - \rho F) \right) > V_{ws} = \alpha \delta \frac{\pi - \rho F}{1 - \delta (1 - \rho)}$$

which is always satisfied. This is intuitive since we are considering the case where it is optimal not to report even if the collusive agreement is going to fail; therefore, one would expect that it would not be optimal to "wait and see".

When $\rho > 1 - q$, firms in the reporting subgame decide to report. If $V_{CR}^{unc} = \frac{\alpha (\pi - \rho F)}{1 - (1 - \rho)\alpha} + (1 - \alpha)(\pi - (1 - \frac{q}{2})F) \geq V_{ws} = \alpha \delta \frac{\pi - \rho F}{1 - \delta (1 - \rho)}$

$$\Rightarrow \alpha(1 - \delta) \frac{\pi - \rho F}{1 - (1 - \rho)\alpha} + (1 - \alpha)(\pi - (1 - \frac{q}{2})F) \geq 0 \quad (7)$$

then allowing for such a strategy does not alter the equilibrium strategy of the firms.

One notes that a sufficient condition for the wait and see strategy not to be an equilibrium strategy is that $\pi - (1 - \frac{q}{2})F \geq 0$. This condition holds when the profit level is higher than the post leniency fine $(\pi > (1 - \frac{q}{2})F)$, which
becomes more likely as the leniency rate increases. Essentially, when firms gain a nonnegative payoff when the bad state occurs they would never wait for uncertainty to dissolve.

6 Extension

In this part of the paper we relax the assumption on the precise timing of the negative shock. We shall generalise the model to capture cases where there is some probability that the shock might arise in each period. Therefore, with probability \(1 - \alpha\), a shock will hit the expected collusive profits from next period onwards. If it does, then the firms will find it optimal to stop colluding from that next period. If the shock does not occur at \(t = 2\), then with probability \(\alpha\) it will hit the expected collusive profits at time \(t = 3\) and so on. Therefore, we consider a setup where there is uncertainty over the concrete timing of the shock and, as a result, the collapse of the cartel agreement.

Interestingly, the results we have obtained so far carry through. The revelation subgame is identical to the one presented in the model above and therefore the condition of Lemma 2 will dictate whether firms will prefer to report or not when the shock in the collusive profits actually takes place.

If the firms prefer not to report then the discounted value is:

\[
\Pi_{CNR} = (1 - \alpha)\left(\pi - \rho F\right) + \alpha(\pi - \rho F + \delta(1 - \rho)\Pi_{CNR}) \Rightarrow \\
\Pi_{CNR} = \frac{\pi - \rho F}{1 - \alpha \delta(1 - \rho)}
\]

If they prefer to report then the present discounted value is:

\[
\Pi_{CR} = (1 - \alpha)\left(\pi - \left(1 - \frac{\alpha}{2}\right)F\right) + \alpha(\pi - \rho F + \delta(1 - \rho)\Pi_{CR}) \Rightarrow \\
\Pi_{CR} = \frac{(1 - \alpha)(\pi - (1 - \frac{\alpha}{2})F) + \alpha(\pi - \rho F)}{1 - \alpha \delta(1 - \rho)}
\]

Now we should check that the present discounted values of the two strategies are optimal also in the cartel formation subgame. Therefore they would need to exceed the deviation profits: \(\Pi_d = 2\pi\).

\[
\Pi_{CNR} = \frac{\pi - \rho F}{1 - \alpha \delta(1 - \rho)} \geq 2\pi \Leftrightarrow -\rho F \leq \pi(1 - 2(1 - \rho)\alpha \delta)
\]

Similarly

\[
\Pi_{CR} = \frac{(1 - \alpha)(\pi - (1 - \frac{\alpha}{2})F) + \alpha(\pi - \rho F)}{1 - \alpha \delta(1 - \rho)} \geq 2\pi \Leftrightarrow \pi(1 - 2(1 - \rho)\alpha \delta) \leq -F((1 - \alpha)(1 - \frac{\alpha}{2}) + \alpha \rho)
\]

Notice that the former condition is also the relevant condition in the absence of a leniency program. Therefore for the leniency policy to have an anticompetitive effect we should have that \(\Pi_{CR} \geq \Pi_{CNR} \Rightarrow \rho > 1 - \frac{\alpha}{2}\).

This implies that collusion would now arise if the probability of detection is relatively high. Nevertheless, this is not possible given that firms compete a la Bertrand and therefore collusion would not be sustainable for probabilities of detection higher than one half. The result is identical with Lemma 4. This is not surprising since the difference between the two strategies, \(\Pi_{CNR}\) and \(\Pi_{CR}\), is simply the payoff in the case the cartel breaks down following a shock. Note that this is the only difference of the two strategies also in the model above.
7 Application: a profitability shock

In this part of the paper we analyse a specific cause of collapse of a cartel agreement, namely that the profits in the market follow a persistent downwards trend. We present this application given the observation by Stephan (2006) that many cartels discovered through leniency programs had failed because of market conditions. 16

We shall assume that the market profits follow the process: \( \theta \pi(p) \) with \( \theta \in (0,1) \) i.e. they weakly fall in each period by a fraction \( \theta \). The idea is that the industry faces a negative shock on profitability which could be due to a demand reduction or a cost increase.

Furthermore, we assume that when an antitrust authority finds a cartel it sets to the parties involved in the illegal activity a proportional fine equal to \( F_t = \lambda \pi_t \), with \( \lambda \) being the coefficient of the proportional fine. This assumption reflects the current revision in the way the European Commission calculates the fines it sets.17 Note that this assumption is crucial to render the problem stationary; if the fine was fixed then with strictly falling profits the decision to collude or not (and to report or not) would depend on the period where we are.

The timing of the game also is identical as in the original model above. Now stage 3 of the game becomes as follows:

Stage 3. Nature draws the state of the economy. With probability \( 1 - \alpha \) a negative shock will hit this sector of the economy (bad state of economy), i.e. \( \theta < 1 \). With probability \( \alpha \) profits will be stable forever (good state) i.e. \( \theta = 1 \). Note that the results hold for any two values of \( \theta \) as long as they are not identical.18

From period 2 onwards there is no uncertainty on the profit realisation.

To solve this game we need to consider first the subgames that start in the second period. Since uncertainty is thereafter dissolved, we obtain the same condition as in Lemma 1, adjusted for the parameter \( \theta \). Therefore, in the no uncertainty scenario:

\[
\delta \geq \frac{(\pi + \rho F_t)}{2\theta(1-\rho)} \equiv \delta'_2 \quad (2')
\]

Note that the critical discount factor value, \( \delta'_2 \), is inversely related to the size of the shock, \( \theta \). Collusion becomes more likely as \( \theta \rightarrow 1 \). On the other hand,

16 The literature of the impact of the evolution of demand on cartel formation started with the paper by Rotemberg and Saloner (1986). They assume that the expected level of future demand is independent of the present state of demand. This implies that the expected cost (or benefit) of deviating from (sticking to) the illegal agreement is always the same. However, a high demand today makes a deviation more attractive and collusion is harder to sustain. Introducing, however, positive correlation between the state of the economy today and tomorrow, as we do in this application, changes the results. In a setting where the demand boom is expected to be persistent, the carrot from colluding increases substantially rendering collusion more likely.

17 More specifically, EC has moved towards a setting that the level of fines reflects the turnover of the companies in question (% of the firm’s relevant turnover).

18 However for cases where in the bad state of the economy \( \theta \leq \frac{1}{2} \) we cannot fall into the interesting range of the discount rate. This happens since we require that \( \frac{\pi + \rho F_t}{2\theta(1-\rho)} < 1 \Rightarrow \rho < \frac{\pi(2\theta - 1)}{F + 2\pi \theta} \). Since \( \rho \in [0,1) \) we require that \( 2\theta - 1 > 0 \Rightarrow \theta > \frac{1}{2} \).
collusion is less likely to be sustainable for small values of \( \theta \) i.e. when the fall in the profits in every period is more severe. When the future of the economy is grim, there is a greater incentive to deviate on the relatively large collusive profits enjoyed in the current period.

Moving now backwards to the first period of the game, we have to consider three cases concerning the optimal strategy of the firms. This happens because the incentive compatibility constraint in the product market is more easily satisfied when we are in the good state of the economy. In equation (2’) \( \delta_{2'} \) is an decreasing function of \( \theta \) and therefore when \( \theta = 1 \) the condition is satisfied for a greater range of values of the discount factor. We obtain two rather trivial cases and one more interesting:

If \( \delta < \delta_{2', \theta=1} \). In this scenario firms will never collude in the perfect information scenario regardless of the state of the economy. Therefore, since from period 2 onwards firms will prefer not to collude, the only Nash Equilibrium is to also not collude in the first period of the game.

If \( \delta \geq \delta_{2', \theta<1} \). In this case we already know that firms will always collude from period 2 onwards. It comes as no surprise that also in the first period the firms prefer to collude.\(^{19}\) Note that for \( \alpha = 0 \) or \( \alpha = 1 \) we obtain the corresponding no uncertainty cases.

If \( \delta \in [\delta_{2', \theta=1}, \delta_{2', \theta<1}) \). This is the interesting case. Here collusion would only be optimal from period 2 onwards as long as the high state of the economy has occurred. On the other hand, when the bad state occurs, firms prefer to compete since they cannot credibly commit not to deviate in the product market. On what follows we assume that the discount factor falls in this range.

We now move backwards into the first period of the game. Then the analysis is identical to the one developed above. Lemmas 2 and 4 as well as Proposition 3 apply.

**Introducing a positive shock**

Lemma 4 predicts that there is no side effect of introducing a leniency program. We would like to investigate whether this finding is robust. We make a small modification of the model. We suppose that in the good state of the economy instead of constant profits, profits are increasing by fraction \( \frac{\alpha}{1-(1-\rho)\delta} \) in each period.

Lemma 5 When \( \theta > \frac{4\pi F}{4\pi} \) in the good state of the economy, the introduction of a leniency program may also have an anticompetitive effect.

\(^{19}\)Now the relevant deviation is whether:
\[
\alpha \left( \frac{\pi-\rho F}{1-(1-\rho)\delta} \right) + (1-\alpha) \left( \frac{\pi-\rho F}{1-\theta(1-\rho)\delta} \right) \geq 2\pi \implies \\
\frac{1-(1-\rho)\delta}{1-(1-\rho)\delta} + \alpha \left( \frac{\pi-\rho F}{1-(1-\rho)\delta} \right) - (1-\alpha) \left( \frac{\pi-\rho F}{1-\theta(1-\rho)\delta} \right) \geq \frac{\pi-\rho F}{1-(1-\rho)\delta} \geq 2\pi \text{ which holds given that we consider the case where } \delta \geq \delta_{2', \theta<1}.\]
Proof: We require that the lower bound of the discount factor is lower than 1:
\[ \frac{8}{8} < 1 \Rightarrow \rho < \frac{2(2-1)}{2} = \frac{2}{2} = 0 \quad (8).\]
Note that equation (8) now depends on \( \theta \). Also from equations (3) and (4) firms would enjoy a higher payoff under reporting than under no reporting (and deterrence would decrease) when:
\[ V_{CR} > V_{CNR} > 2\pi \Rightarrow \rho > 1 - \frac{q}{2}.\]
Therefore we require that:
\[ 1 - \frac{q}{2} < \rho \]
\[ \Rightarrow q > \frac{2\pi + F}{2\pi + F} + \frac{2\pi + F - 4\pi \theta + 2\pi}{2\pi + F}.\]
This can only be satisfied when there are no rewards when:
\[ \frac{2\pi + F - 4\pi \theta + 2\pi}{2\pi + F} < 0 \Rightarrow \theta > \frac{4\pi + F}{4\pi}.\]
which is greater than 1.

Therefore, when \( \theta > \frac{4\pi + F}{4\pi} \) a third, perverse, effect arises. Since collusion would now be sustainable even for very high probability of detection, it is possible that the firms would prefer to collude and then report when the bad state of the market occurs and enjoy the reduction in the fine offered by the leniency program. Such a leniency program would overprotect the firms from the fines. Therefore, their expected profits increase and ex ante there is a higher probability that they enter in the collusive activity.

Essentially the expected higher persistent profits relax the strict conditions of entering into collusive strategies under Bertrand competition.\(^2\) This allows collusion to be sustainable for probabilities of detection higher than one half and as a result the strategy of Collude and Report could make firms better off by providing effective protection from fines. In such a scenario the "cartel amnesty effect" would dominate the race to the courthouse effect and as a result firms would be made better off.

8 Conclusions

We have shown that leniency applications may be triggered when firms realise that the cartel in which they participate is failing. Therefore, in a context of uncertainty when the bad news about the state of the expected collusive profits arrive, firms will apply for leniency if the leniency policy offers effective protection from the fines. This places firms into a Prisoner’s Dilemma situation. However, this is not the only effect of the leniency policy. Indeed, anticipating that there may be desistance later on, collusion may not be achieved ex ante. Not only desistance but also deterrence is achieved.

The leniency programs when a reduction in the fine is offered only to the first informant, is shown to be procompetitive. This implies that the antitrust authorities should not worry about attracting failing cartels. At the same time they should try to exploit the race to the courthouse effect and offer leniency

\(^2\)\footnote{Remember that when \( \theta = 1 \) collusion would not be sustainable for values of the probability of detection higher than one half.}
only to the first firm that reaches their offices. Furthermore, in our model we have assumed that there are only two firms competing in prices. When the number of firms increases then the possibility offered by the leniency program to report makes firms worse off since the race to the courthouse effect would become more pronounced. When not reporting is not an equilibrium strategy, firms would be more likely to be worse off since they would have to share the reduction in the fine. Also, we have shown that when rewards are offered reporting gives the opportunity, to the industries where collusion would collapse anyhow (i.e. in industries hit by the bad realisation of demand), to report and gain on leniency. Collusion could be made more likely ex ante since the expected cost of entering a collusive agreement decreases. Therefore, we suggest, contrary to Spagnolo (2004), that offering rewards might be counterproductive and decrease deterrence.

Furthermore, we have demonstrated that the results we have obtained are relatively robust; first by allowing the firms to wait for uncertainty to be dissolved before taking their decision on joining the illegal activity and secondly by allowing a more general timing of the shock.

Also, we have suggested a particular application of the model when the market conditions deteriorate persistently. As long as there are two possible states of nature where the profit levels are correlated in a persistent way, firms might run into the antitrust authorities when the bad state of the market materialises. When \( \theta \leq 1 \), leniency programs are shown to be procompetitive. Instead, we have shown that a perverse effect could arise when \( \theta > \frac{4\pi+1\theta}{4\pi} \) in the good state of the economy. In such a case, leniency policy might offer firms excessive protection from fines and make firms more likely to collude ex ante. This scenario, however, supposes that the probability of detection is very large and it is therefore relevant only in cases where the participation of firms in cartel activity is extremely likely. In such cases, and when the collusive profits are increasing over time, antitrust authorities should not offer reduction in fines (for example in cases where antitrust investigations have already been opened in the US).

A further possible extension of our model would be to consider a more general set of strategies. More specifically, one might want to consider what happens when following a cartel detection (either through investigation or though reporting) there is an intensified scrutiny in the industry for T periods (see Chen and Rey (2007)). This would allow firms to collude once again. Or, one could account for a more general set of punishment strategies. We could also try to analyse a more general model where the firms could compete either in quantities or in prices, as in Motta and Polo (2003).

\[ \text{21 A complete analysis of the game when rewards are possible is necessary though. This happens since the continuation value of the game from period 2 onwards might change. Recall from Lemma 1 that the ineffectiveness of the leniency policy under perfect information only holds for } q \leq 1. \]
9 Appendix

9.1 Average fine

![Figure 1: Average Cartel Fine](image)

9.2 Leniency Programs

![Figure 2: Leniency Program](image)
9.3 Comparative Statics

9.3.1 Decreasing the probability of the high state, $\alpha$

Equilibrium solutions for: $F = 1$, $\pi = 1$, $a = 0.3$, $\delta = 0.9$

9.3.2 Increasing the Fine, $F$

Equilibrium solutions for: $F = 2$, $\pi = 1$, $a = 0.5$, $\delta = 0.9$
9.3.3 Increasing the Discount Factor, $\delta$

Equilibrium solutions for: $F = 1$, $\pi = 1$, $a = 0.5$, $\delta = 0.96$

9.3.4 Increasing the Collusive Profits, $\pi$

Equilibrium solutions for: $F = 1$, $\pi = 3$, $a = 0.5$, $\delta = 0.9$
10 Bibliography


