The Impact of Leniency and Whistleblowing Programs on Cartels[*]

Cécile Aubert[†], Patrick Rey[‡], and William E. Kovacic[§]

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Abstract

Antitrust authorities have set up leniency programs for cartel members that denounce their collusive agreements. These programs help prosecute participants and can thereby deter collusion. We compare the impact of reduced fines and positive rewards and argue that rewarding individuals, including firm employees, can deter collusion in a more effective way.

We discuss possible adverse effects of whistleblowing programs on firms' behavior, and particularly on turnover, incentives to innovate and cooperation. We also explore explanations for the puzzling fact that managers keep incriminating evidence and argue reward programs actually provide additional incentives for keeping such evidence.

JEL Codes: K21, K42, L41.

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1 Introduction

There is almost universal agreement that price-fixing and market allocation cartels reduce economic efficiency. Yet although most competition laws forbid cartels, cartels continue to form and operate in a significant number of industries (see Connor, 2001, 2004, Levinstein and Suslow, 2004). Evidence from, e.g., the food additive and vitamin cartels, that lasted for ten years, suggests moreover that a number of cartels succeed in maintaining discipline over a long period of time. The main problem is thus an implementation issue, i.e., how to enforce cartel prohibition (see Rey 2003).

National competition agencies have nevertheless recently achieved notable successes in prosecuting cartels. Cartel decisions are increasingly numerous and concern all sectors, from vitamins to plasterboard or fine art auctions – with Christie's denouncing its participation in a cartel with Sotheby's. These successes are in great part the result of leniency programs set up in the United States in 1993 and in the European Union in 1996.[1] This paper investigates the effect of leniency programs on the behavior of firms and argues that more generous programs, offering positive rewards to firms but also to individual informants, might be more effective.

Leniency programs

Leniency Programs reduce the fines for cartel members that bring evidence to the antitrust authority, and their impact can be seen in the recent increase in successfully prosecuted cartels. For example, its Amnesty program allowed the Antitrust Division to secure more fines in 1999 only, than the total sum of fines imposed under the Sherman Act since its adoption, more than a century before. And in 19 months only, over 2002 and 2003, the European Commission took 19 decisions, involving more than 100 companies, for a total amount of fines of almost 3 billion Euro.[2]

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[1] Similar programs have since been set up in United Kingdom in 2000 and in France and Germany in 2001. On the development of leniency programs in the Europe and the United States since 1990, see Harding and Joshua (2003), Kobayashi (2001), and Spratling (2001).

[2] These record numbers are also – but not only – the result of increased fines. For the US, Hammond (2000) reports that the maximal fine imposed before 1993 was of US $ 3 million. Statutory reforms adopted in the United States since the early 1970s have raised criminal fines dramatically (Klawiter, 2001). By virtue of amendments enacted in 2004, the statutory maximum fine under the Sherman Act for corporations today is US $ 100 million.

The corporate leniency program set up in the United States in 1978 has been revised in 1993, to grant full amnesty to the first informant, together with amnesty for individuals ('directors, officials and employees' of the informant firm). The European leniency program has similarly been reinforced in 2002 so as to grant full amnesty to the first reporting firm.[3] The judicial security offered to informants constitutes a key success factor of these revised programs. Confidentiality is guaranteed, in particular with respect to other relevant jurisdictions.[4] Several differences still exist between the American and the European systems: First, individuals are not liable in Europe under the current legislation, contrary to the US.[5] Second, the US leniency program does not grant amnesty to cartel ringleaders. A similar requirement existed in the first version of the EU program but has been essentially removed in 2002 in order to foster deterrence.[6]

Encouraging insiders to bring evidence seems sensible, as they are more likely to possess the type of information needed for establishing a violation of the law. Cartels must reach agreements (on total output levels, output shares, sales territories, etc.) and monitor compliance with agreed-upon terms. Such cooperation often leaves traces, that can be used as proofs by an insider informant. Yet reduced fines may not be sufficiently attractive to fully deter collusion.

This provision permits any violation, regardless of its actual economic impact, to be punished by a fine of as much as US $ 100 million. Corporate violators can be assessed fines equal to twice the gain derived by the wrongdoer or twice the injury suffered by victims of the cartel. As a result, in 1999 Hoffmann-LaRoche and BASF have paid criminal fines of US $ 500 million and US $ 225 million respectively for their participation in the vitamins cartel. Cartel fines have increased in the European Union, too. The highest fine for a single infringement has been imposed in 2001 on Lafarge (249 million Euro in the Plasterboard case); in the same year, Hoffman LaRoche received a fine of 462 million Euro for its role in the Vitamins cartels, which formally constituted 8 distinct infringements, while Rhône-Poulenc obtained full immunity for denouncing the cartel.

[3] Even if the Commission has already started an inspection, provided it does not yet have sufficient evidence. In the US, leniency is automatic only if the cartel is not yet being investigated.

[4] The programs rely for example on privileged oral testimonies in order to avoid generating self-incriminating evidence that could then be used in a civil suit for damages.

[5] According to Hammond (2000) and Spratling (1999), two officials from the Antitrust Division of the DoJ, one of the major reasons of the success of the second version of the American leniency program is the fear of imprisonment for corporate officials.

[6] The only remaining requirement is that the reporting firm must not have taken steps to coerce other firms to participate in the activity.

One might therefore contemplate giving informants not only favorable treatment (partial or full amnesty) as in a leniency program, but also positive rewards.

Leniency programs versus bounties

In practice, only a few systems offer bounties to informants. One such system[7] is the U.S. Civil False Claims Act, which has been used extensively to attack fraud involving the U.S. government's role as purchaser of goods and services (e.g., procurement fraud against the Department of Defense) and as insurer (e.g., fraud involving health care programs covered by Medicare). This Act rewards individuals who inform the government of fraud in procurement contracts by a substantial share of the fines collected – an amount sufficient to compensate employees for the stream of foregone future wages[8]

Related literature

As in McCutcheon (1997), our working assumption is that communication is necessary for collusion: it brings an agreement that firms are then free to implement or not, as in a standard tacit collusion situation, but it also generates evidence that can be found by the antitrust authority, as well as by firms or individuals. This framework is similar to the one used by Motta and Polo (2001) and Spagnolo (2003), who also study the role of leniency programs (on self-reporting, see also Innes , 1999).

Motta and Polo (2001) analyze the impact of reduced fines for cartel members that inform the antitrust authority, when the probability of antitrust intervention is endogenously determined under a balanced budget constraint. They show that it can be efficient to reduce fines even when the antitrust authority has already started an investigation, but has not yet obtained evidence of mis-behavior. While such leniency reduces the cost of collusion for cartel members, it encourages reports that decrease investigation costs. In this model, if the budget of the antitrust authority was high enough, it would be optimal to have no Leniency Program, and to intervene often enough to fully deter collusion: reduced fines are a second best instrument.

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[7]Other bounty systems concern major organized crime, as in the US and Italy, and more recently France. In addition, the US federal government has offered bounties in some cases of terrorism, and federal and state agencies can post bounties for killers and kidnappers.

[8]See Tokar (2000). Kovacic (2001) discusses how the Civil False Claims Act approach could be adapted for use by antitrust authorities in prosecuting cartels.

Spagnolo (2003) also examines the effect of Leniency Programs on the sustainability of cartels, in a framework that is closer to ours. Contrary to Motta and Polo, he assumes that when a cartel is detected, it is also convicted. This allows to focus on the impact of Leniency Programs on cartels that are not already under investigation. Allowing for generic punishment strategies[9], Spagnolo shows that the antitrust authority should not fine firms that deviate from a cartel agreement, should reward only the first party that reports, and should offer a positive reward equal to the sum of the fines paid by the convicted firms (assuming that the antitrust authority is budget constrained). Provided that the maximum fine is high enough, such a reward policy can implement the first-best outcome: full deterrence at no cost. Even if the antitrust authority cannot offer positive rewards, reduced fines for reporting firms can be useful by decreasing the cost of deviating from the cartel agreement. Last, Spagnolo shows that reduced fines always increase the riskiness of an agreement.

Overview of the paper

Our framework differs from the above papers in that we take the probability of an investigation as given, and focus on the consequences of rewards on decisions taken within the cartel and within firms. We show that positive rewards have a larger deterrence effect than reduced fines, and that rewards for individuals can be more effective than corporate ones. We then turn to the potentially adverse effects of rewards mentioned above, such as preventing efficient cooperation between firms, restricting information flows between employees, or inducing a more rigid employment structure. We show that reward programs can be adapted so as to mitigate these costs.

A major puzzle is why evidence is not destroyed once communication has taken place. We explore explanations based on agency problems, both at the cartel level and at the level of the individual firms. We point out that positive rewards may exacerbate these agency problems and encourage firms (or individuals) to gather and keep evidence. This indicates that, while firms may adapt to the new judicial environment and better hide or destroy all traces of communication

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[9]In contrast, Motta and Polo (2001) focus on two types of strategies: 'firms never report and go back to collusion after an investigation, and play Nash forever as soon as one of them reports' and 'firms report to the antitrust authority when ever an investigation is opened, and go back to collusion afterwards'.

with other cartel members,[10] they will probably have to keep some incriminating evidence.

The paper is organized as follows. Section 2 sets up the model. Section 3 analyzes the effect of leniency and reward programs on cartel sustainability. Section 4 considers the effects of rewards on inter-firm communication, intra-firm hiring strategies, and investment incentives. Explanations for the fact that evidence of collusion is often not destroyed are explored in the next section. They rely on agency problems, within the cartel or within the firm. Section 6 concludes.

2 The model

2.1 Modeling collusive agreements

Three different types of model can be used to represent collusive agreements.

Enforceable agreements

The first approach considers enforceable agreements, which would be relevant for legal cartels such as export or crisis cartels. To ban such cartels it suffices to make them illicit, as did Switzerland when it suppressed the cartels bureau. A related approach assumes that parties have ways to ensure that even illegal obligations be executed. These means may arise from repeated relationships but are not explicitly modeled. This is for example the approach taken in the modeling of collusion in static agency situations, as in Laffont and Martimort (1997, 2000).

Tacit collusion

In the second approach collusion emerges as the non cooperative equilibrium of an infinitely repeated game. A coordinated outcome can then be sustained even without any communication between the firms. Antitrust authorities are powerless in front of such purely tacit collusion, since firms simply adopt non-cooperatively strategies that lead to a coordinated outcome (see

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[10]There is ample evidence that firms adapt to the tools used by antitrust authorities. In Europe, it has for example been recognized that parties to illicit agreements were keeping incriminating documents at home, in case the firm's premises were searched. As a result, the European Commission has been given larger investigation powers and is now allowed to search private houses.

Werden, 2004). An example of this difficulty is the well-known woodpulp case, in which the European Commission asserted that the parallel evolution of prices (expressed in dollars, and despite strong fluctuations in the exchange rates of the producing countries) charged by the woodpulp industry between 1971 and 1981 in Europe was an evidence of collusion. This decision was overruled by the European Court of Justice, that re-asserted the principle that price parallelism cannot be taken as incompatible with competitive behavior. Kühn (2001) discusses the difficulties associated with using observable behavior to detect collusion[11].

Collusion with communication

The view taken in this paper is a third one: Collusion has to be self-enforcing, since firms cannot appeal to courts to enforce agreements, but it requires communication. OPEC is a cartel of this type: Its members hold frequent meetings, but there is no available authority to ensure enforcement of agreements. We moreover assume that communication leaves traces.

These assumptions are clearly relevant in many cases in practice. Competition authorities do rely on evidence, and stories abound about how difficult it is to safeguard the implementation of negotiated agreements – even legal ones.[12] Communication may be particularly needed in the first periods of collusion, in order to foster coordination given the existence of multiple potential equilibria. Communication may moreover remain necessary in subsequent periods if there is an uncertainty on the firms' incentives to deviate in each period, for instance uncertainty on their discount factors or costs. Kandori and Matsushima (1998) show that communication may

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[11]Along with other difficulties such as the lack of reliable data on price and quantities, Kühn (2001) cites the sensitivity of quantitative studies to functional form specification. This sensitivity is exemplified by the divergence between two econometric studies on the US railroad cartel in the 1880s. Porter (1983) concludes that although mark-ups were observed, they were compatible with Cournot competition, while Ellison (1994), allowing for auto-correlation on the demand side, obtains estimates close to the full collusion case.

[12]Genesove and Mullin (2001) describe for instance the detailed arrangements used by the US Sugar Institute to maintain a cartelized industry between 1928 and 1936. And the sentencing statement accompanying the agreement of Kuno Sommer, an executive with LaRoche, to plead guilty for his role in orchestrating the vitamins cartel in the 1990s, recounts the extensive, frequent communications by which the vitamins cartel participants organized their production and sales activities, see Gavil et al. (2002, pp. 1017-21). The elaborate mechanisms employed by cartels of bidders in auction markets are documented in Marshall and Meurer (2004).

indeed be necessary to support collusive outcomes when products are differentiated and firms cannot observe each other's prices but only infer them from their own sales. Compte (1998) has similar results. To keep the analysis simple, however, we will refrain here from opening the 'communication' blackbox and postulate instead that communication is a prerequisite for collusion.

2.2 The collusion game

Two firms play an infinitely repeated game where, in each period, they have an opportunity to communicate before interacting on the product market. In the first stage, communication takes place if both firms agree to. In the second stage, firms can always 'compete'; if communication took place, they can instead choose to 'collude' (see the precise timing below). Both firms have the same discount rate $\delta \in (0,1)$ and maximize the expected discounted sum of their profits. In each period, the gross profit of a firm is:

- π^C if both firms compete,

- π^M if both firms collude,

- π^D for a firm that competes while the other colludes, in which case the other firm gets $\underline{\pi}$.

The collusive outcome is indicated by superscript M, since collusion aims at monopolizing the industry. The competitive outcome, indicated by superscript C, can correspond to standard static competition à la Cournot or Bertrand. We moreover assume:

$$\underline{\pi} \leq \pi^C < \pi^M < \pi^D, \ \underline{\pi} + \pi^D < 2\pi^M.$$

These inequalities imply that firms gain from collusion, but each firm benefits at the expense of the other from deviating, i.e., from competing when the other colludes.

2.3 Oversight by an antitrust authority

The antitrust authority maximizes consumer surplus and can impose fines on colluding firms, but only if it obtains evidence about collusion. That assumption restricts the scope for intervention

but corresponds to the actual mandates of antitrust authorities. We moreover suppose that communication is a prerequisite for collusion, and generates some evidence:

Assumption 1 (Collusion generates evidence) *Collusion requires some communication, which generates hard evidence. This evidence can be found by the antitrust authority if it audits the industry; in addition, each firm can bring this evidence to the antitrust authority.*[13] *The evidence lasts for one period.*

We thus assume that communication (and thus collusion) automatically generates evidence, which is moreover systematically found in the case of an audit. We will denote by ρ the probability of audit. The framework could easily be extended so as to allow for more uncertain generation and obtention of evidence. We focus on 'hard' evidence, in the sense that it can be hidden but not manipulated.[14] The assumption that evidence disappears at the end of the period simplifies the analysis, since only current behavior can be 'punished' by the antitrust authority.

The antitrust authority can impose a maximal fine F that is not large enough to deter collusion if it is imposed with probability ρ only: $\pi^M - \pi^C > \rho F$.

Additional tools – e.g., positive rewards – will be considered later on. The reports to the antitrust authority are assumed to be *public*, i.e. observed by all actors in the economy, including firms (the case of secret reports is analyzed in Rey, 2003).

2.4 Timing

In each period, the precise timing is as follows:

1. Each firm chooses whether to communicate.

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[13]This assumption is implicit in several models that introduce intervention by a antitrust authority, and in particular in the papers of Motta and Polo (2001) and Spagnolo (2003). McCutcheon (1997) relies on this assumption to stress possible adverse effects of anti-trust laws – by increasing the cost of renegotiations, they may help firms commit to retaliate.

[14]From a theoretical perspective, we know from the work on implementation (Maskin and Moore, 1999, Moore, 1992, Moore and Repullo, 1988) that obtaining the revelation of past soft information is difficult. From a practical perspective, judges and courts are often reluctant to rely on testimonies which are not backed by factual evidence.

2. If at least one firm prefers not to communicate, firms adopt the competitive strategy. Otherwise,

   a. communication takes place, and evidence is created;

   b. each firm then chooses whether to implement the collusive strategy, or 'deviate' and compete; it can moreover report the evidence of collusion to the antitrust authority.

3. If there is no report, the antitrust authority audits the industry with probability ρ.

Given our focus on the impact of leniency and whistleblowing programs, in the absence of reporting the audit policy is rather simple and assumed to be constant over time and history.[15] When collusion is sustainable, the best collusive strategies then consists in colluding in every period – even after a successful audit. To deter unrealistic collusive strategies (e.g., firms taking turns to report in every period), we will however assume that, once a firm reports a cartel, the industry is kept under close scrutiny ever after.[16]

2.5 Some benchmarks

We first study two benchmark cases: the case in which the antitrust authority can only use an audit technology, without any revelation mechanism, and the case in which it can use revelation mechanisms but is constrained to only offer negative transfers, i.e. reduced fines, to reporting firms.

No revelation mechanisms

Suppose first that the antitrust authority can only rely on audits. Then in each period profits will be

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[15]Frezal (2005) stresses that non-stationary audit policies can be more – and possibly highly – effective at deterring cartels. Harrington (2005) furthermore points out that when the detection probability changes (exogenously) across periods, firms may collude in some periods and take advantage of leniency programs in others.

[16]In practice, once a cartel has been exposed firms are likely to be kept under close scrutiny for some time, whatever the original source of information. In our set-up, adopting an infinite period of close scrutiny in case of reporting not only avoids unrealistic strategies (see the discussion in 3.2), it also does not raise audit costs since reporting does not occur in equilibrium.

- π^C if communication – and thus collusion – does not take place,

- $\pi^M - \rho F$ if communication takes place and both firms collude,

- $\pi^D - \rho F$ if communication takes place and the firm 'deviates', that is, it competes[17] while the other colludes – in which case the other firm obtains $\underline{\pi} - \rho F$.

It can easily be shown that the most profitable collusive strategy is to collude in every period and punish any deviation by returning forever to the static competitive equilibrium, this being the hardest credible punishment that can be imposed on deviating firms. Collusion is therefore sustainable if the gain obtained when deviating, and competing forever afterwards, is lower than the discounted gain from colluding:

$$\pi^D - \rho F + \frac{\delta}{1-\delta}\pi^C \leq \frac{1}{1-\delta}[\pi^M - \rho F],$$

or equivalently

$$\pi^D - \pi^M \leq \frac{\delta}{1-\delta}[(\pi^M - \rho F) - \pi^C]. \tag{1}$$

Leniency programs

Assume now that the antitrust authority can use constrained revelation mechanisms, where it can 'reward' reporting by reducing the fine from F to f but cannot offer positive transfers. To deter reporting, firms should plan again to 'punish' it by reverting forever to competition. This in turn implies that a reporting firm will also choose to deviate, since it will face competition afterwards anyway. Conversely, a deviating firm will denounce its competitor if the reduced fine is lower than the fine expected from random audits: $f < \rho F$. Under this condition, collusion is sustainable if

$$(\pi^D - f) - (\pi^M - \rho F) \leq \frac{\delta}{1-\delta}[(\pi^M - \rho F) - \pi^C].$$

Therefore:

Proposition 1 *If the antitrust authority can reduce fines but cannot reward informants with positive transfers, then revelation mechanisms have a deterrence effect on collusion only if*

$$\pi^D - \pi^M \leq \frac{\delta}{1-\delta}[(\pi^M - \rho F) - \pi^C] \leq \pi^D - \pi^M + \rho F - f.$$

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[17]A firm is thus convicted even if it did not implement the collusive strategy after communication. Unless expressly noted, the analysis would be similar if adopting the competitive strategy sufficed to avoid the fine.

Leniency programs have no impact on the profitability of collusion and affect its sustainability only by giving deviators the opportunity to avoid fines from random audits. Leniency programs can therefore be effective only when the expected fine ρF is large, that is, when collusion would already be fragile without any leniency program.[18]

3 Rewarding informants

To induce firms to report collusion, the antitrust authority needs in general to offer a 'reward' (positive transfer) R large enough to outweigh the punishment from retaliation. For clarity, we will (admittedly arbitrarily) use the term 'reward' for transfers directed at firms, and 'bounty' for transfers directed at individuals.

3.1 Rewarding firms

It is more effective to reward reports that are made before any audit of the industry: Reports made after a successful audit are useless; and reports made after an unsuccessful audit are more costly to induce than before an audit.[19] Note also that it is not possible to make firms reveal past collusion. Indeed,

  i) 'hard information' (evidence) disappears after one period;

  ii) one cannot induce firms to reveal truthfully 'soft information' over past decisions, since these do not affect firms' preferences over future outcomes.[20].

  We can therefore focus on pre-audit reporting. There again, a deviating firm (and only a deviating firm) will choose to denounce its competitor whenever there is some leniency, that is: $R > -\rho F$ (in particular, it will do so if the reward is indeed positive). As already mentioned, the reward R necessary to induce such reporting – and thus break collusion – must compensate

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[18]In particular, leniency programs would have no bite if deviating firms were not subject to fines.

[19]If firms are willing to report even though they are not threatened by the possibility of a fine due to the audit, they would have been willing to report before the audit took place. In addition, Motta and Polo (2001) and Spagnolo (2003) point out that reducing post-audit fines would erode the deterrence effect of these audits.

[20]See, e.g., Moore (1992) for an overview of what can be achieved through Nash- or subgame perfect- implementation.

for the ensuing retaliation, which consists here in returning forever to competition:

$$\left(\pi^D + R\right) - \left(\pi^M - \rho F\right) \geq \frac{\delta}{1 - \delta}\left[\left(\pi^M - \rho F\right) - \pi^C\right].$$

This condition is indeed more stringent than (1) when $R > -\rho F$. We have:

Lemma 1 *In order to induce a firm to report collusion, the antitrust authority must offer a reward at least equal to $\underline{R}$, defined as*

$$\underline{R} \equiv \frac{\delta}{1 - \delta}\left[\left(\pi^M - \rho F\right) - \pi^C\right] - \left[\pi^D - \left(\pi^M - \rho F\right)\right].$$

The minimal reward $\underline{R}$ may be negative (in which case full leniency, for example, would suffice to deter collusion), but it may also be quite large.[21] In particular, it goes to infinity when the discount factor δ gets close to 1.

3.2 Potential implementation issues

Several concerns may arise from the large size of the rewards needed to deter collusion. First, such rewards may not be credible: The antitrust authority may have a limited budget and may not be able to commit credibly to large rewards. As already mentioned, one way to circumvent this issue is to reward the informant with a fraction of the fines paid by the other firms.

A second issue concerns the political acceptance of large rewards. The public opinion may not easily accept the idea of granting large amounts to guilty firms. In that respect, the antitrust authority might wish to keep rewards secret, and bargain discretly with suspected firms. But this would create judicial uncertainty and affect the credibility of the reward.[22]

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[21]We have assumed that a deviating firm can still report evidence of collusion. This seems a relevant assumption: a firm that deviates after negotiating a collusive agreement can still provide evidence of the negotiation that took place. Under the alternative and arguably less realistic assumption that deviating firms have nothing to report to the antitrust authority, a colluding firm could choose to report but would only do so if the reward offered were larger than $\frac{\delta}{1-\delta}[(\pi^M - \rho F) - \pi^C] - \rho F$.

[22]Rewards should be contractually enforceable in court, since a judiciary process may be more reliable than non witnessed promises by an antitrust authority. Relatedly, rewards may be less credible when reports are made secretly. Thus, while secret reports reduce the risk of retaliation by the other firms, potential informants may fear that the antitrust authority reneges, at least partly, on its promises.

In practice, leniency programs often refuse amnesty to ring-leaders. While granting rewards to wrong-doers may not easily be accepted by society, this would still increase the deterrence power of rewards. It is sometimes argued that rewards would give incentives to organize a cartel in order to denounce it. But this would actually have a desirable impact, since firms would then become extremely cautious when offered to participate in a collusive agreement. Offering bounties to any cartel member, including the instigator, would therefore contribute further to deterring collusion.[23]

A third issue related to very large rewards is the possibility that it generates additional incentives to collude. It might for example become profitable for firms to collude and report or to 'take turns' for reporting collusion. If rewards were available to all reporting firms, then firms would find it optimal to collude and systematically report. To counter this, antitrust authorities should restrict rewards to the first informants, say – as it is done for leniency programs – although this may not be sufficient to prevent these reporting strategies from being theoretically profitable. Yet such strategies appear extremely unrealistic. First, high executives would be unwilling to follow such strategies in countries in which they face jail sentences when found guilty, as in the US. Second, in practice, antitrust authorities tend to keep under closer scrutiny the industries that have been found guilty of collusive behavior – and would be unwilling to keep granting leniency or rewards to repeat offenders; hence our assumption (end of section 2.4) that the probability of audit becomes close to one after a report. It is very unlikely that antitrust authorities would not spot this type of collusive behavior. Last, even assuming that they would repeatedly grant rewards to firms from the same industry, 'taking turns' remains unprofitable (compared to colluding without reporting) for reasonable rewards. Suppose that the two firms collude and randomly select one of them for reporting collusion to the antitrust authority. The value of such a strategy would be $\frac{1}{1-\delta}[\pi^M + \frac{R-F}{2}]$. Under (1), such collusion is sustainable whenever it is more profitable than collusion without reporting, that is when $R > (1 - 2\rho)F$. The size of this reward actually increases with the number of firms,[24] implying that perverse incentives are more likely to appear in concentrated industries. To avoid repeating

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[23]On the other hand, denying leniency to ringleaders may discourage potential cartel instigators and exacerbate free-riding in setting-up a cartel.

[24]With N firms, the condition for 'taking turns' to be profitable becomes $R > [1 - N(1 - \rho)]F$.

the discussion, in what follows we will maintain the assumption, introduced in section 2.4, that an industry remains under close scrutiny once a report has been made.[25]

3.3 Rewarding individuals

Firms rely on individuals, which creates potential agency problems; the antitrust authority can try to take advantage of and even exacerbate these agency problems in order to deter collusion more effectively. In the United States, for example, individuals can benefit from a leniency program that shields them from criminal sanctions, including jail. However, contrary to the Civil False Claims Act, this amnesty program does not grant positive rewards to individual informants.[26]

We argue here that positive rewards for individuals can usefully complement corporate amnesty programs. The basic idea is quite simple: if the antitrust authority offers a bounty B to employees[27] reporting incriminating evidence (and full individual leniency when these employ-

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[25]One must nevertheless add that if antitrust authorities were naive, colluding and taking turns for reporting might be more profitable than behaving competitively, and such collusion may even be sustainable in situations in which 'standard' collusion would not be sustainable. Indeed, 'taking turns' is sustainable if:

$$(\pi^D + \frac{R-F}{2}) - (\pi^M + \frac{R-F}{2}) < \frac{\delta}{1-\delta}[(\pi^M + \frac{R-F}{2}) - \pi^C],$$

which is a weaker condition than the one for collusion without reporting. Once again, this type of collusion is quite unlikely to pass unnoticed, and we prefer to assume that the industry is closely supervised once a report has been made.

[26]Leniency programs for individuals can contribute to reinforcing corporate ones. A colluding firm would have to compensate employees for the judicial risk to which they are exposed; a firm therefore gains more when deviating when it can apply for both corporate and individual leniency, as in the US – and thus reduce employee compensation. Individual leniency may also be useful when employees who terminate their relationships with the firm can leave with incriminating evidence.

[27]One can add restrictions to the identity of the individuals allowed to act as informants. Government officials might for instance be required to show that the antitrust authority failed to act for an unreasonable period of time, before they could benefit from the whistleblowing program. Individuals who occupy a special position of trust, as attorneys and internal ombudsmen responsible for administering ethics and corporate compliance programs, should be barred from the program. These people ordinarily gain special knowledge of possible law violations; if they could act as relators, it would greatly complicate the firm's ability to obtain legal counsel or operate a compliance program.

ees would have been liable in case of prosecution), colluding firms will have to 'bribe' informed employees in order to secure their fidelity; the benefits of collusion are thus decreased. This makes collusion less attractive and contributes to making it more fragile.

Suppose for example that: (i) full leniency would not suffice to deter collusion – that is, $\underline{R} > 0$; (ii) collusion requires n informed employees; (iii) employment is 'short-lived', i.e., employees are present for one period only; and (iv) the antitrust authority can protect whistle-blowers from retaliation.[28] Formally, step 2b of the game is modified as follows:

2b. each firm chooses whether to implement the collusive strategy, or 'deviate' and compete; it can moreover report evidence to the antitrust authority. In the absence of any report, firms can bribe their informed employees for not reporting; employees can otherwise report to the antitrust authority.

Since colluding firms must compensate informed employees for not reporting, profits are reduced by nB;[29] thus, collusion is now sustainable only if (assuming for the moment that there is no corporate leniency)

$$(\pi^D - \rho F - nB) - (\pi^M - \rho F - nB) \leq \frac{\delta}{1-\delta}[(\pi^M - \rho F - nB) - \pi^C],$$

or, equivalently:

$$\frac{\delta B}{1-\delta} \leq \frac{\underline{R} + \rho F}{n}.$$

Increasing the bounty B makes this condition more stringent, and thus collusion more fragile. In addition, even if the bounty is paid only to the first employee who denounces collusion, colluding firms must give *each* informed employee the equivalent of B in *each period*; the impact of the

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[28]This is of course the case where bounties for employees are the most powerful. In practice firms may be in a position to retaliate. In particular, the job opportunities of an informant can become uncertain. However, as illustrated by the US Civil False Claims Act, a mere fraction of the fines imposed on convicted firms can be large, even compared to an employee's discounted lifetime salary. More generally, in what follows B can be interpreted as the 'effective' bounty offered by the policy, net of the anticipated cost of retaliation for the informants. In this situation, however, the cost of bounties for the antitrust authority is larger than the benefit for employees, and comparisons with corporate rewards are less straightforward.

[29]In particular, collusion is clearly deterred if $\rho F + nB > F$, since that would imply that firms would rather pay the fine in every period than compensating the employees.

reward policy is thus multiplied, compared with a corporate policy – as the number n of informed employees increases, collusion becomes more and more fragile. Last, since individual bounties affect sustainability by reducing the profitability of future collusion, they have a bigger effect when firms place a larger weight on future profits – precisely when collusion is most likely.

Since a deviating firm is still exposed to prosecution, it must compensate its informed employees which mitigates its incentives to deviate. This suggests a natural complementarity between corporate leniency and rewards for individuals. If for example informing firms can benefit from full leniency, a deviating firm would report rather than compensate its informed employees; collusion would then be sustainable only if

$$\pi^D - (\pi^M - \rho F - nB) \leq \frac{\delta}{1-\delta}[(\pi^M - \rho F - nB) - \pi^C],$$

that is, if

$$\left(\frac{\delta B}{1-\delta} <\right) \frac{B}{1-\delta} \leq \frac{\underline{R}}{n} \left(< \frac{\underline{R} + \rho F}{n}\right).$$

Together, an individual bounty B and a reduction in the fine $(F - f)$ can thus destroy collusion even when each instrument, taken separately, would not suffice. Leniency allows a firm to avoid compensating informed employees when it deviates, thereby increasing the impact of the bounty.[30]

The complementarity between corporate leniency and individual whistle-blowing is even more striking when employment is 'long-lived'. Suppose that informed employees are 'lifetime' employees who stay in the firm forever. The firm's best fidelisation policy then consists in a constant bonus $b = (1-\delta)B$, paid as long as the employee does not report. In the absence of any leniency program, a deviating firm would however have to pay a 'full compensation' B during the period in which it deviates; the total discounted cost of individual bounties for a deviating firm, nB, is therefore the same as for a firm that keeps colluding forever, $\frac{1}{1-\delta}[n(1-\delta)B] = nB$. An individual bounty policy would thus have no impact on the sustainability of collusion[31] (it would however still make collusion less profitable, and thus less attractive).

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[30]This insight remains valid as long as deviating firms remain somewhat exposed to prosecution; in the extreme case where a firm that deviates were entirely immune to prosecution, leniency would have no bite (see footnote 15, relating to Proposition 1).

[31]Collusion is not sustainable if $(\pi^D - nB) - [\pi^M - \rho F - n(1-\delta)B] > \frac{\delta}{1-\delta}[\pi^M - \rho F - n(1-\delta)B - \pi^C]$, which amounts to $\pi^D - (\pi^M - \rho F) > \frac{\delta}{1-\delta}[\pi^M - \rho F - \pi^C]$, or $\underline{R} < 0$.

In contrast, when a deviating firm can apply for amnesty, it can both save the fine and avoid compensating informed employees. Collusion is therefore not sustainable whenever

$$\pi^D - (\pi^M - \rho F - n(1-\delta)B) > \frac{\delta}{1-\delta}[(\pi^M - \rho F - n(1-\delta)B) - \pi^C],$$

or:

$$B > \frac{\underline{R}}{n}.$$

Thus, individual bounties, which would not affect the sustainability of collusion in the absence of corporate leniency, can now destroy it – all the more so when more individuals are involved.

A similar analysis applies when employees remain with the firm for a limited time, provided they know for how long they will remain in office; in that case again, each employee will 'cost' B to the firm: the firm can pay a compensation equal to B when the employee is about to leave and the recurrent bonus $(1-\delta)B$ in the previous periods. This implies that the firm will prefer informed employees to stay longer in office, so as to limit turn-over and the bonuses[32] – a point we will stress again in subsection 4.2.

Individual mechanisms can therefore be a very effective complement to corporate leniency programs. Note that even if rewards are not supposed to be ever paid in equilibrium, a competition authority will find it easier to commit to rewards that are not excessively high. A whistle-blowing mechanism directed at firms' employees can in that respect be preferable to a corporate one.[33]

A caveat concerns the potential adverse effects of bounties on the organizational structure of the firm, on its incentives to delegate, communicate or efficiently restructure. These issues are considered in the following section.

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[32]For example, replacing the employee every T periods would cost the firm $b(1 + \delta^T + \delta^{2T}...) = \frac{b}{1-\delta^T}$; this cost increases with the rate of turn-over (that is, when T decreases). Similarly, if employees face in each period a probability ϵ of leaving the firm before they obtain evidence, for exogenous reasons (relocation, accident, and so forth), the firm's best policy consists in paying in each period a bonus $b = [1 - \delta(1-\epsilon)]B$; there again, the cost for the firm increases with the rate of turn-over increases ϵ.

[33]Another argument in favor of individual whistle-blowing programs is that reporting may be more easily kept secret than in the case of corporate programs.

4 Side-effects of whistle-blowing programs

Bounty mechanisms have been criticized on two grounds. First, they may deter not only collusion, but also 'good' cooperation between firms. We show however how these programs can be adapted so as to limit these costs. Second, bounty programs can influence firms' internal organization and decisions. They may for example induce firms to limit turn-over excessively, so as to reduce the bribes given to informed employees. The induced rigidity tends however to make collusion less attractive, which in itself is a desirable side-effect. Whistle-blowing programs may also induce firms to adopt more 'innocent' attitudes, which again increases the cost of collusion.[34]

4.1 Impact on desirable cooperation

Whistle-blowing mechanisms may deter socially desirable cooperation as well as harmful collusion. For example, exchanging information about the evolution of demand or costs may allow firms to take better decisions.[35] It may however be difficult to distinguish such cooperation from the type of communication involved in price-fixing agreements. For example, firms may end up taking similar decisions as to quantities and prices, since communication removes any heterogeneity in behavior stemming from asymmetric information. Empirically, it may not be possible to distinguish such alignment of prices from a cartelization of the industry.

A simple model

Assume that there are now three strategies for the firms: They can either compete, communicate in order to compete more efficiently, or communicate in order to collude. Both competitive

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[34]While we focus here on potentially adverse effects of leniency and whistle-blowing programs, we should note that they may also reduce some of the adverse effects that antitrust supervision may otherwise generate. For example, Harrington (2004) stresses that antitrust authorities' tendency to intervene in the case of sudden price changes may facilitate collusion, by discouraging deviations from it. This effect would no longer arise if deviating firms could benefit from leniency or be rewarded for denouncing the collusive arrangement.

[35]This argument has been formally explored by Athey and Bagwell (2001) in the case of asymmetric information on costs. Communication is necessary to achieve cost efficiency, which requires that the lowest cost firm serves a larger share of the market. Athey and Bagwell point out that if firms are patient, they will be able to collude on high prices, be communication allowed or not. Forbidding communication is then useless from the point of view of consumer surplus, while preventing cost efficiency.

situations constitute equilibria of the constituent game – and can thus be sustained forever in the repeated interaction game. The new strategy, 'communicate and compete', consists in exchanging information so as to allow firms to make more efficient production choices, while still competing on the market. While communication might increase firms' profits without being socially efficient[36], to focus on possible adverse effects of whistle-blowing mechanisms, we assume here that communication increases social welfare, compared to the situation in which firms compete without communication. Yet, this efficient communication leaves evidence that is similar to that left by collusion, and the antitrust authority can mistake one type of communication for the other.

The precise timing of the game is now as follows; in each period:

1. Each firm chooses whether to communicate in order to collude, to communicate in order to compete more efficiently, or not to communicate at all. If there is no consensus for communication, then firms compete; otherwise the game proceeds as follows.

2.   a. If both firms have chosen to communicate in order to collude, each firm then decides whether to compete or deviate. If both firms have chosen to communicate and compete, then they compete but more efficiently than without communication.

  b. Each firm moreover decides whether to report evidence of communication to the antitrust authority. The latter mistakes the evidence left by efficient communication for collusion with probability $\hat{\mu} \in]0, 1[$. Conversely, it mistakes actual collusion for efficient communication with probability $\mu \in]0, 1[$.

3. In the absence of reports, the antitrust authority audits the industry with probability ρ. It makes mistakes with the same probabilities as above.

Letting $\hat{\pi}^C$ denote the profits achieved when both firms communicate and compete, the expected profits for each firm are:

- $\frac{\pi^C}{1-\delta}$ if communication does not take place and firms compete,

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[36]See Kuhn and Vives (1994) for a survey of the ways in which firms exchange information, and their impact on competition.

- $\frac{\hat{\pi}^C - \rho\hat{\mu}F}{1-\delta}$ if communication takes place for efficiency reasons,

- $\frac{\pi^M - \rho(1-\mu)F}{1-\delta}$ if communication takes place and firms collude.

We suppose that, in the absence of any leniency program, firms prefer collusion to any competition, but still prefer to communicate in order to compete more efficiently rather than simply compete; that is, we have $\pi^M - \rho(1-\mu)F > \hat{\pi}^C - \rho\hat{\mu}F > \pi^C$.[37]

The impact of positive rewards

Suppose that firms have chosen to communicate and compete. When a whistle-blowing system is introduced, a firm may have incentives to falsely 'denounce collusion' in order to obtain the reward R (with probability $\hat{\mu}$). In order to make this strategy as costly as possible, the firms should commit never to communicate information again as soon as one falsely reports.

To deter firms from falsely reporting collusion, the antitrust authority can impose a fine, $\hat{F}$, when a firm reports collusion which is not confirmed by the prosecution.[38]. But since the antitrust authority can misinterpret real evidence for false claims, such a fine can backfire by deterring truthful reports.

The antitrust authority should therefore set up the reward R and the additional fine $\hat{F}$ so as to satisfy the following constraints:

1. a collusive firm that deviates should prefer to report as well, that is:

$$(1-\mu)R - \mu\hat{F} \geq -\rho(1-\mu)F \quad \Leftrightarrow \quad R \geq -\rho F + \frac{\mu}{1-\mu}\hat{F};$$

2. a firm that competes and communicates should prefer not to make a false report, that is:

$$R \leq -\rho F + \frac{1-\hat{\mu}}{\hat{\mu}}\hat{F} + \frac{\delta}{\hat{\mu}(1-\delta)}[(\hat{\pi}^C - \rho\hat{\mu}F) - \pi^C].$$

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[37] This will be the case if collusion generates more profits than any form of competition $\left(\pi^M > \hat{\pi}^C\right)$ and the probability of audit ρ is moreover small.

[38] Note that this mechanism is similar to judicial rules according to which defendants can recover their costs when the judicial authority rejects the report made by individuals, as in the U.S. Civil False Claims Act. If there is a private right of action, the defendant might be allowed to recover the costs from the lawsuit when he is judged innocent. In addition, the antitrust authority might have the right to ask the court to dismiss cases where the informant's allegations are baseless.

It is indeed possible to find 'safe' reward policies $\left(R, \hat{F}\right)$ that induce deviating firms to denounce collusion without triggering false alarms whenever the antitrust agency does not excessively make mistakes; a sufficient condition is $\frac{\mu}{1-\mu} < \frac{1-\hat{\mu}}{\hat{\mu}}$, or $\mu + \hat{\mu} < 1$.[39]

4.2   Impact on turn-over

Whistle-blowing programs targeting individuals may also have side-effects. In particular, as stressed in Section 3.3, with individual whistle-blowing programs the cost of maintaining collusion decreases with (informed) employees' job duration. Collusive firms thus have an incentive to lengthen the tenure of their 'informed' employees and may have a less flexible employment structure, with employees remaining in office for longer periods than in competitive companies. Similarly, a firm may wish to restrict the internal circulation of information, even at the cost of a lower productivity.

Assume for example that it would be efficient for the firm to replace an employee, due to the obsolescence of his skills or to his low intrinsic productivity. If this employee has evidence that the firm colludes with its competitors, firing him could trigger denunciation and thus requires an adequate compensation; the firm may then prefer not to replace the worker if the bounty is large enough.[40]

Formally, consider a firm participating in a collusive agreement, in which n employees are involved, and assume that the firm anticipates having the opportunity to restructure in T periods. In period T, the firm decides whether to restructure, in which case the n employees are dismissed or affected to other tasks; we will denote with a hat all profits after restructuring (with higher-ability employees). Since employees know that they will not have any evidence from period T onwards, they must be given the full amount of the reward at this date. If the firm has been colluding in the past, at the time at which it can restructure it will thus obtain (we omit for simplicity the bribe B paid in any event to each incumbent employee):

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[39]When safe rewards do not suffice to deter collusion, setting larger rewards involves a trade-off between deterring efficient communication and increased collusion deterrence.

[40]A similar reasoning would apply to the impact of whistle-blowing programs on inside communication: A firm may prefer to restrict information flows, at the cost of lessened productivity, rather than bribe additional employees.

- $\frac{\hat{\pi}^M - \rho F}{1-\delta} - nB$ if it chooses to restructure and keep colluding;

- $\frac{\hat{\pi}^C}{1-\delta}$ if it chooses to restructure and compete afterwards;

- $\frac{\pi^M - \rho F}{1-\delta}$ if it prefers to keep colluding without restructuring.

The choice over either competing and restructuring, or colluding without restructuring, is not affected by the bounty: in either case, the firm does not need to 'bribe' any other employee. Among those two outcomes, the firm prefers the collusive one if $\hat{\pi}^C < \pi^M - \rho F$. We will focus on this worst case scenario, where the firm prefers to keep colluding without restructuring (the worst outcome for society) rather than restructuring to compete.[41] At the time where the restructuring opportunity arises, the firm then prefers to stick to collusion, with or without restructuring, if it has been colluding before. The firm then moreover prefers not to restructure, to avoid bribing additional employees, if

$$nB > \frac{\hat{\pi}^M - \pi^M}{1-\delta}.$$

Large bounties can thus be socially costly, by discouraging collusive firms from efficient restructuring.[42]

Let us now consider the incentive to collude ex ante. The discounted profits under collusion, $\frac{\pi^M - \rho F}{1-\delta} - nB$, must then be compared to the discounted from competition, $\frac{(1-\delta^T)\pi^C + \delta^T \hat{\pi}^C}{1-\delta}$. The firm will prefer not to collude in the first place if

$$\pi^M - \rho F - (1-\delta)\, nB < (1-\delta^T)\pi^C + \delta^T \hat{\pi}^C.$$

Hence, if the competitive profits after restructuring and the bounty for employees are large enough, the firm will prefer to sacrifice initial collusive profits in order to save on the bounty and to restructure.

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[41]When instead $\hat{\pi}^C > \pi^M - \rho F$, the firm would rather restructure and compete than stick to collusion without restructuring; it will therefore restructure when the opportunity arises, whether it was already colluding or not; conversely, the restructuring opportunity has no impact on the initial choice between collusion and competition.

[42]We implicitly assume here that the firm can commit not to restructure; otherwise, once the employee is convinced that he will stay in charge, the firm would have an incentive to restructure anyway. While the firm may find it difficult in practice to 'surprise' the employee in this way (particularly so if informed employees can keep evidence of past collusion), the analysis may overestimate here the potential adverse effect of whistle-blowing programs on turnover and restructuring.

To summarize, if the bounty is small, efficient collusion is preferred (the firm colludes and restructures). If instead the bounty is large enough, collusion may no longer be preferred in the first period. Still assuming $\hat{\pi}^C < \pi^M - \rho F$, it is only when the bounty lies in an intermediate range that the firm would prefer to collude from the beginning and not to restructure when the opportunity arises: more precisely, B has to be such that:

$$\hat{\pi}^M - \pi^M < (1 - \delta)nB < [\pi^M - \rho F] - [(1 - \delta^T)\pi^C + \delta^T\hat{\pi}^C].$$

Note that this possibility can only arise when restructuring brings relatively small efficiency gains, reflected here by $\hat{\pi}^M$ and $\hat{\pi}^C$: as these gains increase, the left-hand side increases while the right-hand side decreases, up to a point where the intermediate range disappears.

The lessons from this framework are the following:

- Individual rewards may indeed induce inertia in the employment structure of colluding firms: they may prefer not to restructure in order to save on bribes. This adverse effect can however only arise when restructuring yields moderate efficiency gains.

- If initially the firm chooses to collude, then the later choice between competing after restructuring, and colluding without restructuring, does not depend on the bounty, but only on the profits and the expected fine.

- Last, even when the bounty induces inertia, the prospect of foregoing these efficiency gains may deter the firm from colluding in the first place.

While we focused so far on the profitability of the various scenarios, whistle-blowing programs also contribute – and are actually primarily designed – to destabilize collusion. Suppose for example that the bounty B lies in the above intermediate range. Combined with corporate leniency programs, at the time when the restructuring opportunity arises, collusion is no longer sustainable (implying in turn that it would not be sustainable before) if $(1 - \delta)nB > [\pi^M - \rho F] - [(1 - \delta)\pi^D + \delta\hat{\pi}^C]$.[43] This condition is weaker than the corresponding one without restructuring opportunities (obtained simply by replacing $\hat{\pi}^C$ with $\pi^C < \hat{\pi}^C$);

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[43]Assuming that in period T the firm would prefer to stick to collusion without restructuring, it will prefer to deviate from such collusion if $\pi^D - [\pi^M - \rho F - n(1 - \delta)B] > \frac{\delta}{1-\delta}[(\pi^M - \rho F - n(1 - \delta)B) - \hat{\pi}^C]$.

hence, any whistle-blowing program that deters collusion in the absence of structuring opportunities will a fortiori deter collusion when such opportunities are present.

4.3 Impact on firms' behavior

Whistle-blowing mechanisms may also encourage firms to adopt 'innocent' attitudes, in order to avoid raising suspicions. For example, employees and managers routinely make decisions on how much to invest (in new technologies, in training employees, in modernizing the organization of tasks, etc.) in order to become more efficient. But the incentive to invest depends on the competitiveness of the environment in which the firm operates. In this context, whistle-blowing programs tend to make collusion less profitable and may encourage productive investments. But in addition, firms may undertake such investments to prevent employees from 'sensing trouble', so as to discourage them from nosing around and acquiring convicting evidence.

Encouraging productive investments

To fix ideas, suppose that, at the beginning of the competition game, firm 1 has the opportunity to invest in a R&D project: this project costs I and succeeds with probability ϵ, in which case it drastically decreases costs, allowing the firm to take over the whole market and get $\hat{\pi} > \pi^M$. The investment is socially desirable, and firm 1 would invest if it anticipates to face competition:

$$I < I^C(\delta) \equiv \epsilon \frac{\hat{\pi} - \pi^C}{1 - \delta}.$$

If instead firm 1 anticipates collusion, it will invest only if

$$I < I^M(\delta) \equiv \epsilon \frac{\hat{\pi} - (\pi^M - \rho F)}{1 - \delta}.$$

The firm will clearly invest less often when collusion is sustainable, since the benefits of obtaining a cost advantage are lower when competition is initially less intense. Collusion becomes however less profitable if the firm must pay a bonus $b = (1 - \delta)B$ to a 'long-lived' informed employee, and the firm will then invest if

$$I < \epsilon \frac{\hat{\pi} - (\pi^M - \rho F - (1 - \delta)B)}{1 - \delta} = I^M(\delta) + \epsilon B. \tag{2}$$

Thus, the higher the bounty, the higher the bonus will have to be and the more likely the firm will prefer to invest.

Encouraging innocent behavior

As mentioned above, the behavior of the firm can also allow individuals to infer information as to whether the industry is collusive or not.[44] To see this, suppose for example that the discount factor can take two values: it is high ($\overline{\delta}$) with probability ν and low ($\underline{\delta}$) with probability $1 - \nu$, and collusion can only be sustained in the former case:

$$\frac{\overline{\delta}}{1 - \overline{\delta}} > \frac{\pi^D - (\pi^M - \rho F)}{(\pi^M - \rho F) - \pi^C} > \frac{\underline{\delta}}{1 - \underline{\delta}}.$$

Managers observe the discount factor but employees do not, and thus do not know whether collusion can be sustained; however, by sinking some cost C one of the employees can obtain (hard) evidence of collusion whenever it takes place. We assume that the firm would always invest if it expects competition to prevail (i.e., $I < I^C(\delta)$), so that not investing raises suspicions of collusion.

The antitrust authority offers corporate amnesty and a bounty B to individual informants. The precise timing of events is as follows:

1. Nature draws the discount factor δ, which managers observe.

2. The manager of firm 1 decides whether to invest. The employee observes the investment decision and its outcome. If firm 1 invests, with probability ϵ it takes over the market and competition prevails in all subsequent periods. If firm 1 does not invest or the investment is unsuccessful, the following game is played repeatedly.

3. In each period, the game described in subsection 3.3 is played, with one modification: if no firm reports to the antitrust authority, the employee can invest in the search for evidence of collusion, in which case he obtains evidence whenever firms are indeed colluding; then, either the manager bribes the employee or the employee reports to the antitrust authority.

If the bounty is too small (namely, $B < C$), the employee will never search for information even if he knows for sure that firms collude. In contrast, a large enough bounty (namely, such

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[44]The individuals who are the most likely to know about these decisions are employees of the firm, but other individuals (consultants, in particular) may also have access to this information.

that $\nu B > C$) will always induce the employee to look for evidence, even if the investment decision does not bring any additional information.[45]

In the intermediate case, where

$$\nu B < C < B,$$

the decision to search for evidence depends on what is learned from the investment behaviour of the firm. To fix ideas, suppose that, when the discount factor is high:

- in the absence of bounties, firm 1 would invest only under competition:

$$I^M(\bar{\delta}) < I < I^C(\bar{\delta}),$$

- collusion is sustainable even if firm 1 must bribe the employee:

$$B < \frac{\bar{\delta}}{1 - \bar{\delta}}[(\pi^M - \rho F) - \pi^C] - [\pi^D - (\pi^M - \rho F)].$$

By assumption, the firm will invest if the discount factor is low. Consider now the case where the discount factor is high. If the firm does not invest, the employee infers that the discount factor is $\bar{\delta}$ and anticipates collusion if the investment fails. He will thus search for evidence in the first period and ask for a bounty. If instead the firm invests, the investment decision is uninformative and employee's prior beliefs are such that he will not search for information. The firm may therefore choose to invest, so as to blur the employee's information acquisition and to avoid paying a bribe. More precisely, the expected profits of firm 1 are:

- $\frac{\pi^M - \rho F}{1 - \bar{\delta}} - B$ when it does not invest,

- and $\frac{\epsilon \hat{\pi} + (1 - \epsilon)(\pi^M - \rho F)}{1 - \bar{\delta}} - I$ when it does invest.

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[45]We implicitly assume here that innocent firms do not suffer from the fact that employees wrongfully search for information. Yet in practice, as has been observed by some critics of reward programs, employees may well use their working time to hunt for information instead of executing productive tasks. In addition, the fact that employees look for information may create a work environment where suspicion prevent efficient cooperation and destroy team spirit and corporate culture. Innocent firms may therefore suffer additional costs, and may even decide to over-invest so as to signal that they are not collusive. An innocent firm will be even more at risk of incurring costs if employees and the antitrust authority can make mistakes.

Firm 1 will invest – behave as a competitive firm – whenever

$$I < \frac{\hat{\pi} - (\pi^M - \rho F)}{1 - \overline{\delta}} + B = I^M(\overline{\delta}) + B.$$

Under this condition, B is large enough to offset the cost of over-investing. The larger the bounty, the more valuable it is for a colluding firm to 'fool' the agent by imitating the investment behavior of a competitive firm.[46]

To summarize:

1. The existence of a positive bounty gives incentives to employees to look for information, and to report it when they have it (or to ask for a bribe not to report it, which decreases the benefits of colluding from the point of view of firms).

2. If the bounty is not large enough to deter collusion, it may nevertheless encourage more investment in productivity improvement – for instance, because firms wish to deter employees from looking for evidence.[47]

5 Retaining evidence

The fact that antitrust authorities are so often able to find hard evidence of collusion, such as notes and memos, appears at first glance rather puzzling; firms indeed appear to keep very incriminating documents.[48] The need for communication and for coordinating actions is of course understandable, and there is little doubt that in practice communication often generates

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[46]This condition is similar to condition (2), except that the impact of the bounty is now larger, since investing allows the firm to save the bribe even if the investment does not succeed (hence the term B rather than ϵB).

[47]We have assumed that the investment was socially beneficial, but it may not always be the case. If this investment is, for instance, predatory and/or not accompanied by sufficient efficiency gains, increasing the bounty so as to increase the costs of collusion without inducing over-investment will be preferable.

[48]The example of the 'Lombard cartel' of Austrian banks, convicted on June 11, 2002 by the EC, is instructive: Investigators have found hundreds of documents, from file and telephone notes to memos, where more or less explicit reference to the aim of restricting competition was made – the firms tried to claim that they were not conscious of violating the Law, but some of the documents expressly referred to the need to avoid or destroy traces of collusive meetings...

evidence. But we also need to understand why firms then keep such evidence rather than destroying it as soon as communication has taken place. One possible reason is that agreements may be very complex, due to the variety of products and prices involved, and to the number of possible contingencies; limited memory may then call for keeping notes about the agreement. But other reasons than bounded rationality or memory can be relevant as well. Keeping evidence can be a response to the threat of deviations within a cartel, or to agency problems within firms.

5.1 Keeping evidence to report and obtain leniency

If a leniency program is set up, firms may want to keep evidence so as to decrease the expected fine they have to pay when they are convicted of collusion. And indeed, some critics of leniency programs fear that they could be used to lessen antitrust sanctions. We show below that, while reward programs may indeed generate incentives to keep information in order to reduce antitrust fines, this can only occur if rewards are excessively high.

We will suppose here that firms are entirely free to either keep or destroy the evidence of communication; to fix ideas, we will assume that the probability that the antitrust authority finds evidence is divided by two when only one firm keeps information, and falls to zero when no firm keeps evidence. If a firm is confident that collusion will prevail and that the other will not keep any evidence, it will prefer as well to destroy evidence and be immune to antitrust action. However, firms may be tempted to keep evidence if they fear that the others do so; and this strategy may moreover appear attractive if there is a risk of collusion break-down.

To see this, suppose that with probability ϵ a firm, say firm 1, can benefit from a drastic innovation, in which case it appropriates the whole market and get $\hat{\pi}^C > \pi^M$ while the other firm exits the market. The collusive game is thus modified as follows:

1. Each firm chooses whether to communicate or not. If at least one firm chooses not to communicate, they compete. Otherwise, the game proceeds as follows.

2. If both firms have chosen to communicate, evidence of communication is created and each firm chooses whether to keep it or not. This decision is perfectly observed by the other firm.

3. Firms then learn the state of nature.

   a. If the innovation occurs, firms compete. If no innovation occurs, each firm chooses whether to compete or (if communication has taken place) collude.

   b. At the same time, if a firm kept evidence of communication in the previous stage, it decides whether to report it or not.

Firms may be tempted to keep evidence and collude until firm 1 benefits from the innovation, in which case they both report to the antitrust authority. The expected profits for firm i are then

$$\frac{(1 - \epsilon)(\pi^M - \rho F) + \epsilon(\frac{\hat{\pi}_i^C}{1-\delta} + \frac{R-F}{2})}{1 - \delta(1 - \epsilon)},$$

where $\hat{\pi}_i^C$ equals $\hat{\pi}^C$ for firm 1 and 0 for firm 2.

We now check that this is indeed an equilibrium. First, if firms keep evidence, they will indeed report it when the innovation occurs whenever $R > -\rho F$. Indeed, knowing that there will be no collusion in the future, each firm prefers to deviate and report its evidence, even if it believes that the other does not, in order to get the reward R rather than be exposed to the expected fine ρF from random audits; and if a firm anticipates that the other will report, it will have an incentive to report as well and try to get the reward.

Second, keeping information in each period can be optimal for a firm. If a firm anticipates that the other keeps evidence (and will report it if an innovation happens), then it will keep it as well if

$$\epsilon\frac{R - F}{2} - (1 - \epsilon)\rho F \geq -\epsilon F - (1 - \epsilon)\frac{\rho}{2}F,$$

or

$$R \geq \left[(1 - \epsilon)\frac{\rho}{\epsilon} - 1\right] F.$$

Thus, if this condition is satisfied, keeping information indeed constitutes an equilibrium.[49] And this condition becomes more likely to be satisfied as the probability ϵ that collusion breaks down

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[49]If a firm expects that the other has not kept evidence, it will nevertheless keep it if $0 \leq -(1 - \epsilon)\frac{\rho}{2}F + \epsilon R$, or $R \geq \frac{(1-\epsilon)\rho}{2\epsilon}F$. Thus, if $R \geq \max\{[(1 - \epsilon)\frac{\rho}{\epsilon} - 1]F, (1 - \epsilon)\frac{\rho}{2\epsilon}F\}$, keeping information is preferred whatever the beliefs on the other firm's behavior.

increases.[50]

We should stress that, even though they reduce expected fines, rewards have no perverse effects on the sustainability of collusion. Indeed, the above collusive strategy will be sustainable if

$$(\pi^D + R) - (\pi^M - \rho F) \leq \frac{\delta(1-\epsilon)}{1 - \delta(1-\epsilon)}[(\pi^M - \rho F) - \pi^C].$$

If instead firms do not keep evidence (and assuming that they can discipline themselves to do so[51]), the antitrust supervision would be ineffective and collusion would be sustainable if

$$\pi^D - \pi^M \leq \frac{\delta(1-\epsilon)}{1 - \delta(1-\epsilon)}[\pi^M - \pi^C],$$

which is a less stringent condition than the previous one whenever $R \geq -\rho F$. Thus collusion is more difficult with rewards than without (in which case there is no evidence to be found). While both firms can indeed decrease expected antitrust sanctions when they learn that collusion will break-down, a deviating firm can still surprise its cartel partners and obtain the full reward, so that its incentives to deviate remain unambiguously stronger with rewards.

Last, both firms would favor the collusive strategy where they keep evidence only if $(1 - \epsilon)\rho F > \epsilon\frac{R-F}{2}$, or $R > (1 + 2\rho\frac{1-\epsilon}{\epsilon})F$. This will thus only be satisfied for quite large rewards (higher than the fine F in any event), especially if the probability that collusion breaks down is small.

To sum-up, firms may be tempted to keep evidence in order to benefit from leniency or rewards when they expect collusion to break down. However, such collusive behavior is profitable only for rather large rewards (higher than the fine F) and, in any event, is less sustainable than when firms do not keep evidence. Hence, this possible use of leniency and whistle-blowing programs cannot make collusion more likely.

Uncertainty can have another effect by making communication more valuable for colluding firms. When firms' environment is uncertain, communication allows firms to collude in a more efficient way, as shown for example by Athey and Bagwell (2001). As emphasized by Green

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[50]For example, the condition boils down to $R \geq -\rho F$ when the probability of innovation coincides with that of random audits ($\varepsilon = \rho$).

[51]Such discipline may be obtained by threatening for example of reverting to competition it is proved that one of the firms has kept evidence.

and Porter (1984), uncertainty about the environment makes also collusion more difficult to sustain, as the interaction becomes less transparent. Firms can be tempted to take advantage of the uncertainty and try to deviate from the agreement without being detected, blaming the resulting harm to the other members on 'bad luck'. To avoid this, the cartel must enter a 'disciplinary' phase (e.g., competing for some time) when an bad luck indeed occurs. The larger the uncertainty, the more frequent and the longer the disciplinary periods, which reduces the profitability of the cartel arrangement. Mouraviev (2004) stresses that firms may wish in that case to exchange hard evidence of what they did (prices, volumes, and so forth), so as to clarify whether an incident is due to bad luck or misbehavior. Even if doing so sometimes allows the antitrust authority to convict the firms, the expected fine ρF can be lower that the cost of the disciplinary phases that the cartel should otherwise endure. There again, introducing rewards for individuals, for example, makes collusion with communication less profitable and thus more difficult to sustain.

5.2 Evidence as a disciplining device

A colluding firm can use evidence of collusion to threaten to denounce its partners in case of deviation. This has been pointed out by Spagnolo (2000), who shows how moderate leniency (contrary to rewards) can help sustain collusive agreements under Bertrand competition in a one-shot game, provided that the profits from collusion – or from a deviation – must be paid back in case of detection (as with the US system of damages). Moderate leniency programs are therefore harmful since they help sustain collusive agreements.[52] By contrast, we consider here repeated relationships and allow firms to destroy evidence if they wish to. We point out that firms may indeed keep evidence to take advantage of antitrust enforcement and ... foster collusion. This possible adverse effect comes however from the (standard) antitrust sanction, not from a leniency program.

We have assumed until now that when a firm deviates, it surprises the other cartel members and obtains the reward for sure. Let us now consider a situation in which deviating requires

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[52]In Spagnolo's setting, reporting is optimal in case of deviation in order to avoid paying an expected fine due to antitrust intervention, whenever the reduced fine falls between zero (included) and the expected fine (ρF with our notations). This in turn increases the cost to deviate, and helps sustain collusion.

taking some observable steps, so that the other firm can react immediately and both firms have 'equal chances' of being the first to report to the antitrust authority.

The timing is now the following:

1. Each firm chooses whether to communicate or not. If at least one firm prefers not to communicate, they compete. If both firms choose to communicate, the game proceeds as follows.

2. Each firm chooses whether to keep evidence of communication or not. This decision is perfectly observed by the other firm.

3. Each firm chooses whether to deviate or to collude, and this decision is observed by the other firm. A firm that has kept evidence then decides whether to report it.

No leniency

Since not keeping evidence makes the cartel immune to prosecution, firms will rather not keep evidence if the cartel is sustainable without it. Let us therefore consider a situation in which collusion is not sustainable when firms do not keep information:

$$\pi^D - \pi^M > \frac{\delta}{1-\delta}[\pi^M - \pi^C].$$

Collusion may nevertheless be sustainable if both firms keep information, and threaten to denounce the other if it deviates[53]:

$$(\pi^D - F) - (\pi^M - \rho F) \leq \frac{\delta}{1-\delta}[(\pi^M - \rho F) - \pi^C].$$

Moreover, there always exists an equilibrium in which both firms report information when they observe a deviation (if a firm anticipates that the other will report, it is indifferent between reporting or not). This perverse effect – the increased sustainability of collusion – comes exclusively from the fine.

With leniency and rewards

Assume that firms have kept evidence. If a leniency program is set up, after a deviation, each firm strictly prefers to report, if it anticipates that the other firm will do so.

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[53]The two equations can be compatible if $\rho < 1 - \delta$.

If firms do not keep evidence, collusion is by assumption not sustainable. But if they do keep it, the existence of a leniency program (resp. a reward program) decreases the cost borne by a deviating firm since it will benefit from a reduced fine (resp. a reward) with probability $\frac{1}{2}$ (the standard effect of leniency). Collusion is therefore less often sustainable than in the absence of such a program.

To summarize, firms may want to keep evidence so as to discipline the cartel by taking advantage of standard antitrust enforcement. If a leniency or reward program is set up, keeping evidence may no longer suffice to ensure the sustainability of the cartel. As usual, if rewards are large enough, collusion will no longer be sustainable. The motivation to keep evidence will disappear, but so will collusion.

5.3 Retaining evidence because of intra-firm agency problems

Individuals may also want to keep evidence of collusion because of agency problems within the firm, particularly between the owner(s), the manager and the involved employee(s). Antitrust reward programs can exacerbate, or even create such agency problems.[54] The employee that negotiates or implements the cartel agreement may want to keep evidence in order to increase his bargaining power vis-à vis the manager or the shareholders, and obtain a pay raise, as seen in subsection 3.3.

The bargaining over a cartel agreement is important in determining how collusive firms will share total profits. If they delegate it to a negotiating agent (e.g., the manager), they must give him adequate incentives, which may be difficult or costly without appropriate information on the conditions under which the agreement was reached. The agent should for instance get a share of profits to exert effort in the negotiation (see Holmström, 1979). This is costly if the agent is risk averse or has limited liability. It may then be more profitable for the shareholders to ask for hard evidence about the negotiation process, and reward the agent under complete information.

Keeping evidence of the information transmitted may be necessary if there are commitment

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[54]The investment model presented in subsection 4.3. provides an example of how rewards can create agency issues within the firm, by providing employees with incentives to obtain evidence of collusion.

issues: If an informed employee cannot commit not to report collusion, the shareholder will be better off delaying the payment of bonuses until the end of the last employment period; if the shareholder also lacks commitment power, then the employee will keep evidence until this payment occurs. An employee may also want to keep evidence that the actions he took conform to the orders given by his hierarchy, or by the owners. For example, as we have seen in Section 4, shareholders may be less keen to invest and to restructure when the firm colludes. Yet the manager may find it difficult to justify small levels of investment if shareholders change.[55]

6 Conclusion

6.1 Rewarding firms

Positive rewards provide stronger tools than leniency programs for the prevention of cartels. Rewards should be large enough to be effective, and to avoid potential adverse effects. Large rewards have strong deterrence properties by making collusion no longer sustainable. This deterrence effect is increased by allowing cartel leaders to obtain rewards – except if it coerced the other firms into participation in the illicit agreement.

Rewards have been criticized for restricting efficient exchanges of information between competing firms. Yet, introducing fines for false denunciations limits the scope of this inefficiency. These fines also help deter strategic false reports meant to harm competitors.

Last, paradoxically, rewards can give firms increased incentives to keep information, in order to decrease expected fines in case the cartel breaks down. Yet, collusion remains less sustainable when firms can use leniency programs in this way than when they do not keep evidence, and thus make no use of the programs.

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[55]Even if shareholders can commit to reward him when he exerts little effort, one of the important assets a manager has is his reputation. If outsiders observe that the firm (or branch) he is managing has not improved in efficiency as much as others in similar situations, their appreciation of a manager's quality is likely to be low, even when profits are high. A manager accepting to undertake little investment because of collusion may thus face a tough market when changing firms, and ask for a compensation for his future foregone earnings.

6.2 Rewarding individuals

Introducing bounties for individuals decreases the benefits of collusion, especially when the number of employees informed on the agreement is large. While such individual rewards may induce rigidity in the employment structure of the firm, this makes collusion less attractive in the first place and can thus bring additional deterrence.

A colluding firm may also have to adopt a seemingly competitive behavior so as not to arouse the suspicions of their employees. This generates an additional cost for colluding firms, which reinforces again the deterrence effect of bounties.

Bounties can also create or exacerbate agency problems between owners and employees. Individuals are indeed given incentives to keep hard information, making it more likely that the antitrust authority will find evidence of collusion, and increasing the cost of collusion by the amount that firms have to pay to prevent their employees from reporting evidence.

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