The deterrence effect of excluding ringleaders from leniency programs∗

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Abstract

This paper looks at the implications of excluding ringleaders from leniency programs for the sustainability of collusion. We find that excluding ringleaders decreases the sustainability of collusion by forgoing the information an additional potential whistleblower means for the antitrust authority. On the other hand, a ringleader will ask for a compensation for not being able to apply for leniency. Such a compensation, however, results in an asymmetry between the ringleader and the other cartel members which may destabilize collusion. We show that if an antitrust authority investigates an industry only with a low probability, excluding ringleaders from leniency programs increases the sustainability of collusion. If the probability of review is high, an exclusion may decrease the sustainability.

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Keywords: cartel, collusion, leniency program, ringleader, whistleblowing.

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1 Introduction

In the context of cartels, ringleaders seem to play a crucial role. They often guarantee the stability and the functioning of a cartel. They organize initial meetings, collect data, and ensure a safe and repeated communication between the cartel members. There are many examples of such ringleaders in the history of cartel cases.¹

For example, the leader of the “Alloy cartel”, Usinor, did the calculations at the first meeting and sent the conclusions of the meeting together with the definitive calculation to the producers after the meeting.² In the “Amino-acid (lysine) cartel”, the Archer Daniels Midland Company (ADM) and Ajinomoto organized the secretariat of the quantity-monitoring system.³ ADM – together with Hoffmann-La Roche – also was at the helm of the “Citric-acid cartel” where it chaired the meetings and organized the collection and distribution of data.⁴ In the cartel concerning gas-insulated switchgear, Siemens and Alstom acted as (cartel) secretaries. As such, they arranged contacts between the cartel members and had a crucial role in the organization of meetings and in the compilation of information submitted by and passed on to the members. Moreover, they managed the communication on behalf of the European undertakings with the Japanese secretariat. They also convened and chaired meetings, took care of the quotas, and managed the system of ‘E-mails Secure Transmission’.⁵

These examples illustrate that activities to run a cartel had to be organized by at least one of the cartel members. The characteristics of these activities per se do not require a special market position, size, or knowledge of the firm which acts as a ringleader.⁶ Therefore, even if a reliable ringleader

¹Ganslandt, Persson, and Vasconcelos (2008) suggest that during the period between 2002 and 2007 a ringleader was explicitly identified in approximately 23 percent of the European cartel cases.

²Case IV/35.814 – Alloy surcharge (1998), paragraph 81.


⁴Case COMP/E-1/36 604 – Citric acid (2001), paragraph 273.

⁵Case COMP/F/38.899 – Gas insulated switchgear (2007), paragraphs 147, 173, 511–513.

⁶Ganslandt, Persson, and Vasconcelos (2008) argue that ringleaders tend to be large firms since they have firm-specific indivisible cost associated with collusion, e.g. the cost of protecting the cartel by buying out potential entrants. There are further characteristics which may determine leadership and which are more firm-specific. For example, Hoffmann-La Roche and BASF as two instigators of the vitamins cartel – due to a wide range of products – had a stronger position in relation to their customers than other firms selling a single or limited number of products only. They also had a greater flexibility to structure prices, promotions, as well as discounts, and had a much greater potential for tying. Moreover, they enjoyed greater economies of scale and scope and an
is crucial to run a successful and stable cartel, it appears that any firm of an industry could be a possible ringleader under such circumstances. In any case, this paper will focus on the consequences of excluding the ringleader from leniency programs and not on the evolution of ringleaders.

Before thinking about the question how to treat ringleaders, it seems important to point out that identifying initiators of cartels is actually possible. For instance, in the cartel case of the Fédération Nationale Bovine in France, it became “[...] clear from the documents [...] that the initiative for a price scale [...] came from the Fédération Nationale Bovine (FNB). The FNB was especially emphatic in support of an oral agreement, as statements (in the press) made by its vice-president show.”7 An antitrust authority may also rely on evidence provided by cartel members, as was often the case in the cartel cases described above, or it identifies the instigator of the cartel as the leader.

The fact that ringleaders play an important role for collusive agreements raises the question how antitrust authorities should deal with them. Having a closer look at the legal approaches of the EU Competition Commission and of the US Department of Justice reveals that ringleaders are indeed treated differently in both jurisdictions.8 The leniency program established in the US law in 1978, stipulates that it is not possible for ringleaders to obtain a fine reduction through leniency. To be eligible for leniency requires that “the corporation did not coerce another party to participate in the illegal activity and clearly was not the leader in, or the originator of the activity”.9 When the EU set up its leniency program in 1996, this ringleader-discrimination rule was adopted.10 However, due to the changes in the EU regulations in 2002 and 2006, ringleaders now have the possibility to participate in the leniency program.11 Nevertheless, both antitrust regimes specify a fine load implicit (or explicit) threat of a refusal to supply would have been much more credible (Case COMP/E-1/37.512 — Vitamins (2001), paragraphs 712–718). In the Nintendo case, Nintendo enjoyed a unique position as the manufacturer of the products (Cases COMP/35.587, COMP/35.706, COMP/36.321 – Nintendo (2002), paragraphs 406, 228–238). However, the model developed in this paper will not focus on the evolution of ringleaders, though.

7Case COMP/C.38.279/F3 — Viandes bovines françaises (2003), paragraph 175.
8See e.g., Aubert, Rey, and Kovacic (2006), Spagnolo (2007), and Feess and Walzl (2005) for more detailed comparisons of the different approaches of the leniency program in the EU and in the US.
11European Commission (2002), Commission Notice on immunity from fines and reduction of fines in cartel cases, OJ C 45, 19/02/2002, pp. 3–5, paragraph A 11 (c) and
Concerning the implications of these different approaches, it is often argued that excluding ringleaders from leniency programs is detrimental as it hinders the detection and the deterrence of cartel activities. As AUBERT, REY, and KOVACIC (2006) point out, this was indeed the idea of the new EU leniency law which now gives ringleaders the opportunity to benefit from leniency. In a similar vein, SPAGNOLO (2007) argues that allowing ringleaders to apply for leniency may seed distrust among cartel members which may finally deter cartelization. Also, LESLIE (2006) argues that extending amnesty to ringleaders may increase deterrence since cartel members will then find it harder to trust even trust the ringleader.

Apart from these few qualitative arguments, there is one experimental paper by BIGONI, FRIDOLIFSON, LE COQ, and SPAGNOLO (2008) who test the effect of excluding ringleaders from leniency. They show that if the ringleader is excluded from the leniency program, the deterrence effect of leniency decreases. However, they point out that this unambiguous result might be due to the experimental design. In the experiment “subjects were matched pairwise into duopolies to avoid social preferences effects towards non-defecting third parties. This, however, is the worst conceivable situation [...] of excluding ringleaders, as the ban leaves only one cartel member with the option to self-report obtaining leniency, eliminating the incentives to ‘race to report’ generated by the risk that another cartel member could do it before. With more than two firms, therefore, it is likely that the [ringleader] treatment will show more desirable properties.”

There has been no rigorous formal study to theoretically analyze the effect of ringleader exclusion on the sustainability of collusion. The developed model, aims to fill this gap by setting up a model to allow for both scenarios in order to get a better understanding of the effects described above. It is found that both regimes, i.e. the ones with and without ringleader discrimination, may be superior. More specifically, it is found that a regime where ringleaders are treated in the same way like other cartel members (symmetric case) is always superior if the antitrust authority reviews industries with a relatively

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13On the other hand, the author also observes that “in an adversarial system [like the one in the US], where testimony is crucial to persuade juries, testimony by a ringleader may not be convincing.”
small probability only. In such a situation, giving ringleaders an incentive to reveal information (to blow the whistle) leads to a higher probability that the antitrust authority successfully prosecutes the cartel and thus decreases the sustainability of collusion in general.

On the other hand, an antitrust authority which forgoes this additional information – by giving ringleaders no incentives to reveal information (asymmetric case) – would therefore run the risk of more cartel activity. However, if the antitrust authority reviews the industries with a relatively high probability, the effect that more information leads to less collusion decreases in importance. Excluding the ringleader (asymmetric case) may be the better option now. These ambiguity results from the three different effects of excluding one potential whistleblowing firm.

First, as argued in the literature above, if the ringleader is excluded from the leniency program, the probability that the antitrust authority is able to convict the cartel decreases. *Ceteris paribus* the lower probability of being convicted leads to more collusive activity of all firms.

Second, since the number of firms competing in the “race to report” is reduced when ringleaders are excluded from this “race”, the expected fine of each (whistleblowing) ordinary cartel member decreases. This is due to the fact that the probability that one of them gets the full fine reduction increases if less firms are able to apply for a fine reduction. The resulting lower expected fine results – *ceteris paribus* – in more collusion.

Third, if the ringleader is excluded from leniency, it faces a higher expected fine than an ordinary cartel member. As a consequence, firms would face asymmetric expected profits from collusion if the ringleader and the members where to share the collusive industry profit equally. At the margin, the cartel has an incentive to reallocate the collusive profit to account for the difference. A ringleader requires a compensation for the higher expected fines which increases its share of the collusive industry profit per period. Such a reallocation of the collusive profit decreases *ceteris paribus* the sustainability of collusion. This effect becomes stronger if the probability that industries are reviewed increases. Generally speaking, a higher probability of being reviewed by the antitrust authority decreases the expected profit from collusion through the reduction of the expected number of collusive periods. If the expected number of collusive periods becomes smaller, the compensation scheme for the ringleader has to go up, which increases the asymmetry of the industry and the sustainability of collusion decreases even more.

Thus, if the probability that a industry is reviewed is sufficiently high, the asymmetry – resulting from ringleader exclusion – may outweigh the two cartel-enhancing effects of excluding the ringleader argued before.
The following sections are organized as follows. In the next section, the model is developed. In Sections 3 and 4, the cases without and with ringleader discrimination are analyzed. In Section 5 we run some numerical simulations on the results of the section above. Section 6 discusses briefly an extension of the model to allow for a higher fine for ringleaders compared to the ordinary cartel members. The last section concludes.

2 The model

2.1 Firms

Consider an infinite number of industries where each industry consists of \( n \geq 3 \) ex-ante perfectly identical firms. The industry-specific market is made up of an infinitely large number of submarkets.\(^{14}\) Firms compete in prices for an infinite number of periods \( t \in \{0, 1, 2, ..., \infty\} \) and sell an industry-specific homogeneous product at constant marginal costs \( c > 0 \) by placing selling bids on the submarkets. The monopoly industry profit is given by \( \Pi \).

If firms form a cartel, one of the firms has to act as a ringleader. An exogenously given ringleader is considered, i.e. the evolutionary forces (or the strategic options) which lead to a specific firm’s status as a ringleader will not be analyzed. Thus, it is assumed that one of the \( ex \ ante \) identical firms is chosen randomly as the ringleader. Furthermore, it is assumed that any collusive agreement produces evidence about the organization of the cartel. Thus, when deciding on collusion, firms have to take into account the enforcement policy of the antitrust authority.

2.2 Antitrust policy

The antitrust authority commits to an enforcement policy targeting collusive behavior. The authority is assumed to be constrained in the number of investigations per period. Thus, in any period the authority reviews a specific industry with probability \( \rho \leq 1 \). Once the review is under way and if firms have colluded in this period or in any period before the review has started, the antitrust authority finds evidence to convict all firms of the cartel with probability \( \hat{\mu} < 1 \). The fact that \( \hat{\mu} < 1 \) can be explained by pointing out that usually antitrust authorities employ both economists who “look for smoke” and lawyers who help convict firms. The first group would be in charge of

\(^{14}\)This assumption can be justified when considering a global economic environment with a large number of regional submarkets. The aim of this assumption is to allow for allocations of even every small market shares to firms.
the initial review whose results are then used by the second group. As a consequence, even if the first group finds evidence that a specific industry output is driven by cartel behavior, the lawyers per se do not have no enough evidence to convict the cartel for collusion any time.

In the case that the cartel is found guilty of collusion, the antitrust authority levies a fine $f$. The fine is proportional to the collusive per-period profit of the convicted firm. Indeed, a proportional fine seems to be more realistic than a lump-sum fine which is often used in the literature. As such, firms which have benefited more from the cartel have to pay larger fines which is true for antitrust case laws all over the world.\footnote{E.g. in European antitrust law, the basic amount of the fine is calculated as a percentage of the value of the sales linked to cartel activity. (European Commission (2006), Guidelines on the method of setting fines imposed pursuant to Article 23(2)(a) of Regulation No 1/2003, OJ C 210, pp. 2–5, paragraphs 13.–18.)}

Furthermore, the antitrust authority commits to a leniency program. The program is captured by the fine reduction $\phi$ (with $0 < \phi \leq 1$).\footnote{Several authors (e.g., Aubert, Rey, and Kovacic (2006)) argue that an optimally defined leniency program requires rewards for whistleblowing firms. However, no leniency program so far allows such rewards for firms that reveal information. Thus, $\phi = 1$ is the limit, which is equal to full immunity from fines.} It is assumed that only one firm (the first whistleblower) is allowed to benefit from the leniency program.\footnote{The European and the US leniency program differ in that point. In the US, only the first whistleblowing firm is eligible for the leniency program. The EU does not use such a “the-winner-takes-it-all” approach. Even the second and the third whistleblower may be eligible for leniency if they come up with sufficient enough additional evidence to the authority. For a detailed discussion of these different regimes see, Feess and Walzl (2005).} Moreover, the antitrust authority must decide whether or not a ringleader is eligible to apply for leniency. Note that it is assumed that the identification of the ringleader is not subject to controversy due to the evidence the antitrust authority has access to.

To account for the information revealed to the antitrust authority by the ringleader – as an additional whistleblowing firm – it is assumed that each whistleblowing firm leads to an increase in the probability $\mu$ that the cartel is indeed convicted in case of a review by $\kappa$, i.e. $\mu = \hat{\mu}(1 + \kappa \hat{n})$, where $\hat{n}$ represents the number of the whistleblowing firms (with $\hat{n} \in \{0, 1, \ldots, n - 1, n\}$). Note that even if one firm decides to blow the whistle, the conviction probability must not necessarily be equal to one. This may be justified by procedural problems or a time and budget constraint of the antitrust authority.\footnote{These constraints are indeed relevant as pointed out by practitioners: “Seit 2002 sind in Brüssel so viele Selbstbeschuldigungen eingegangen, daß die Kartellbeamten sie längst nicht alle bearbeiten können. Nur einem Bruchteil der Selbstbeschuldigungsschreiben folgten}
Furthermore, it is assumed that the authority is able to ensure that if firms (or a specific industry) are convicted once, they will never have the chance to collude again.  

2.3 Timing of the game

The timing of the game is as follows: In period $t = 0$, the legal environment is defined: The antitrust authority commits to a specific law-enforcement policy, i.e. it chooses $\rho$, $\bar{\mu}$, $\phi$, and $f$ as well as its ringleader policy.

The subsequent periods $t = 1, 2, ..., \infty$ all have the same structure given by:

**Stage 1**: Firms decide whether or not to collude as well as whether and how to split the collusive industry profits between the ringleader and the ordinary cartel members by allocating submarkets.

**Stage 2**: Firms place bids on the submarkets.

**Stage 3**: The antitrust authority reviews the industry with probability $\rho$. 

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Weitere Schritte der Kommission, kritisiert der Brüsseler Kartellanwalt Ulrich Soltész. ‘Die Verfolgung erfolgt nach dem Zufallsprinzip. Einige Fälle bleiben jahrelang unbearbeitet liegen, während in manchem Sektor jeder Verstoß gnadenlos und konsequent verfolgt wird’ [...] Claus Dieter Ehlermann, langjähriger Chef der Generaldirektion Wettbewerb in der Kommission und heute als Anwalt tätig, schätzt, daß die Kommission etwa zehn Kartellfälle im Jahr entscheiden kann. Die Zahl der jährlichen Anträge liegt um ein ‘Vielfaches’ darüber.” (Since 2002 Brussels has received so many self-reportings that cartel officials have not been able to process all of them. The Commission initiated further steps only in a fraction of the cases, criticizes the Brussels cartel lawyer Ulrich Soltész. ‘The prosecution is according to a random choice. Some cases are not processed for years while in some industry sectors, every infringement is prosecuted without mercy and with determination’. Claus Dieter Ehlermann, long-time head of the Commission’s DG Comp and a lawyer today, estimates that the Commission can decide on around ten cartel cases per year. The number of yearly self-reportings is several times above.), Frankfurter Allgemeine Zeitung (FAZ), December 5, 2006, no. 283, p. 22, ‘Mehr Rechtssicherheit für Kronzeugen’.

19There is a discussion in the literature if a firm which has been convicted once will be able to revert to collusion in the future. E.g. AUBERT, REY, and KOVACIC (2006) assume that collusion will break down forever after a conviction, MOTTA and POLO (2003) assume that firms have to interrupt the collusive activity for one period after the antitrust authority finds them guilty, and in HERRE and WAMBACH (2008) it is argued that firms are able to revert to collusion immediately after conviction.
Stage 4: Firms decide whether or not to reveal information to the antitrust authority (whistleblowing).

Stage 5: The antitrust authority proceeds as committed to in period 0.

2.4 Firms’ strategies

Since this model is aimed at analyzing the effect of excluding the ringleader from the leniency program, it concentrates on an equilibrium strategy where indeed all firms would be willing to blow the whistle. The other cases where not all or even no firm has an incentive to blow the whistle in equilibrium are discussed in detail below. First, the following equilibrium strategy is analyzed:

**AW (All firms blow the whistle)** Firms collude from $t = 1$ on as long as no firm deviates. If in period $t$ the antitrust authority reviews the industry, all firms which have the possibility to benefit from the leniency program blow the whistle and reveal information to the antitrust authority. If the authority is not able to convict the cartel, firms revert to collusion in period $t + 1$. If the authority successfully convicts the cartel or if one firm has deviated, firms choose a price equal to marginal costs, $p = c$, in every submarket in every subsequent period (grim-trigger strategy, see Friedman (1971)).

Before turning to the equilibrium analysis, the following assumption – regarding the value an additional whistleblowing firms means for the antitrust authority – is made:

**Assumption 1** $\kappa \leq \bar{\kappa} = \min \left\{ \frac{\phi_f}{n(n-1+(1-\phi)\bar{f})}; \frac{1-\hat{\mu}}{n\hat{\mu}} \right\}$.

This assumption ensures two important specifications of the model. The first term ensures that the increase in the conviction probability $\hat{\mu}$ through whistleblowing is not too large so that the AW strategy as described above is an equilibrium. We will comment on the derivation of this upper bound for $\kappa$ in the next section. The second term ensures that if all firms in an industry blow the whistle, the total probability of conviction is not larger than one, i.e. $\hat{\mu}(1+n\kappa) \leq 1$. 

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3 Symmetric case: no ringleader discrimination

If the antitrust authority decides not to make a difference between a ringleader and an ordinary cartel member when designing a leniency program – as it has been the policy of the EU since 2002 – firms are symmetric ex post as well.

3.1 Joint whistleblowing as an equilibrium strategy

Consider a situation where collusion can be sustained in equilibrium and AW is an equilibrium strategy: Thus, all $n$ firms will blow the whistle if the antitrust authority reviews the industry. Then, the collusive firm value of each firm amounts to

$$V^{+}_{\{n\}} = \frac{\Pi}{n} + (1 - \rho) \delta V^{+}_{\{n\}} + \rho \left( -\hat{\mu}(1 + \kappa n) \frac{\Pi f}{n} \left( \frac{1 - \phi}{n} + \frac{n - 1}{n} \right) + \left( 1 - \hat{\mu}(1 + \kappa n) \right) \delta V^{+}_{\{n\}} \right). \quad (1)$$

Since the firms are identical, each of them gets the same share of the monopoly industry profit, $\frac{\Pi}{n}$, in every collusive period. With probability $(1 - \rho)$ the antitrust authority does not review the industry and the firms continue to collude in the following period. This is represented by the second term of equation (1). The third term of equation (1) reflects the case when the antitrust authority reviews the industry with probability $\rho$. This term consists of two elements. First, the antitrust authority manages to convict the cartel with probability $\hat{\mu}(1 + \kappa n)$. Remember that $\hat{\mu}$ is the probability of conviction which is increased by each of the $n$ whistleblowing firms by the value of $\kappa$. By assumption, only the first whistleblowing firm is allowed to benefit from the leniency program. If $n$ firms blow the whistle simultaneously, it is assumed that one of them is chosen randomly as the first whistleblower. Therefore, a firm gets a reduction of $(1 - \phi)$ of the full fine $\frac{\Pi f}{n}$ with probability $\frac{1}{n}$. Consequently, with probability $\frac{n-1}{n}$ a firm has to pay the full fine even if it has blown the whistle. If the antitrust authority convicts the cartel, collusion breaks down. Second, with probability $(1 - \hat{\mu}(1 + \kappa n))$ the antitrust authority is not able to convict the cartel – even with the help of the whistleblowing firms. In this case, firms continue to collude in the following period.

For expositional simplicity the total probability of conviction in the sym-
metric case is defined as
\[ \mu_n \equiv \hat{\mu}(1 + \kappa n) \]  
(2)
and the expected realization of the fine reduction as
\[ \psi_n \equiv \frac{1 - \phi}{n} + \frac{n - 1}{n} = \frac{n - \phi}{n}. \]  
(3)

Then, equation (1) can be rearranged to give
\[ V^+_{\{n\}} = \frac{\Pi}{n} \left( \frac{1 - \rho \mu_n f \psi_n}{1 - \delta(1 - \rho \mu_n)} \right). \]  
(4)

Next, the value of a firm that deviates from collusion is analyzed. The realization of the deviating profit depends on the incentives of the firms to blow the whistle if one firm has deviated. Note that if one firm has deviated, due to the collusive strategy defined above, collusion breaks down and there is no returning to the collusive outcome in any of the following periods.

**Lemma 1** Under Assumption 1 it is an equilibrium that all firms blow the whistle if the industry is reviewed in case of deviation. Thus, the firm value of a deviating firm amounts to
\[ V^D = \Pi - \frac{\Pi}{n}(\rho \mu_n f \psi_n). \]  
(5)

**Proof** We have to compare the individual expected realization of the fine. To this end, we have to consider four different scenarios. First, if no firm blows the whistle, firms expect a fine of
\[ E[F]_{\{0\}} = -\rho \hat{\mu} f \frac{\Pi}{n}. \]  
(6)
If all firms blow the whistle, the expected fine is given by
\[ E[F]_{\{n\}} = (1 + \kappa n) \frac{n - \phi}{n} E[F]_{\{0\}}. \]  
(7)

Next, if the other firms do not blow the whistle, a firm that does so faces an expected fine of
\[ E[F]_{\{1\}} = (1 + \kappa)(1 - \phi) E[F]_{\{0\}}. \]  
(8)

Last, a firm that does not blow the whistle – while the other firms do – expects a fine of
\[ E[F]_{\{n-1\}} = (1 + \kappa(n - 1)) E[F]_{\{0\}}. \]  
(9)
Suppose that given one firm deviated, no other firm blows the whistle. Then, blowing the whistle for a single firm would be optimal whenever $E[F]_{\{1\}} \leq E[F]_{\{0\}} \leftrightarrow \kappa \leq \frac{\phi}{1-\phi}$. Comparing this value with $\frac{\phi f}{n(n-1+(1-\phi)f)}$ which is one of the two possible values of $\bar{\kappa}$ from Assumption 1 reveals that $E[F]_{\{1\}} \leq E[F]_{\{0\}}$ holds for all $n \geq 1$. Thus, consider the case where all firms blow the whistle after deviation by one firm. Then, not blowing the whistle must not be optimal for a single firm, i.e. $E[F]_{\{n-1\}} \geq E[F]_{\{n\}} \leftrightarrow \kappa \leq \frac{\phi}{n(n-1+(1-\phi)f)}$. Again, we have $E[F]_{\{n-1\}} \geq E[F]_{\{n\}}$ holds for any $n \geq 1$ when compared with $\kappa \leq \frac{\phi f}{n(n-1+(1-\phi)f)}$. As the other value for $\bar{\kappa}$, $\frac{1-\bar{\mu}}{n\mu}$, is either even lower or not relevant, we can conclude that all firms blow the whistle if one firm has deviated and if the antitrust authority has started to review the industry.

Equation (5) implies that a firm that deviates gets the whole monopoly industry profit, $\Pi$, and expects a total fine of $\frac{\Pi}{n}(\rho \mu_n f \psi_n)$ since all firms have an incentive to blow the whistle.\(^{20}\)

Collusion can be sustained if the firm value from collusion, $V^+_{\{n\}}$, is larger than the firm value from deviation, $V^D$. Thus, the critical discount factor above which collusion can be sustained is given by:

$$\bar{\delta}_{\{n\}} = \frac{n-1}{(n-\rho \mu_n f \psi_n)(1-\rho \mu_n)}.$$ \hspace{1cm} (10)

3.2 Whistleblowers and silent firms

If firms collude and the industry-specific discount factor is larger than $\bar{\delta}_{\{n\}}$ and no firm has deviated, not all firms (in every industry) have an incentive to blow the whistle if a review is started. Thus, AW may no be equilibrium strategy in every industry, or more precisely for every critically industry-specific discount factor, $\bar{\delta}$. The main reason for this is that each whistle-blowing firm increases the probability of conviction – and thus for an end of collusive profits – by $\kappa$.

If the industry-specific discount factor converges to one and if firms face a relatively small probability of being reviewed, not all firms (or even no firm) may have an incentive to blow the whistle and thus stay silent if the review is under way. This is due to the fact that the firm value from collusion, equation

\(^{20}\)Note that if one firm has deviated, this period is excluded from the collusive phase as collusion breaks down by assumption. Thus, it is assumed that the single deviation profit, $\Pi$, is not considered by the antitrust authority when evaluating the fine. This makes sense as the antitrust authority should not punish the deviating firm more than the other cartel members in order to increase its incentives to deviate. On the other hand, in order to leave the model as general as possible a per-se fine reduction for the deviating firm is not assumed.
(4), goes to infinity if $\delta \to 1$ and $\rho \to 0$. Then, firms face a trade-off between reducing their own expected fine when blowing the whistle and increasing the probability of getting collusive profits in the next periods if they do not blow the whistle. At the same time, this includes a second trade-off: When blowing the whistle, firms may reduce their expected individual fine through the possibility of benefiting from the leniency program but they also increase the probability of being convicted – and thus of having to pay the fine – by the amount of $\kappa$.

To account for this, two additional critical discount factors have to be calculated. The first one, denoted by $\tilde{\delta}_{\{n-1\}}$, reflects a situation where it is not optimal for some firms – or at least one of them – to blow the whistle. The second one, denoted by $\tilde{\delta}_{\{0\}}$, represents a value of the discount factor above which no firm has an incentive to blow the whistle.

3.2.1 Some firms blow the whistle (SW)

To account for the cases where at least one firm has no incentive to blow the whistle, consider the following equilibrium strategy:

**SW (Some firms blow the whistle)** Firms collude from $t = 1$ on as long as no firm deviates. If in period $t$ the antitrust authority reviews the industry, at least one (but not all firms which have the possibility to benefit from the leniency program) blows the whistle and reveals information to the antitrust authority. If the authority is not able to convict the cartel, firms revert to collusion in period $t+1$. If the authority successfully convicts the cartel or if one firm has deviated, firms set prices equal to marginal costs in every submarket in every subsequent period.

As described above, to identify the parameter space where SW is an equilibrium strategy, the border above which at least one firm has no incentive to blow the whistle has to be calculated. To calculate this border the one-stage deviation principle is used. Due to this, it is sufficient to prove that the collusive firm value of a firm – unlike the other firms – which does not blow the whistle once (when the collusive industry is reviewed) is larger when being silent once, $\{s1\}$. Such a silent firm has the following collusive firm value:

$$V_{\{n,s1\}}^+ = \frac{\Pi}{n} + (1 - \rho) \delta V_{\{n\}}^+ + \rho \left( -\hat{\mu}(1 + \kappa(n - 1)) \frac{\Pi f}{n} + (1 - \hat{\mu}(1 + \kappa(n - 1))) \delta V_{\{n\}}^+ \right).$$ (11)
A silent firm faces a smaller probability of conviction, $\hat{\mu}(1 + \kappa(n - 1))$, compared to the probability under the AW strategy in equation (1), $\hat{\mu}(1 + \kappa n)$. At the same time, this means that the probability of getting collusive profits in the future, $(1 - \hat{\mu}(1 + \kappa(n - 1)))$, is increased. On the other hand, it forgoes the possibility of getting a reduced fine through leniency and has to pay the full fine, $\frac{\Pi_f}{n}$, when convicted. This strategy is profitable if $V_{\{n,s1\}}^+ \geq V_{\{n\}}^+$ which holds if

$$
\delta \geq \frac{((1 + \kappa n)\phi - \kappa n)f}{(1 + \kappa n)(1 - \rho\hat{\mu}(1 + (n - 1)\kappa))\phi - \kappa n)f + \kappa n} \equiv \bar{\delta}_{\{n-1\}}. \quad (12)
$$

Given this expression Assumption 1 can be justified. As matter of fact, comparing $\bar{\delta}_{\{n-1\}}$ and $\bar{\delta}_{\{n\}}$ reveals that $\bar{\delta}_{\{n\}} \leq \bar{\delta}_{\{n-1\}}$ for all $\hat{\rho} \leq \frac{((1+\kappa n)\phi-\kappa n)f-\kappa n(n-1)}{(1+\kappa n)\phi-\kappa n)(1+\kappa n)\mu}$. Note that $\hat{\rho} = 0$ for $\kappa = \frac{\phi f}{n(n-1)[1-\phi]f}$. This means that only for a $\kappa$ lower than this value, there exists a region where all colluding firms have an incentive to blow the whistle and thus AW always is the collusive strategy.

3.2.2 No firm blows the whistle (NW)

If no firm has an incentive to blow the whistle in equilibrium, the equilibrium strategy has to be defined as follows:

**NW (No firm blows the whistle)** Firms collude from $t = 1$ on as long as no firm deviates. If in period $t$, the antitrust authority reviews the industry, no firm blows the whistle. If the authority is not able to convict the cartel, firms revert to collusion in period $t + 1$. If the authority successfully convicts the cartel or if one firm has deviated, firms set a price equal to marginal costs in every submarket in every subsequent period.

If NW is the equilibrium strategy, the collusive firm value of each firm amounts to

$$
V_{\{0\}}^+ = \frac{\Pi}{n} + (1 - \rho) \delta V_{\{0\}}^+ + \rho \left( -\frac{\hat{\mu} f}{n} + (1 - \hat{\mu}) \delta V_{\{0\}}^+ \right). \quad (13)
$$

Thus, all firms have to pay the full fine, they do not increase the probability of being convicted, and they do not decrease the probability of getting collusive profits in the future. Again, due to the one-stage deviation principle, a single firm which – unlike the other firms – blows the whistle once, $\{b1\}$, has the following collusive firm value:
\[ V_{\{0,\delta\}}^+ = \frac{\Pi}{n} + (1 - \rho) \delta V_{\{0\}}^+ + \rho \left(-\hat{\mu}(1 + \kappa) \frac{\Pi f(1 - \phi)}{n} + (1 - \hat{\mu}(1 + \kappa)) \delta V_{\{0\}}^+\right). \] (14)

The single whistleblower increases the probability of being convicted by \( \kappa \). However, this firm can be sure to benefit from the leniency program in the case of conviction. On the other hand, whistleblowing reduces the probability of getting future profits from collusion from \((1 - \hat{\mu})\) to \((1 - \hat{\mu}(1 + \kappa))\). A firm would choose this strategy if \( V_{\{0,\delta\}}^+ \geq V_{\{0\}}^+ \). To calculate the corresponding critical discount factor, equation (13) can be rearranged to

\[ V_{\{0\}}^+ = \frac{\Pi}{n} \left(\frac{1 - \rho \hat{\mu} f}{1 - \delta(1 - \rho \hat{\mu})}\right). \] (15)

Thus, the critical discount factor above which no firm blows the whistle is given by:

\[ \delta = \frac{(1 + \kappa)\phi - \kappa) f}{(1 + \kappa)(1 - \rho \hat{\mu})\phi - \kappa) f + \kappa} \equiv \bar{\delta}_{\{0\}}. \] (16)

Note that the existence of the SW and NW strategies is not discussed in detail since they are not the focus of this model. However, the existence and the size of these regions depend on the value of \( \kappa \). If the additional value by which a firm increases the probability of being convicted goes to zero, firms no longer face the trade-offs as described above, i.e. equations (12) and (16) show that if \( \kappa \to 0 \) and if the antitrust authority reviews the industry, it is always an equilibrium strategy that all firms blow the whistle.

### 3.3 Numerical example

Now a numerical example is considered to illustrate the findings so far. To this end, let \( n = 3, \hat{\mu} = \frac{1}{3}, f = 10, \phi = 1, \) and \( \kappa = \frac{1}{10} \). Note that \( f = 10 \) implies that firms have to pay a fine ten times their collusive per-period profit. This seems to be an adequate assumption since if \( \rho \) is smaller than one, firms enjoy collusive profits for some periods before being convicted. The fine then accounts for the profits made during these periods.\(^{21}\) Furthermore, \( \phi = 1 \)

\(^{21}\)Moreover, e.g., the Guidelines of the EU require the basic amount of the fine to be multiplied by the number of years of infringement (European Commission (2006), Guidelines on the method of setting fines imposed pursuant to Article 23(2)(a) of Regulation
implies that the case where the first whistleblowing firm gets full leniency is investigated. The resulting characteristics of the critical discount factors are shown in the following figure: The critical discount factor is given by the

![Critical discount factor without ringleader discrimination](image)

**Figure 1:** Critical discount factor without ringleader discrimination

thick solid line in *Figure 1*. For any discount rates below the dashed line, AW is an equilibrium strategy. If the industry-specific discount factor lies in between the dashed line and the thin solid line, SW is an equilibrium. Whenever the discount factor is larger than the one represented by the thin solid line, firms opt for the NW strategy and no firm will blow the whistle in equilibrium.

Now the asymmetric case where the ringleader cannot apply for leniency is investigated.

No 1/2003, OJ C 210, pp. 2-5, paragraph 19.)
4 Asymmetric case: ringleader discrimination

As mentioned in the introduction, the US Department of Justice (just like the former EU leniency program) excludes ringleaders from the leniency program. Intuitively, from the discussion of the symmetric case, one would expect that a smaller number of firms that are eligible for leniency would have the effect of reducing the expected fine for the whistleblowing firms and that the probability of conviction decreases by $\kappa$. These two effects should increase the sustainability of collusion and thus decrease the critical discount factor for these firms. This reasoning, however, falls short of one important aspect: The excluded ringleader faces a higher expected fine. Ceteris paribus, if firms share the collusive industry profit equally as in the symmetric case, the sustainability of collusion is reduced and the critical discount factor of the ringleader rises due to the higher expected fine. Using the identical parameters values from the numerical example in Section 3.3, these two opposing effects are illustrated in Figure 2.

![Figure 2: Critical discount factors with ringleader discrimination and symmetric profit sharing](image-url)
The solid line represents the critical discount factor for the symmetric case. The upper dotted line gives the unadjusted critical discount factor for the ringleader. As such, it must lie above the one for the symmetric case as the expected fine for the ringleader is larger. The lower dotted line shows that a symmetric sharing of the industry profit would result in a lower critical discount factor for the ordinary cartel members. At the margin, though, firms may now agree on a shifting of profits from the members to the ringleader such that the ringleader’s critical discount factor may be reduced – which comes at the cost of a higher critical discount factor for the ordinary cartel members. It is a priori not clear whether the resulting profit-sharing rule will actually lead to a higher or a lower critical discount factor than in the symmetric case.

More specifically, on the one hand, the adjusted critical discount factor may be lower than in the symmetric case since the total probability of conviction will be lower. Furthermore, the expected fine for a colluding ordinary cartel member decreases. The ordinary members have a higher probability of benefiting from the leniency program, since the number of firms which “race to report” is reduced. In addition they face a lower fine, due to the effects of the proportional fine \( f \) in the context of the profit shifting. These effects increase the sustainability of collusion.

On the other hand, the need to compensate the ringleader for the higher expected fine decreases the collusive firm value of an ordinary cartel member. Furthermore, the firm value of a deviating cartel member increases since – as already discussed – the probability of being the firm which benefits from the leniency program increases. This decreases the sustainability of collusion.

Given these considerations and the assumption that the leniency program is designed in a way such that \( AW \) is the equilibrium strategy, the collusive firm values of a ringleader, \( V_{RL,n-1}^+ \), and a cartel member, \( V_{M,n-1}^+ \), can be written as

\[
V_{RL,n-1}^+ = \lambda \Pi + (1 - \rho) \delta V_{RL,n-1}^+ + \rho \left( -\hat{\mu} (1 + \kappa (n - 1)) \lambda \Pi f + \right. \\
+ \left. (1 - \hat{\mu} (1 + \kappa (n - 1))) \delta V_{RL,n-1}^+ \right) \quad (17)
\]
and

\[ V_{M,\{n-1\}}^+ = \frac{(1 - \lambda)\Pi}{n-1} + (1 - \rho)\delta V_{M,\{n-1\}}^+ + \\
+ \rho \left( -\hat{\mu} \left(1 + \kappa(n-1)\right) \frac{(1 - \lambda)\Pi f}{n-1} \left(\frac{1 - \phi}{n-1} + \frac{n - 2}{n-1}\right) + \\
+ (1 - \hat{\mu} \left(1 + \kappa(n-1)\right)) \delta V_{M,\{n-1\}}^+ \right). \quad (18) \]

As described above, the collusive firm values may be asymmetric now. The ringleader gets a share \( \lambda \) of the collusive industry profit, \( \Pi \), in every collusive period. Consequently, since a ringleader never benefits from the leniency program, it always has to pay the full fine, \( \lambda\Pi f \), in the case of conviction. The remaining profit, \( (1 - \lambda)\Pi \), is shared equally between the \( n - 1 \) ordinary cartel members. Thus, every cartel member gets a per-period profit of \( \frac{(1 - \lambda)\Pi}{n-1} \) and has to pay \( f \) times this value if the cartel is convicted. Since the ringleader has no incentive to blow the whistle, the total probability of conviction is reduced from \( \hat{\mu}(1 + \kappa n) \) to \( \hat{\mu}(1 + \kappa(n - 1)) \) compared to the symmetric case. Furthermore, as the ringleader will never have an incentive to blow the whistle, the members’ expected realization of the fine is reduced from \( \frac{1 - \phi}{n} + \frac{n-1}{n} \) to \( \frac{1 - \phi}{n-1} + \frac{n-2}{n-1} \).

To take both effects into account the total probability of conviction is defined as

\[ \mu_{n-1} \equiv \hat{\mu}(1 + \kappa(n - 1)) \quad (19) \]

and the expected realization of the fine reduction as

\[ \psi_{n-1} \equiv \frac{1 - \phi}{n-1} + \frac{n - 2}{n-1} = \frac{n - 1 - \phi}{n - 1}. \quad (20) \]

Then, equations (17) and (18) can be rearranged to give

\[ V_{RL,\{n-1\}}^+ = \lambda\Pi \left( \frac{1 - \rho\mu_{n-1}f}{1 - \delta(1 - \rho\mu_{n-1})} \right) \quad (21) \]

and

\[ V_{M,\{n-1\}}^+ = \frac{(1 - \lambda)\Pi}{n-1} \left( \frac{1 - \rho\mu_{n-1}f\psi_{n-1}}{1 - \delta(1 - \rho\mu_{n-1})} \right). \quad (22) \]

Now the analysis can be turned to the differences between the firm values of a deviating ringleader and a deviating cartel member. As in the symmetric case, the result is recorded in the following lemma:
Lemma 2  Under Assumption 1 it is an equilibrium that all ordinary car- 
tel members blow the whistle if the industry is reviewed in case of deviation. 
Thus, the firm values of a ringleader that deviates from the collusive agree-
tment, $V^D_{RL}$, and of a cartel member that deviates, $V^D_M$, amount to

$$V^D_{RL} = \Pi - \lambda \Pi (\rho \mu_{n-1} f)$$  \hspace{1cm} (23)

and

$$V^D_M = \Pi - \frac{(1 - \lambda) \Pi}{n - 1} (\rho \mu_{n-1} f \psi_{n-1}).$$  \hspace{1cm} (24)

Proof  The proof is similar to the proof of Lemma 1. We only have to 
compare a cartel member’s individual expected realization of the fine. The 
ringleader will never have an incentive to blow the whistle. Therefore, the 
ringleader’s firm value from deviation is only influenced by t he cartel mem-
bbers incentives to blow the whistle. To this end, we have to consider four 
different scenarios. First, if no cartel member blows the whistle, each member 
expects a fine of

$$E[F]_{M,\{0\}} = -\rho \hat{\mu} f \frac{(1 - \lambda) \Pi}{n - 1}.$$  \hspace{1cm} (25)

If all $n - 1$ cartel members blow the whistle, the expected fine is given by

$$E[F]_{M,\{n-1\}} = (1 + \kappa (n - 1)) \frac{n - 1 - \phi}{n - 1} E[F]_{M,\{0\}}.$$  \hspace{1cm} (26)

Next, a cartel member that is the only one to blow the whistle faces an 
expected fine of

$$E[F]_{M,\{1\}} = (1 + \kappa) (1 - \phi) E[F]_{M,\{0\}}.$$  \hspace{1cm} (27)

Last, a cartel member that is the only one not to blow the whistle expects a 
fine of

$$E[F]_{M,\{n-2\}} = (1 + \kappa (n - 2)) E[F]_{M,\{0\}}.$$  \hspace{1cm} (28)

Suppose now that given one cartel member deviated, no other member blows 
the whistle. Then, blowing the whistle for a single member would be op-
timal whenever $E[F]_{M,\{1\}} \leq E[F]_{M,\{0\}} \Leftrightarrow \kappa \leq \frac{\phi}{1 - \phi}$. Comparing this value 
with $\frac{\phi f}{\alpha(n-1)(1-f)}$, which is one of the two possible values of $\bar{\kappa}$ reveals that $E[F]_{M,\{1\}} \leq E[F]_{M,\{0\}}$ holds for all $n \geq 1$. Thus, consider the case where 
all members blow the whistle after deviation by one firm. Then, not blowing 
the whistle must not be optimal for a single member, i.e. $E[F]_{M,\{n-2\}} \geq E[F]_{M,\{n-1\}} \Leftrightarrow \kappa \leq \frac{\phi}{(n-1)(1-\phi)}$. Again, this means that $E[F]_{M,\{n-2\}} \geq \frac{\phi f}{\alpha(n-1)(1-f)}$. Thus, for all $n \geq 1$, $\kappa \leq \frac{\phi}{1 - \phi}$. Therefore, it is an equilibrium that no other member blows the whistle if the whistle is blown by a single firm.
$E[F]_{M',\{n-1\}}$ holds for any $n \geq \frac{1}{2} + \sqrt{\frac{1-4f(1-\phi)}{n(1-\phi)f}} < 1$ when compared with $\frac{\phi}{n(n-1+(1-\phi)f)}$. As the second value for $\bar{\kappa}$, $\frac{1-\mu}{n\mu}$, is either even lower or not relevant, we can conclude that all members of the cartel blow the whistle if one firm has deviated and if a review is under way.

Equations (23) and (24) point to the fact that a ringleader or a cartel member that deviates appropriates the whole industry profit, $\Pi$. However, they expect a different total fine. A cartel member is able to apply for leniency and hence expects a fine of $(1-\lambda)\Pi_{n-1}((1-\phi)f)_{n-1}$. Since a convicted ringleader always has to pay the full fine, it expects a fine of $\lambda\Pi(1-\mu_{n-1}f)$. Then, the critical discount factors for the ringleader as well as the members are given by

$$\delta = \frac{1 - \lambda}{(1 - \lambda(1-\phi)f)(1 - \mu_{n-1})} \equiv \bar{\delta}_{RL,\{n-1\}}$$  \hspace{1cm} (29)$$

for the ringleader and

$$\delta = \frac{1 - \lambda - (n - 1)}{(1 - \lambda(1-\phi)f_{n-1} - (n - 1)(1 - \mu_{n-1}))} \equiv \bar{\delta}_{M,\{n-1\}}.$$  \hspace{1cm} (30)$$

for the ordinary cartel members.

As discussed above, intuitively the ordinary cartel members will be willing to forgo some of their collusive profits at the margin in order to induce the ringleader to participate in the collusive agreement. This is indeed always true if AW is the equilibrium strategy, as can be seen from the proof of Proposition 1 below. To this end, the equilibrium profit-sharing rule at the margin is such that $\bar{\delta}_{RL,\{n-1\}} = \bar{\delta}_{M,\{n-1\}}$. The resulting profit share of the ringleader then equals

$$\lambda^* = \frac{1}{2\rho(1-\psi_{n-1}} \left( \frac{1}{2}(1-\phi)f_{n-1} + (1 - \mu_{n-1}f)n - \sqrt{(1 - \mu_{n-1}f)((1 - \mu_{n-1}f)n^2 + 4\rho(1-\psi_{n-1})n(1-\mu_{n-1}f)(n-1))} \right).$$  \hspace{1cm} (31)$$

Having a closer look at the ringleader’s profit share reveals the following:

**Lemma 3** The ringleader’s profit share increases with the probability of being reviewed by the antitrust authority, i.e. $\frac{\partial \lambda^*}{\partial \rho} > 0$, if the AW strategy is an equilibrium.

**Proof** The derivative is given by

$$\frac{\partial \lambda^*}{\partial \rho} = \frac{2\rho(1-\psi_{n-1})((1-\mu_{n-1}f)n^2 + 4\rho(1-\psi_{n-1})n(1-\mu_{n-1}f)(n-1))}{2\rho^2(1-\psi_{n-1}) \sqrt{(1 - \mu_{n-1}f)((1 - \mu_{n-1}f)n^2 + 4\rho(1-\psi_{n-1})n(1-\mu_{n-1}f)(n-1))}}.$$  \hspace{1cm} (31)$$
From equation (31), one can show that \( \lambda^* \leq 1 \) if and only if \( \rho \leq \frac{1}{\mu_{n-1}f} \). Furthermore, the denominator of \( \frac{\partial \lambda^*}{\partial \rho} \) is always non-negative for all \( \rho \leq \frac{1}{\mu_{n-1}f} \). The numerator is equal to zero if and only if \( \rho = 0 \) and is always negative if \( \rho \geq \frac{1}{\mu_{n-1}f} n^2 - 4(1-\psi_{n-1})(n-1) = \frac{1}{\mu_{n-1}f} n^2 - 4\phi \) which is always larger than \( \frac{1}{\mu_{n-1}f} \) for any \( n > 2 \). Thus, \( \frac{\partial \lambda^*}{\partial \rho} > 0 \) for all \( \lambda^* \leq 1 \).

Making use of these results the following proposition can be stated.

**Proposition 1** If all firms blow the whistle in the case of an industry review and if the ringleader is discriminated from leniency, ordinary cartel members shift profits to the ringleader at the margin until their critical discount factors are the same.

**Proof** Consider \( \rho = 0 \). Then, (29) changes to \( \bar{\delta}_{RL,(n-1)} \geq 1 - \lambda \) and (30) to \( \bar{\delta}_{M,(n-1)} = -\frac{1-\lambda-(n-1)}{n-1} \). Consequently, the profit-sharing scheme amounts to \( \lambda = \frac{1}{n} \). Together with Lemma 3, we get \( \lambda^* > \frac{1}{n} \) if \( \rho > 0 \). If \( \bar{\delta}_{RL,(n-1)} \neq \bar{\delta}_{M,(n-1)} \) there exists a set of industries \( i = (\rho, \bar{\delta}) \) where, at the margin, ringleader and ordinary cartel members could adjust \( \lambda \) to coordinate on a critical discount factor between \( \bar{\delta}_{RL,(n-1)} \) and \( \bar{\delta}_{M,(n-1)} \) if \( \lambda < \lambda^* \) or on a critical discount factor between \( \bar{\delta}_{M,(n-1)} \) and \( \bar{\delta}_{RL,(n-1)} \) if \( \lambda > \lambda^* \).

Lemma 3 and Proposition 1 point to the fact that the per-period profit of a ringleader always exceeds its share in the non-discriminating case, i.e. \( \lambda^* \geq \frac{1}{n} \). Furthermore, the new share is increasing in the probability that the antitrust authority reviews the industry.

These results indeed depend on the equilibrium AW strategy which will be obvious from the discussion of the SW and NW strategies below.

### 4.1 Whistleblowers and silent firms

Again, it has to be taken into account that the value of an additional whistle-blowing firm, \( \kappa \), significantly affects the equilibrium strategy. Since the ringleader will never blow the whistle, only the incentives of the cartel members have to be considered. The analysis is started with the SW strategy where at least one member does not have an incentive to blow the whistle.

#### 4.1.1 Some firms blow the whistle (SW)

Due to the one-stage deviation principle, a cartel member that is the only one not to blow the whistle once (being silent once, \( \{s1\} \)) if the industry is
reviewed has a collusive firm value of

\[ V^+_{M,\{n-1,s1\}} = \frac{(1 - \lambda)\Pi}{n - 1} + (1 - \rho) \delta V^+_{M,\{n-1\}} + 
+ \rho \left( -\hat{\mu}(1 + \kappa(n - 2)) \frac{(1 - \lambda)\Pi}{n - 1} + (1 - \hat{\mu}(1 + \kappa(n - 2))) \delta V^+_{M,\{n-1\}} \right). \] (32)

By doing so, this cartel member forgoes the possibility of benefiting from the leniency program but does not increase (decrease) the probability that the cartel is convicted (the probability of collusive profits in the next period). This strategy is profitable if

\[ V^+_{M,\{n-1,s1\}} \geq V^+_{M,\{n-1\}} \]

which holds if

\[ \delta \geq \frac{((1 + \kappa(n - 1))\phi - \kappa(n - 1))f}{((1 + \kappa(n - 1))(1 - \rho\hat{\mu}(1 + \kappa(n - 2)))\phi - \kappa(n - 1))f + \kappa(n - 1)} \equiv \delta_{\{n-2\}}. \] (33)

Comparing (33) with the analogous critical discount factor in the symmetric case given by equation (12), shows that both only differ in \(-\kappa\), the additional value of the probability of conviction which is missing here due to the exclusion of the ringleader. This is intuitively straightforward since the number of firms which are able to blow the whistle is reduced from \(n\) to \(n - 1\).

Last, the boundary for the NW strategy where no firm blows the whistle has to be checked.

### 4.1.2 No firm blows the whistle (NW)

If no cartel member has an incentive to blow the whistle, the corresponding collusive firm value of a cartel member amounts to

\[ V^+_{M,\{0\}} = \frac{(1 - \tilde{\lambda})\Pi}{n - 1} + (1 - \rho) \delta V^+_{M,\{0\}} + \rho \left( -\hat{\mu} \frac{(1 - \tilde{\lambda})\Pi}{n - 1} + (1 - \hat{\mu}) V^+_{M,\{0\}} \right). \] (34)

Note that the new profit share for the ringleader, \(\tilde{\lambda}^*\), will differ from the equilibrium profit share, \(\lambda^*\), under the AW strategy. Moreover, \(\tilde{\lambda}^*\) will be different from the symmetric profit share as well. As no ordinary cartel member blows the whistle under a NW strategy, the ringleader and the cartel members have the same collusive firm value under collusion. On the other hand, due to the finding in Lemma 2 that cartel members always blow the whistle if one firm has deviated and if a review is under way, a ringleader has a lower firm value from deviation and thus a lower incentive to deviate. As
this results in a lower critical discount factor, the profit has to be shifted in the other direction than under the AW strategy, i.e. from the ringleader to the ordinary cartel members.

Then, the collusive firm value of a ringleader amounts to

$$V_{RL,\{0\}}^+ = \tilde{\lambda}\Pi + (1 - \rho) \delta V_{RL,\{0\}} + \rho \left(-\hat{\mu}\tilde{\lambda}\Pi + (1 - \hat{\mu}) V_{RL,\{0\}}^+\right). \quad (35)$$

To calculate $\tilde{\lambda}$, the new critical discount factors for the ringleader and for the cartel members, $\tilde{\delta}_{RL,\{0\}}$ and $\tilde{\delta}_{M,\{0\}}$ have to be calculated. Equations (35) and (34) and as well as Lemma 2 gives that

$$\delta = \frac{1 - \hat{\lambda}(1 + \rho f(\mu_{n-1} - \hat{\mu}))}{(1 - \hat{\lambda}\rho\mu_{n-1}f)(1 - \rho\hat{\mu})} \equiv \tilde{\delta}_{RL,\{0\}} \quad (36)$$

and

$$\delta = \frac{(1 - \hat{\lambda})(1 + \rho f(\mu_{n-1}\psi_{n-1} - \hat{\mu})) - (n - 1)}{{(1 - \hat{\lambda})\rho\mu_{n-1}f\psi_{n-1} - (n - 1))(1 - \rho\mu_{n-1})} \equiv \tilde{\delta}_{M,\{0\}}. \quad (37)$$

As $\tilde{\delta}_{RL,\{0\}} = \tilde{\delta}_{M,\{0\}}$ has to hold at the margin, the new equilibrium profit share for the ringleader is

$$\tilde{\lambda}^* = \frac{1}{2\rho\mu_{n-1}f(1 - \psi_{n-1})} \left(\rho\mu_{n-1}f(1 - \psi_{n-1}) + n - \right. \left. - \sqrt{\left[\rho\mu_{n-1}f(1 - \psi_{n-1}) + n\right]^2 - 4\rho\mu_{n-1}f(1 - \psi_{n-1})}\right). \quad (38)$$

Note that, from comparing equations (38) and (31) reveals that both profit-sharing parameters are indeed different. Furthermore, one can show that $\tilde{\lambda}^*$ is always decreasing in $\rho$ as argued above.\(^{22}\) Now the analysis can be turned to the resulting critical discount factor. An ordinary cartel member would deviate from the SW strategy if the associated profit is higher than in the case where the firm is the only one to blow the whistle once, \(\{b1\}\), if the collusive industry is reviewed. Such a deviating member would have a

\(^{22}\)Setting $\frac{\partial\tilde{\lambda}^*}{\partial \rho}$ equal to zero and solving it for any of the parameter values, does not give a solution. Moreover, using the parameter values from Section 3.3 give $\tilde{\lambda}^* = \frac{6 + 6\rho - \sqrt{36 + 24\rho + 36\rho^2}}{12\rho}$. From this numerical example it is easy to see that $\frac{\partial\tilde{\lambda}^*}{\partial \rho} < 0$. Thus, $\frac{\partial\tilde{\lambda}^*}{\partial \rho} < 0$ in any case.
collusive firm value of
\[
V^+_{M,\{0, b_1\}} = \frac{(1 - \tilde{\lambda}^*) \Pi}{n - 1} + (1 - \rho) \delta V^+_{M,\{1\}} + \rho \left( -\hat{\mu} (1 + \kappa) \frac{(1 - \tilde{\lambda}^*) \Pi f (1 - \phi)}{n - 1} + (1 - \hat{\mu} (1 + \kappa)) \delta V^+_{M,\{1\}} \right). 
\] (39)

At least one cartel member would choose to deviate from NW if \( V^+_{M,\{0, b_1\}} \geq V^+_{M,\{0\}} \). To calculate the corresponding critical discount factor, equation (34) can be rearranged such that
\[
V^+_{M,\{0\}} = \frac{(1 - \tilde{\lambda}^*) \Pi}{n - 1} \left( \frac{1 - \rho \hat{\mu} f}{1 - \delta (1 - \rho \hat{\mu})} \right). 
\] (40)

Thus, the critical discount factor above which no firm would blow the whistle if the industry is reviewed is then given by
\[
\delta = \frac{((1 + \kappa) \phi - \kappa) f}{((1 + \kappa)(1 - \rho \hat{\mu}) \phi - \kappa) f + \kappa} \equiv \bar{\delta}_{\{0\}}. 
\] (41)

Interestingly, equation (41) is equal to the corresponding boundary of the symmetric case given in equation (16). This means in turn that the the critical discount factor for the NW strategy, is independent of the equilibrium profit-sharing rule, since \( \tilde{\lambda}^* \leq \frac{1}{n} \).\(^23\)

Note that all these calculations have to be done to prove that the AW strategy can be an equilibrium. However, the results are important to specify the parameter values of the analysis below. On the other hand, the existence of the parameter spaces where SW and NW are equilibrium strategies is a second-order problem in the evaluation if ringleader discrimination is superior or not. If in equilibrium not all firms have an incentive to blow the whistle if the cartel is reviewed, then excluding one firm has no effect. Of course, it affects the deviation profits since all firms would have an incentive to blow the whistle if one firm has deviated and if the antitrust authority starts a review.

Now it can be turned to the comparison of both scenarios.

\(^{23}\)This results from \( \lim_{\rho \to 0} \tilde{\lambda}^* = \frac{1}{n} \) and \( \frac{\partial \tilde{\lambda}^*}{\partial \rho} < 0. \)
4.2 Comparison with the non-discrimination case

Consider a situation where the antitrust authority has chosen an enforcement policy such that AW maximizes the number of industries which are able to sustain collusion. Note that this does by no means imply that the leniency program has a strictly adverse effect; it just excludes those cases where for a relatively high value of $\kappa$, firms would be able to collude for a larger $\rho$ through the use of NW.\(^\text{24}\) Hence, the boundaries calculated above, from which on firms switch from AW to SW and from SW to NW, only affect the strategy by which collusion is sustained in equilibrium, but not the sustainability of collusion in general. Under this condition only the slope of the critical discount factor of the AW strategy determines the sustainability.

Concerning the AW strategy, however, the effects of discriminating ringleaders on the sustainability of collusion may be ambiguous. Consider again the numerical example from Section 3.3 Plugging the parameter values into the equilibrium profit share of a ringleader given by equation (31), results in

$$\lambda^*(\rho) = \frac{3 - 12\rho - \sqrt{180\rho^2 - 84\rho + 9}}{6\rho}. \quad (42)$$

Making use of $\lambda^*(\rho)$, the critical discount factors for the asymmetric case, $\tilde{\delta}_{RL,(n-1)} = \tilde{\delta}_{M,(n-1)}$, and the other relevant discount factors ($\tilde{\delta}_{(n)}$, $\tilde{\delta}_{(n-1)}$, $\tilde{\delta}_{(n-2)}$, and $\tilde{\delta}_{(0)}$) can be calculated. They are drawn by Figure 3.

Again, the solid line represents the critical discount factor for the regime where all firms are able to benefit from the leniency program and where firms share the monopoly industry profit equally. The dotted line represents the critical discount factor for the asymmetric case, given the adjustment of the ringleader per-period profit to $\lambda^*(\rho)$. As can be seen from the figure both discount factors are the same for $\rho = \tilde{\rho}$ (with $\tilde{\rho} \in [0, 1]$) and $\tilde{\rho} \approx 0.13$, in our example.

\(^{24}\)Technically that means $\tilde{\delta}_{(0)} < \tilde{\delta}_{[n]} \geq \tilde{\delta}_{RL,(n-1)} = \tilde{\delta}_{M,(n-1)}$. We will no go into detail but numerical simulations suggest that this condition does not hold if $\kappa$ is so large (a single whistleblowing firm is very valuable) that excluding the ringleader from the leniency program would unambiguously increase the sustainability of collusion, i.e. $\tilde{\delta}_{[n]} \geq \tilde{\delta}_{RL,(n-1)} = \tilde{\delta}_{M,(n-1)}$.\[291x94]
If the probability that the authority reviews the industry is small \((\rho \leq \tilde{\rho})\) a regime where the ringleader is discriminated results in a lower critical discount factor and thus in more collusion. This is due to the lower total probability of conviction when the antitrust authority excludes the ringleader. From Proposition 1 it is known that for \(\rho \to 0\) firms shift a smaller share of the monopoly industry profit to the ringleader, \(\lambda \to \frac{1}{n}\). So if \(\rho\) is small, the expected profit from deviation for excluded ringleaders and ordinary cartel members is more or less equal to the symmetric case. At the same time, the expected fine is increasing if firms are treated equally since this would result in a higher probability of conviction and less profitability of collusion. Consequently, an antitrust authority which can only commit to review an industry with a relatively small probability will be better off when allowing ringleaders to benefit from leniency programs.

On the other hand, if \(\rho\) increases, it holds that \(\lambda \to 1\). If the probability that the industry is reviewed becomes larger, the ringleader will obtain a larger part of the collusive monopoly industry profit. This increases the asymmetry between the ringleader and the cartel members by reducing the
per-period profit of the ordinary cartel members (and their expected fines) and thus increases their incentives to deviate even if the discount rate is high. As can be seen in Figure 3, this effect on the sustainability of collusion may dominate the sustainability-reducing effect of a larger probability of conviction in the case where the ringleader may join the leniency program (for $\rho > \bar{\rho}$).

Note that for $\kappa = 0$, it is obvious that excluding the ringleader has to be always superior. The antitrust authority would forgo nothing by excluding the ringleader while the internal stability of the cartel decreases in $\rho$, since – as discussed in Lemma 3 and Proposition 1 – the profit of a ringleader has to rise since the probability of been reviewed $\rho$ is increasing, $\frac{\partial \lambda^*(\rho)}{\partial \rho} > 0$.

The effect of a more asymmetric cartel does not necessarily outweigh the effect of a larger probability of conviction. Figure 4 gives an example for the case where $\kappa$ is so large such that excluding the ringleader would always result in more collusive industries.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure4.png}
\caption{Ringleader exclusion fares always worse (c.p. $\kappa$ increased from $\frac{1}{10}$ to $\frac{2}{5}$)}
\end{figure}

Compared to the situation before, as $\kappa$ increases, the antitrust authority
would forgo very valuable information by excluding the ringleader. Such a large \( \kappa \) would increase the probability of conviction to such an extent that non-discrimination is superior in any case for the antitrust authority, since it results in less collusion.

The considerations above can be summarized in the following proposition.

**Proposition 2** If \( \kappa > 0 \) and if \( AW \) is the collusive strategy, there may exist a \( \tilde{\rho} \) such that for any \( \rho > \tilde{\rho} \) ringleader discrimination by the antitrust authority reduces the sustainability of collusion. If \( \rho < \tilde{\rho} \) non-discrimination is optimal for the antitrust authority.

**Proof** Follows from a comparison of equations (10) and (29) (or (30)) given the expression for \( \lambda \) in equation (31).

The comparison of Figures 3 and 4 also reveals the assessment of both regimes it quite involved. All of the relevant parameters, i.e. the value by which a whistleblower increases the probability that the antitrust authority finds enough evidence to convict the cartel, \( \kappa \), the scope of the leniency program, \( \phi \), the fine, \( f \), the probability that the antitrust authority finds enough evidence to convict the cartel without the help of a single firm, \( \hat{\mu} \), and the number of firms within the cartel, \( n \), affect the sustainability of collusion for a given probability of review, \( \tilde{\delta}(\rho) \). At the same time, these parameters also affect the differences between the two different legal environments – and thus the position (or the existence) of a \( \tilde{\rho} \).Since the effect of \( \rho \) on \( \lambda^* \) is present only under ringleader discrimination, the equilibrium share of the industry profit that a ringleader gets, \( \lambda^*(\rho) \), affects the position of \( \tilde{\rho} \) significantly.

Numerical simulations based on the example from Section 3.3 give some insight into how the different parameters affect the optimality of one regime or the other. The tentative results are given in Table 1 below.

**Table 1**: Comparative statics on \( \tilde{\delta}, \lambda^*, \) and \( \tilde{\rho} \)

<table>
<thead>
<tr>
<th>( x )</th>
<th>( f )</th>
<th>( \hat{\mu} )</th>
<th>( \phi )</th>
<th>( n )</th>
<th>( \kappa )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{\partial \tilde{\delta}(\rho)}{\partial x} )</td>
<td>( \geq 0 )</td>
<td>( \geq 0 )</td>
<td>( \leq 0 )</td>
<td>( &gt; 0 )</td>
<td>( \geq 0 )</td>
</tr>
<tr>
<td>( \frac{\partial \lambda^*(\rho)}{\partial x} )</td>
<td>( \geq 0 )</td>
<td>( \geq 0 )</td>
<td>( \geq 0 )</td>
<td>( \leq 0 )</td>
<td>( \geq 0 )</td>
</tr>
<tr>
<td>( \frac{\partial \tilde{\rho}}{\partial x} )</td>
<td>( &lt; 0 )</td>
<td>( &lt; 0 )</td>
<td>( &lt; 0 )</td>
<td>( &gt; 0 )</td>
<td>( \leq 0 )</td>
</tr>
</tbody>
</table>
If $\tilde{\rho}$ decreases, the parameter space where a regime that discriminates ringleaders is superior (for the antitrust authority) extends. Antitrust authorities should then again favor excluding ringleaders instead of counting on the additional information ringleaders have even if they have a relatively low probability of investigating the industry. On the other hand, if $\tilde{\rho}$ increases, the parameter space where a regime that does not discriminates against ringleaders is superior becomes larger.

By making use of numerical simulations, the results of the comparative statics will be characterized and described in the following section.

5 Numerical simulations

5.1 Impact of $f$

If the fine increases, collusion becomes less valuable and thus sustainability of collusion decreases in general in both regimes, i.e. $\frac{\partial \bar{\delta}(\rho)}{\partial f} > 0$ for all $\rho > 0$. At the same time, for a given probability of review, the ringleader will ask for a higher compensation than under lower fines, i.e. $\frac{\partial \lambda^*(\rho)}{\partial f} \geq 0$. This increases the asymmetry between the ringleader and the ordinary cartel members and additionally decreases the sustainability of collusion, since the ringleader ask for nearly the whole monopoly profit for a lower $\rho$ now (see Figure 5).
Figure 5: Example for $\frac{\partial \lambda^*(\rho)}{\partial f} \geq 0$ ($f$ increases from 10 to 15)

Regarding the position of $\tilde{\rho}$, the argumentation above yields that both effects go in the same direction. Consequently, $\tilde{\rho}$ has to decrease if fines increase (and vise versa), i.e. $\frac{\partial \tilde{\rho}}{\partial f} < 0$. For an example, see Figure 6.
5.2 Impact of $\hat{\mu}$

The probability that the antitrust authority is able to convict the cartel without the help of any firm, $\hat{\mu}$, is related to the probability that the industry is reviewed, $\rho$. The total probability that a cartel is convicted depends on both probabilities. If the antitrust authority becomes stronger in finding enough evidence, sustaining collusion becomes harder – no matter if the ringleader is excluded or not, i.e. $\frac{\partial & \delta}{\partial & \hat{\mu}} \geq 0$. At the same time, the ringleader has to get a larger part of the monopoly industry profit, $\frac{\partial \lambda^*(\rho)}{\partial & \hat{\mu}} \geq 0$ and asymmetry increases in the same way the fine $f$ increases asymmetry. Again, both effects affect $\tilde{\rho}$ in the same way. Thus, an increase in $\hat{\mu}$ results in a decrease in $\tilde{\rho}$ (and vice versa), i.e. $\frac{\partial & \tilde{\rho}}{\partial & \hat{\mu}} < 0$. For an example, see Figure 7 below.
5.3 Impact of $\phi$

If the leniency program becomes less generous (e.g. the fine reduction decreases from $\phi = 1$ ("full immunity") to $\phi = \frac{3}{4}$) the expected total fine of each cartel member (that is eligible to apply for leniency) increase. As a result, the critical discount factors under both regimes are larger for all $\rho > 0$ if $\phi$ decreases, i.e. $\frac{\partial \bar{\delta}(\rho)}{\partial \phi} \leq 0$. However, this effect on the critical discount factors differ in their strength under both regimes.

This is the standard adverse effect of the fine reduction in the context of leniency programs. Leniency programs could ‘in principle [...] increase cartel activity’ (Spagnolo, 2004). That the leniency policy can have the perverse effect of making collusion more stable is also shown by Spagnolo (2000), Chen and Harrington (2007), as well as Herre and Wambach (2008). In the context of fines, Becker (1968) is the first to argue, that infinite fines would always prevent individuals (or firms) from illegal activities. These findings do not imply that starting a leniency program is fundamentally wrong. It allows the antitrust authorities to collect information about cartel activity and thus gives the authority the information it needs to detect cartels and may help to prevent firms from forming cartels in the future.
In contrast to all other parameters of the model, $\phi$ affects only the critical discount factor of cartel members which are eligible for leniency. Thus, if the ringleader is excluded the critical discount factor of the ringleader is (initially) not affected by such a change (see equations (29) and (30)). Different from that, under a regime where the ringleader is eligible for leniency, all firms are affected by an change in $\phi$.

Under a regime of ringleader exclusion, the firm value of the ringleaders is however affected indirectly by the new profit sharing due to higher expected fines for the ordinary cartel members. Since ceteris paribus only the expected profits of ordinary cartel members decrease, the critical discount factor of the ringleader does not change. Only the critical discount factor of the ordinary cartel members moves upwards. From the discussion in Section 4 it is known that firms with the lower critical discount factor always have an incentive to transfer shares of the collusive industry profit to firms with a higher critical discount factor as long as the critical discount factors are not equal. Consequently, the equilibrium profit share a ringleader gets decreases weakly at the margin if $\phi$ decreases, i.e. $\frac{\partial \lambda^*(\rho)}{\partial \phi} \geq 0$.

However, since the critical discount factor of the ringleader is not directly affected by a change in $\phi$, it is obvious that the profit sharing rule at the points where $\delta = \frac{1}{n}$ ($\rho = 0$) and $\delta \to 1$ has the be equal irrespective of $\phi$. Thus, asymmetry between ringleaders and ordinary cartel member decreases if the leniency program becomes less generous, but the asymmetry decreases only very weakly since the change in $\lambda^*(\rho)$ is limited (see Figure 8).

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26 Since $\lambda^*(\rho)$ has to be adjusted when $\phi$ is changed, the critical discount factor of the ringleader is only affected indirectly after this adjustment.
Knowing that the critical discount factor of the ringleader is not affected directly by $\phi$, it is clear that the effect of $\phi$ on the critical discount factor in a regime of ringleader exclusion has to be very limited. The relatively weak change in $\phi$ on $\lambda^*(\rho)$ is the reason, why the effect of a decreasing sustainability of collusion if ringleaders are eligible for the leniency program outweighs the effect of the weakly increasing asymmetry if ringleaders are excluded. Thus $\tilde{\rho}$ increases if the leniency program becomes less generous (and vice versa), i.e. $\frac{\partial \tilde{\rho}}{\partial \phi} < 0$ (see Figure 9).
Figure 9: Example for \( \frac{\partial \tilde{\rho}}{\partial \phi} < 0 \) (\( \phi \) decreases from 1 to \( \frac{3}{4} \))

5.4 Impact of \( n \)

A change in the size of the collusive industry changes the terms of sustainable collusion significantly. In particular, adjusted profit sharing leads to significant changes in the firm values from collusion and deviation. If the number of the colluding firms increases, all firms have to forgo a part of their former collusive profit share since the industry profit is shared between more firms now. Thus, sustainability of collusion is reduced under both regimes in general by a larger incentive to deviate, i.e. \( \frac{\partial \tilde{\delta}(\rho)}{\partial n} > 0 \).

Note that even for \( \rho = 0 \) sustainability of collusion is reduced if \( n \) increases. Hence, the ringleader should get a smaller part of the monopoly industry profit now. On the other hand, as sustainability of collusion is reduced in general, the ringleader would get a larger part of the monopoly industry profit in equilibrium if \( \rho \) is large: The ringleader will ask for nearly the whole monopoly industry profit (\( \lambda^*(\rho) \rightarrow 1 \)) for a lower \( \rho \) than in collusive industries with less firms, since the antitrust authority has access to more evidence now if all ordinary cartel members blow the whistle. Thus, the
effect of an increase in the number of colluding firms on the collusive profit sharing between ringleaders and ordinary cartel members is ambiguous, i.e. \( \frac{\partial \lambda^*(\rho)}{\partial n} \leq 0 \), which can be seen in Figure 10 below.

\[ \lambda^*(n=4) \]
\[ \lambda^*(n=3) \]

\( \rho \)

\( \lambda^* \)

\( n \)

\[ 0.05 \quad 0.1 \quad 0.15 \]

\[ 0.4 \quad 0.6 \quad 0.8 \quad 1 \]

**Figure 10:** Example for \( \frac{\partial \lambda^*(\rho)}{\partial n} \leq 0 \) (\( n \) increases from 3 to 4)

Again, as already observed in the analysis of the impact of \( \phi \), the effect of the number of collusive firms on \( \lambda^* \) is relatively weak (in particular if \( \rho \) is high). This can be seen from a comparison of Figure 5, 8, and 10. Moreover, if the number of firms increases, the probability of conviction increases too. This effect is stronger the more firms are eligible for leniency. Thus, the effect of reducing sustainability due to more firms should be stronger in a regime where all firms are able to pass on information to the antitrust authority. Numerical simulations suggest that this effect on the position of \( \tilde{\rho} \) is always stronger than the effect of reducing sustainability due to the larger share of the industry profits firms shift to the ringleader if \( \rho \) is large. Thus, \( \tilde{\rho} \) increases in \( n \), i.e. \( \frac{\partial \tilde{\rho}}{\partial n} > 0 \).

Note that changes in the number of colluding firms have to be – in reality – always integer. In the example, this has the effect that with one additional
whistleblowing firm a regime which allows the ringleader to blow the whistle becomes superior now (see Figure 11).

\[ \bar{\rho} \rightarrow \tilde{\rho} (n = 3) \]

\[ \begin{array}{ccc}
0 & 0.05 & 0.1 \\
0.7 & 0.8 & 0.9 \\
\end{array} \]

Figure 11: Example for \( \frac{\partial \bar{\rho}}{\partial n} > 0 \) (n increases from 3 to 4)

5.5 Impact of \( \kappa \)

The effect of a change in the value by which an additional whistleblowing firm increases the probability that the antitrust authority finds enough evidence to convict the cartel, \( \kappa \), on \( \tilde{\rho} \) is ambiguous. A larger \( \kappa \) makes it harder to sustain collusion since the expected fine increases if more firms blow the whistle. As a result, the sustainability of collusion has to decrease in general and the ringleader would ask for a larger share of the monopoly industry profit since the effect on \( \lambda^*(\rho) \) and \( \bar{\delta}(\rho) \) is similar to the effect of \( f \) and \( \hat{\mu} \).\(^{27}\) Independent of this, Figure 12 illustrates that the affect of \( \kappa \) on \( \tilde{\rho} \) is ambiguous and thus differs from the affects of \( f \) and \( \hat{\mu} \) (see Table 1).

\(^{27}\)Thus \( \frac{\partial \bar{\delta}(\rho)}{\partial n} > 0 \) and \( \frac{\partial \lambda^*(\rho)}{\partial n} > 0 \) if \( \rho > 0 \) has to hold again.
Figure 12: Impact of $\kappa$ on $\tilde{\rho}$ with three numerical examples

The thick solid line indicates a change of the optimality of both regimes subject to $\kappa$. From the discussion above it is known that if $\kappa = 0$ the antitrust authority is always better off with ringleader discrimination. If the antitrust authority has only limited resources to investigate a specific industry (i.e. if $\rho$ is small) then the parameter space where a regime of no ringleader discrimination is superior widens as $\kappa$ increases. In this case, the evidence every firm can pass on to the authority can be viewed as a substitute for the low probability of review. Now if ringleaders are not eligible for leniency, then the antitrust authority forgoes a good opportunity to convict the cartel. As a result, $\tilde{\rho}$ increases. However, from Figure 12 it can be seen that if a review is very likely already (e.g., $\rho = \tilde{\rho}_2$) and $\kappa$ is large at same time (e.g., $\kappa = \frac{1}{10}$) then $\tilde{\rho}$ decreases if $\kappa$ increases further. The antitrust authority would rather want to exclude the ringleader from the leniency program in order to increase the asymmetry between the firms. This is due to the effect which was already discussed above. If the value of the information of an additional firm is sufficiently high, the sustainability-reducing effect of an additional whistleblowing firm is stronger than the effect of reducing the sustainability through an asymmetric sharing of monopoly profits between ringleader and
ordinary cartel members (see e.g. Figure 4 and the example for $n = 4$ in Figure 11).

6 Extension: fine load for ringleaders

The discussions in the sections above have shown that the exclusion of ringleaders may result in more collusion. Leslie (2006) discusses this effect (intuitively) and suggests a way to deal with the stabilizing effect of ringleader exclusion: He notes that “a proper way to signal antitrust law’s particular displeasure with cartel instigators and ringleaders is to assign higher penalties to them, as the Sentencing Guidelines currently do. This allows greater punishment for the offender who has done something worse. [...] To the extent that making ringleaders eligible for amnesty may reduce the expected cost of cartelization (and thus reduce deterrence), increasing ringleader penalties compensates for this effect and maintains deterrence.”

In the model developed above one could think of doing so by introducing a fine load of $(1 + l)f$ (with $l > 0$) for the ringleader. In both cases put forward above, this would mean that the sustainability of collusion would be reduced since the total fine for the industry would increase in general. However, this would lead to a greater asymmetry within the industry which would require an asymmetric profit-sharing rule in the non-discriminating case as well. Such a rule would shift more profits to the ringleader. If levying a fine load is possible in the non-discriminating case, it is also feasible in the discriminating case. Then, however, there will be parameter regions where the result affiliated above still applies.

7 Conclusions

This paper has focused on whether ringleaders of illegal cartels should be given the chance to apply for leniency or not. The model identifies the different forces at work which make one regime appear more favorable than the other. It was shown that both approaches may be a useful means to curb cartel activity. Indeed, the model shows that giving ringleaders the opportunity to participate in the leniency program is the better option if the antitrust authority reviews industries with a relatively small probability. In such a situation, the additional information provided by ringleaders leads to a higher probability of conviction and thus decreases the sustainability of collusion in general. However, if the antitrust authority commits to a relatively high probability of review, the exclusion of the ringleader from
the program may fare better. This is due to the fact that the ringleader faces a higher expected fine, which calls for a compensation by ordinary cartel members. The resulting asymmetry between the firms reduces the sustainability of the cartel.

The analysis is based on specific assumptions concerning the functioning and the homogeneity of the firms. The model assumes that firms are symmetric and that one of these firms takes on the role of a ringleader. As a result, firms become asymmetric since they are treated differently. However, as mentioned in the introduction, while certain ringleader activities do not seem to require a specific type of firm, other firm-specific factors (profit, revenue, size, etc.) may be crucial for firms to become ringleaders. It would be interesting to analyze the characteristics which make cartel leadership more likely and how they finally affect collusive stability. Clearly, introducing heterogeneous firms into the model would imply that there is an a priori asymmetry in the market which negatively affects the sustainability of collusion in general. Depending on the ringleader’s characteristics, granting access to the benefits of the leniency programs only to ordinary cartel members, will anyhow still have the effects discussed above.

References


