The deterrence effect of excluding ringleaders from leniency programs*

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Preliminary version

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 with a low probability, excluding ringleaders from leniency programs increases the sustainability of collusion. The opposite holds for the case where the probability of review is high.

JEL classification: L40, L41.

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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 the 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 cartels.

For example, in 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.[1] In the amino-acid (lysine) cartel, Archer Daniels Midland Company (ADM) and Ajinomoto organized the secretariat of the quantity-monitoring system.[2] ADM—together with Hoffmann-La Roche—was also at the helm of the citric-acid cartel where it chaired the meetings and organized the collection and distribution of data.[3] In the cartel concerning gas insulated switchgear, Siemens and Alstom acted as (cartel) secretary. As such, they were the contact point between the cartel members and had a crucial role for the organization of meetings and the compilation of information from and for the members. Moreover, it managed the communication on behalf of the European undertakings with the Japanese secretariat. It also convened and chaired meetings, took care of the quotas, and managed the system of E-mails Secure Transmission.[4]

Note that all of the activities in the above examples had to be organized by one of the cartel members in order to keep the cartel going. 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.[5] Therefore, even if a reliable ringleader 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.

Before thinking about the question how to treat ringleaders, it seems important to point out that identifying initiators of cartels is actually verifiable. 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."[6]

[1] See *IV/35.814 – Alloy surcharge* (1998), paragraph 81.

[2] See *COMP/36.545/F3 – Amino acids (Lysin)* (2000), paragraph 330.

[3] See *COMP/E-1/36 604 – Citric acid* (2001), paragraph 273.

[4] See *COMP/F/38.899 – Gas insulated switchgear* (2007), paragraphs 147, 173, 511–513.

[5] There are other 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 were more flexible with respect to structuring prices, promotions, as well as discounts and had a much greater potential for tying. Moreover, they enjoyed greater economies of scale and scope. Last, an implicit (or explicit) threat of a refusal to supply would have been much more credible (see *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 (see *COMP/35.587, COMP/35.706, COMP/36.321 – Nintendo* (2002), paragraphs 406, 228–238). We will not focus on the evolution of ringleaders, though. See Ganslandt, Persson, and Vasconcelos (2008) for a model where firms may want to merge to become a ringleader that is capable of covering the indivisible costs of cartel leadership.

[6] See *COMP/C.38.279/F3 – Viandes bovines françaises* (2003), paragraph 175.

HABEN WIR VIELLEICHT EIN PAAR EMPIR. DATEN HINSICHTLICH DER ÖKONOM. (GELDMÄSSIGEN) BEDEUTUNG DER FÄLLE??

The fact that ringleaders play an important role for collusive agreements raises the question how antitrust authorities should deal with them. Looking 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.[7] According to the US leniency program established in 1978, it is not possible for ringleaders to obtain a fine reduction. When the EU set up its leniency program in 1996, this ringleader-discrimination rule was adopted. After the changes in the EU regulations in 2002 and 2006, ringleaders now have the possibility to participate in the leniency program. Both antitrust regimes specify a fine load for ringleaders.

With respect to 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 . In a similar vein, Spagnolo (2006) argues that allowing ringleaders to apply for leniency may seed distrust among cartel members which may finally deter cartelization.[8] Leslie (2006) suggests a way to deal with the stabilizing effect of ringleader exclusion by noting that "[t]o 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. This also gives the ringleader a greater incentive to defect first because it has more to lose if someone else confesses first. Knowing that the ringleader has a relatively greater incentive to confess makes the ringleader less trustworthy. This could deter cartel formation."

Apart from these qualitative arguments, there has been no rigorous formal study to theoretically analyze the effect of ringleader exclusion on the sustainability of collusion.[9] In this paper, we try to fill this gap by setting up a simple model to compare both scenarios in order to get a better understanding of the effects described above. We find that both regimes, i.e. the ones with and without ringleader discrimination, may be beneficial in deterring cartel activity. More specifically, we show 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 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, this reasoning may not hold in general. Excluding the ringleader may be the better option now. The intuition for this is as follows: If the ringleader

[7] See Aubert, Rey, and Kovacic (2006) and Spagnolo (2006) for a more detailed comparison of the different approaches in the EU and in the US.

[8] On 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."

[9] See Bigoni et al. (2008) for an experimental study.

is excluded from the leniency program, it faces a higher expected fine than an ordinary cartel member. As a result, firms would face asymmetric expected profits from collusion if the ringleader and the members 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 would ask for 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 may decrease the sustainability of collusion. This effect becomes stronger if the probability that industries are reviewed increases. 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 in general. 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.

The paper is organized as follows. In the next section, we set up the model. In sections 3 and 4, we analyze the cases without and with ringleader discrimination. Section 5 discusses a possible extension. The last section concludes.

2 The model

In what follows, we will introduce the players (firms, antitrust authority) as well as the timing of the game. We then look at the strategies available to the firms.

2.1 Firms

Consider an infinite number of industries where each industry consists of n ex-ante identical firms (with $n \geq 3$). Each firm is active on an industry-specific market which is made up of an infinitely large number of submarkets. 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 Π. If firms agree to collude, one of the firms has to act as a ringleader. We assume that any collusive agreement produces evidence and that each firm holds a share κ of this evidence. Furthermore, firms take into account the enforcement policy of the antitrust authority. We consider an exogenously given ringleader, i.e. we do not analyze the evolutionary forces (or the strategic options) which lead to a specific firm's status as a ringleader. Thus, we assume that one of the *ex ante* identical firms is chosen randomly as the ringleader.

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 decided to collude in any of the periods before the review has started, the antitrust authority finds evidence

with probability $\hat{\mu} < 1$. This represents the probability that the cartel is indeed convicted in case of a review. The setup reflects the circumstance that usually antitrust authorities employ both economists who 'look for smoke' and lawyers who help convict firms. The first group is in charge of the initial review whose results are then used by the second group. The fact that $\hat{\mu} < 1$ can be explained by pointing out that typically, even if there is evidence, this does not necessarily mean that (all) cartel members will be convicted.

If the cartel is found guilty, the antitrust authority imposes 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.

Furthermore, the antitrust authority commits to a leniency program. The program is captured by the fine reduction ϕ (with $0 < \phi \leq 1$).[10] We assume that only one firm (the first whistleblower) is allowed to benefit from the leniency program. Moreover, the antitrust authority must decide whether or not a ringleader is eligible to apply for leniency. Note that we assume that the identification of the ringleader is not subject to controversy due to the evidence the antitrust authority has access to.

Each whistleblowing firm reveals its share of evidence κ to the antitrust authority which leads to a linear increase in the conviction probability $\hat{\mu}$. Hence, cartel members are convicted with probability $\mu = \hat{\mu}(1 + \kappa\hat{n})$ where $\hat{n}$ represents the number of whistleblowing firms (with $\hat{n} \in \{0, 1, .., n-1, n\}$). Note that even if all firms decide to blow the whistle, the conviction probability is not necessarily equal to one. This may be justified by procedural problems or a time and budget constraint of the antitrust authority.

Furthermore, it is assumed that if firms are convicted, 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 ρ, $\hat{\mu}$, ϕ, and f as well as its ringleader policy.

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

[10] Several authors (see, 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, we have $\phi = 1$ as the limit which is equal to full immunity from fines.

Stage 1: Firms decide whether or not to collude, 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 submarket(s).

Stage 3: The antitrust authority reviews the industry with probability ρ.

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 we are interested in the effect of excluding at least one firm from the leniency program, we have to concentrate on a equilibrium strategy were indeed all firms would be willing to blow the whistle. We will discuss the possible cases where not all or even no firm has an incentive to blow the whistle in equilibrium in detail below. Thus, we state the following equilibrium strategy:

AW (All firms blow the whistle): *Firms collude from $t = 1$ on as long as no firm deviates. If the antitrust authority reviews the industry in period t, 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 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, we make the following assumption regarding the value an additional whistleblowing firms means for the antitrust authority:

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

This assumption highlights two important specifications of the model. The first term ensures that the increase in the conviction probability $\hat{\mu}$ by κ is not too large so that the AW strategy as described above is chosen in equilibrium. We will comment on the derivation of this upper bound for κ 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. $\hat{\mu}(1 + n\kappa) \leq 1$.

3 Symmetric case: No ringleader discrimination

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

3.1 Whistleblowing as a dominant strategy

To analyze this case, consider a situation where collusion can be sustained in equilibrium. At the same time, however, the leniency program is defined such that AW is an equilibrium strategy: Indeed, all n firms have an incentive to blow the whistle if the antitrust authority reviews the industry. Then, the collusive firm value of each firm amounts to

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

Since the firms are identical, each of them gets the same profit Π/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. The third term in equation (1) represents the case when the antitrust authority reviews the industry with probability ρ. 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 n whistleblowing firms by the value of κ. By assumption, only the first whistleblowing firm is allowed to benefit from the leniency program. If n firms blow the whistle simultaneously, we assume that one of them is chosen randomly as the first whistleblower. Therefore, a firm gets a reduction of ϕ of the full fine $\Pi f/n$ with probability $1/n$. Consequently, with probability $(n-1)/n$, 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 firms. In this case, firms continue to collude in the following period.

For expositional simplicity, we define the total probability of conviction in the symmetric case as

$$\mu_n := \hat{\mu}(1+\kappa n) \quad (2)$$

and the expected realization of the fine reduction as

$$\psi_n := \frac{1-\phi}{n} + \frac{n-1}{n} = \frac{n-\phi}{n}. \quad (3)$$

Equation (1) can then be rearranged to

$$V^+_{\{n\}} = \frac{\Pi}{n}\frac{1-\rho\mu_n f\psi_n}{1-\delta(1-\rho\mu_n)}. \quad (4)$$

Next, we turn to the value of a firm that deviates from collusion. The realization of the deviating profit depends on the incentives of the firms to blow the whistle if one firm has deviated. By blowing the whistle, a firm may reduce its own fine but on the other hand, it increases the probability that it actually has to pay the fine. More precisely, the exact outcome depends on the number n of the rivals competing

for the fine reduction, on the generosity ϕ of the leniency program, and on how much a single firm increases the total probability of conviction by whistleblowing, i.e. κ.

Lemma 1 *Under* Assumption 1*, a deviating firm has the following firm value:*

$$V^D = \Pi - \frac{\Pi}{n}\rho\mu_n f\psi_n. \tag{5}$$

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

$$E[F]_{\{0\}} = -\frac{\Pi}{n}\rho\hat{\mu}f. \tag{6}$$

Next, a firm that blows the whistle, while the other firms do not, faces an expected fine of

$$E[F]_{\{1\}} = (1+\kappa)(1-\phi)E[F]_{\{0\}}. \tag{7}$$

A firm that is the only one not to blow the whistle expects a fine of

$$E[F]_{\{n-1\}} = (1+\kappa(n-1))E[F]_{\{0\}}. \tag{8}$$

Last, if all firms blow the whistle, the expected fine is given by

$$E[F]_{\{n\}} = (1+\kappa n)\frac{n-\phi}{n}E[F]_{\{0\}}. \tag{9}$$

Suppose that given one firm deviated, no other firm blows the whistle. Then, blowing the whistle for a single firm would be optimal whenever $E[F]_{\{1\}} \geq E[F]_{\{0\}} \Leftrightarrow \kappa \leq \phi/(1-\phi)$. Comparing this value with $\phi f/(n(n-1+(1-\phi)f))$ which is one of the two possible values of $\bar{\kappa}$ reveals that $E[F]_{\{1\}} \geq E[F]_{\{0\}}$ holds for all $n \geq 1$.

Consider now 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. $E[F]_{\{n-1\}} \geq E[F]_{\{n\}} \Leftrightarrow \kappa \leq \phi/(n(1-\phi))$. We again compare this value with $\phi f/(n(n-1+(1-\phi)f))$ which reveals that $E[F]_{\{n-1\}} \geq E[F]_{\{n\}}$ holds for any $n \geq 1$. As the other value for $\bar{\kappa}$, i.e. $(1-\hat{\mu})/(n\hat{\mu})$, is either even lower or not relevant, we can conclude that all firms blow the whistle if one firm has deviated. Thus, all firms always have an incentive to blow the whistle if one firm deviates and if the antitrust authority reviews the industry. ■

Equation (5) implies that a firm that deviates gets the whole monopoly industry profit Π and expects a total fine of $\Pi\rho\mu_n f\psi_n/n$.[11] If one firm has deviated, due to the collusive strategy defined above, collusion breaks down forever.

[11] Note that if one firm has deviated, we exclude this period from the collusive phase as collusion breaks down. Thus, we assume that the single deviation profit Π 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, to keep our model as general as possible we do not assume a per-se fine reduction for the deviating firm.

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

$$\bar{\delta}_{\{n\}} \geq \frac{n-1}{(n-\rho\mu_n f\psi_n)(1-\rho\mu_n)}. \tag{10}$$

3.2 Whistleblowers and silent firms

In contrast to the deviation case, not necessarily all firms have an incentive to blow the whistle in the event of a review if the industry-specific discount factor is (considerably) larger than $\bar{\delta}_{\{n\}}$. Then, AW is no equilibrium strategy anymore. The main reason for this is that each whistleblowing firm increases the probability of conviction by κ.

If the industry-specific discount factor converges to one and if firms face a relatively small probability of being reviewed, not all (or even no) firm(s) may have an incentive to blow the whistle and stay(s) silent. This is due to the fact that the firm value from collusion, equation (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 period if they do not blow the whistle. At the same time, there is 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 by the amount of κ.

To account for this, we have to calculate two additional critical discount factors. The first one, denoted by $\bar{\delta}_{\{n-1\}}$, reflects a situation where it is not optimal for at least one firm to blow the whistle. The second one, denoted by $\bar{\bar{\delta}}_{\{0\}}$, 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)

Consider the following equilibrium strategy:

SW (Some firms blow the whistle): *Firms collude from $t = 1$ on as long as no firm deviates. If the antitrust authority reviews the industry in period t, at least one but not 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 convicts the cartel or if one firm has deviated, firms play grim-trigger strategies in every submarket in every subsequent period.*

As described above, in order to identify the parameter space where SW is an equilibrium strategy, we have to calculate the border above which at least one firms has no incentive to blow the whistle. Due to the one-stage deviation principle, a firm which does not blow the whistle when the collusive industry is reviewed while the other firms do has a collusive firm value of

$$V^{+}_{\{n-1\}} = \frac{\Pi}{n} + (1-\rho)\,\delta V^{+}_{\{n\}} + \rho\left(-\hat{\mu}(1+\kappa(n-1))\frac{\Pi f}{n} + (1-\hat{\mu}(1+\kappa(n-1)))\,\delta V^{+}_{\{n\}}\right). \quad (11)$$

Such a firm faces a smaller probability of conviction $\hat{\mu}(1+\kappa(n-1))$ compared to the probability under the AW strategy in equation (1) given by $\hat{\mu}(1+\kappa n)$. 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 $\Pi f/n$ when being convicted. This strategy is profitable if $V^{+}_{\{n-1\}} \geq V^{+}_{\{n\}}$ which holds if

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

Given this expression, we can justify *Assumption 1*. As matter of fact, comparing $\bar{\delta}_{\{n-1\}}$ and $\bar{\delta}_{\{n\}}$ reveals that $\bar{\delta}_{\{n\}} \leq \bar{\delta}_{\{n-1\}} \Leftrightarrow \rho \leq (((1+\kappa n)\phi - \kappa n)f - \kappa n(n-1))/(((1+\kappa n)\phi - \kappa n)f(1+\kappa n)\hat{\mu})$. Note that this value is less than 0 for $\kappa > \phi f/(n(n-1+(1-\phi)f))$. This means that only for a κ lower than this threshold, there exists a region where all collusive firms have an incentive to blow the whistle and thus firms will indeed sustain collusion by playing the AW strategy.

BILDET DIE ANALYSE HIER TATSÄCHLICH AUCH DEN FALL "AT LEAST" AB???

3.2.2 No firm blows the whistle (NW)

Consider the following equilibrium strategy:

NW (No firm blows the whistle): *Firms collude from $t = 1$ on as long as no firm deviates. If the antitrust authority reviews the industry in period t, 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 convicts the cartel or if one firm has deviated, firms play grim-trigger strategies in every submarket in every subsequent period.*

If NW is the equilibrium strategy, no firm has an incentive to blow the whistle. Then, the collusive firm value of each firm amounts to

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

Consequently, all firms have to pay the full fine. On the other hand, by using NW, firms 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 blows the whistle when the collusive industry is reviewed while the other firms do not has a collusive firm value of

$$V^+_{\{1\}} = \frac{\Pi}{n} + (1-\rho)\,\delta V^+_{\{0\}} + \rho\left(-\hat{\mu}(1+\kappa)\frac{\Pi f(1-\phi)}{n} + (1-\hat{\mu}(1+\kappa))\,\delta V^+_{\{0\}}\right). \quad (14)$$

The single whistleblower increases the probability of being convicted by κ. 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 $V^+_{\{1\}} \geq V^+_{\{0\}}$. To calculate the corresponding critical discount factor, we rearrange equation (13) to

$$V^+_{\{0\}} = \frac{\Pi}{n}\frac{1-\rho\hat{\mu}f}{1-\delta(1-\rho\hat{\mu})}. \quad (15)$$

Thus, we get the following critical discount factor above which no firm blows the whistle:

$$\bar{\delta}_{\{0\}} \geq \frac{((1+\kappa)\phi-\kappa)f}{((1+\kappa)(1-\rho\hat{\mu})\phi-\kappa)f+\kappa}. \quad (16)$$

Note that we will not discuss the existence of the SW and NW strategies in detail since this is not the focus of this paper. However, the existence and the size of these regions depend crucially on κ. If the additional value by which a firm increases the probability of being convicted goes to zero, firms no longer face the trade-offs described above, i.e. it becomes clear from expressions (12) and (16) that if $\kappa \to 0$ and if the antitrust authority reviews the industry, blowing the whistle (AW) would always be the dominant strategy.

3.3 Numerical example

We now consider a numerical example to illustrate our findings so far. To this end, let $n = 3$, $\hat{\mu} = 1/2$, $f = 10$, $\phi = 1$, and $\kappa = 1/10$. 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 as we will look at low values of ρ below. If ρ is small, firms enjoy collusive profits for some periods before being convicted. The fine then accounts for the profits made during these periods. Furthermore, we investigate the case where the first whistleblowing firm gets full leniency by setting $\phi = 1$. The critical discount factors are depicted in *Figure 1*.

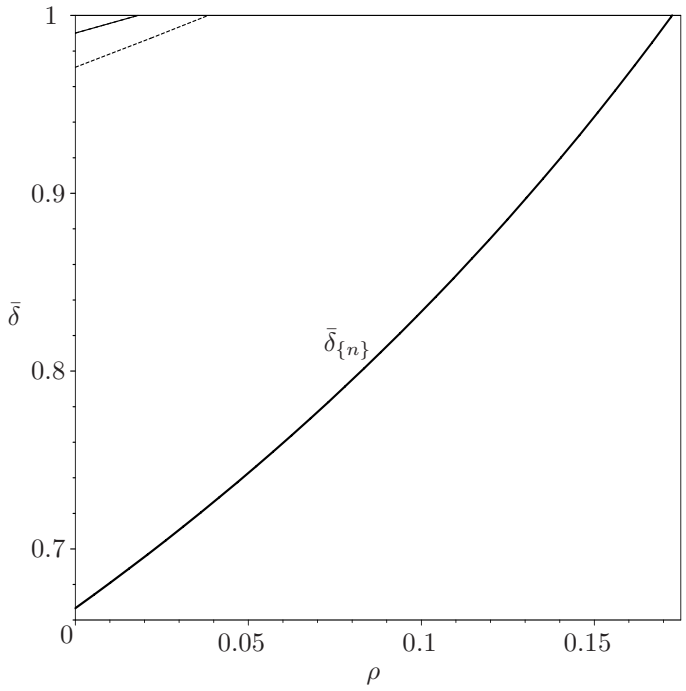

Figure 1: Critical discount factors without ringleader discrimination.

The critical discount factor for the case where firms follow the AW strategy is given by the thick solid line. For any discount factors below the dashed line, firms follow the AW strategy. If the industry-specific discount factor lies in between the dashed line and the thin solid line, firms play the SW strategy. 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.

We now turn to the asymmetric case where the ringleader cannot apply for leniency.

4 Asymmetric case: Ringleader discrimination

Again, we start with the situation where whistleblowing is the dominant strategy.

4.1 Whistleblowing as a dominant strategy

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 these firms and decreases the probability of conviction by κ. 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, the sustainability of

collusion is reduced and the critical discount factor of the ringleader rises due to the higher expected fine. Using the identical parameter values from the numerical example in the previous section, these two opposing effects are illustrated in *Figure 2*.

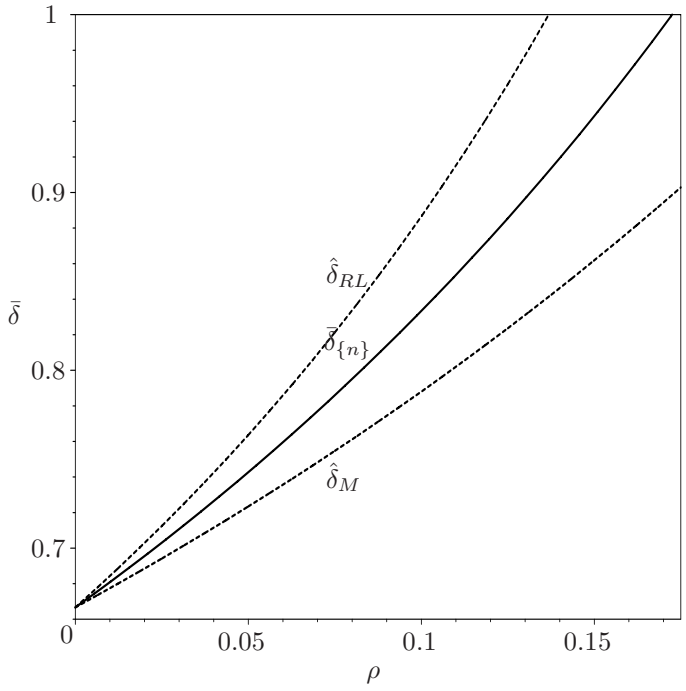

Figure 2: Critical discount factors with ringleader discrimination and symmetric profit sharing.

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 higher. However, the fact that there are less firms which are able to report to the antitrust authority results in a lower critical discount factor for the members which can be seen from the lower dotted line. At the margin, though, firms 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 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 if one firm (the ringleader) has no incentive to reveal information to the antitrust authority. Furthermore, because of the proportional fine and the profit shifting to the ringleader, the expected fine for a colluding cartel member decreases. Additionally, the cartel members have a higher probability of benefiting from the

leniency program which further reduces their expected fine. 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 a cartel member. Furthermore, due to the effects of the proportional fine in the context of profit shifting and the higher probability of being the firm which benefits from the leniency program, the firm value of a deviating cartel member increases. This decreases the sustainability of collusion. We will discuss these trade-offs in detail below.

WO GENAU NOCHMAL??? EIGENTLICH GIBT ES JA DANN AUCH 2 EFFEKTE, DIE ZU ABSENKUNG FÜHREN (DEVIATION HOCH BEI ORDINARY MEMBER); ABER: KDF BEI GEWÖHNLICHEN MITGLIEDERN SINKT; BEI RL STEIGT ER, D. H. WIR WISSEN JA EIGENTLICH, WELCHE EFFEKTE IM EINZELNEN (AUF DER JEWEILIGEN SEITE) ÜBERWIEGEN – BRAUCHEN ALSO NUR NOCH EINEN VGL. DER KDF, DER WIEDRUM AN DER GEWINNREGEL HÄNGT

Given these considerations and the fact that the leniency program is designed in a way such that firms choose the AW strategy, the collusive firm values of a ringleader $V^+_{RL,\{n-1\}}$ and a cartel member $V^+_{M,\{n-1\}}$ can be written as

$$V^+_{RL,\{n-1\}} = \lambda\Pi + (1-\rho)\delta V^+_{RL,\{n-1\}} + \rho\left(-\hat{\mu}\left(1+\kappa(n-1)\right)\lambda\Pi f + \left(1-\hat{\mu}\left(1+\kappa(n-1)\right)\right)\delta V^+_{RL,\{n-1\}}\right) \quad (17)$$

and

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

As described above, the collusive firm values may be asymmetric now. The ringleader gets a share λ of the collusive (monopoly) industry profit Π in every collusive period. Consequently, since a ringleader never benefits from the leniency program, it always has to pay the full fine $\lambda\Pi f$ when being convicted. The remaining profit $(1-\lambda)\Pi$ is shared equally between all of the $n-1$ ordinary cartel members. Thus, every cartel member gets a per-period profit of $(1-\lambda)\Pi/(n-1)$ and has to pay f times this value if the 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. For the same reason, the members' expected realization of the fine is reduced from $(1-\phi)/n + (n-1)/n$ to $(1-\phi)/(n-1) + (n-2)/(n-1)$.

To take both effects into account, let us define the total probability of conviction as

$$\mu_{n-1} := \hat{\mu}(1+\kappa(n-1)) \quad (19)$$

and the expected realization of the fine reduction as

$$\psi_{n-1} := \frac{1-\phi}{n-1} + \frac{n-2}{n-1} = \frac{n-1-\phi}{n-1}. \tag{20}$$

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

$$V^{+}_{RL,\{n-1\}} = \lambda\Pi \frac{1-\rho\mu_{n-1}f}{1-\delta(1-\rho\mu_{n-1})} \tag{21}$$

and

$$V^{+}_{M,\{n-1\}} = \frac{(1-\lambda)\Pi}{n-1} \frac{1-\rho\mu_{n-1}f\psi_{n-1}}{1-\delta(1-\rho\mu_{n-1})}. \tag{22}$$

Now we turn to the firm values of a deviating ringleader and a deviating cartel member. As in the symmetric case, we can state our result in the following lemma:

Lemma 2 *Under* Assumption 1*, the firm values of a ringleader that deviates from the collusive agreement (V^{D}_{RL}) and of a cartel member that deviates (V^{D}_{M}) are given by*

$$V^{D}_{RL} = \Pi - \lambda\Pi\rho\mu_{n-1}f \tag{23}$$

and

$$V^{D}_{M} = \Pi - \frac{(1-\lambda)\Pi}{n-1}\rho\mu_{n-1}f\psi_{n-1}. \tag{24}$$

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. As the ringleader will never blow the whistle, the ringleader's firm value from deviation only depends on the cartel members' 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

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

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

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

Third, a cartel member that does not blow the whistle while the other members do expects a fine of

$$E[F]_{M,\{n-2\}} = (1+\kappa(n-2))E[F]_{M,\{0\}}. \tag{27}$$

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

$$E[F]_{M,\{n-1\}} = (1+\kappa(n-1))\frac{n-1-\phi}{n-1}E[F]_{M,\{0\}}. \tag{28}$$

Suppose now that given one cartel member deviated, no other member blows the whistle. Then, blowing the whistle for a single member would be optimal whenever $E[F]_{M,\{1\}} \geq E[F]_{M,\{0\}} \Leftrightarrow \kappa \leq \phi/(1-\phi)$. Comparing this value with $\phi f/(n(n-$

$1+(1-\phi)f))$ which is one of the two possible values of $\bar{\kappa}$ reveals that $E[F]_{M,\{1\}} \geq E[F]_{M,\{0\}}$ holds for all $n \geq 1$.

Thus, consider the case where all members would blow the whistle after deviation by one firm. Then, not blowing the whistle must not be optimal for a single member, i.e. $E[F]_{M,\{n-2\}} \geq E[F]_{M,\{n-1\}} \Leftrightarrow \kappa \leq \phi/((n-1)(1-\phi))$. Again, this means that $E[F]_{M,\{n-2\}} \geq E[F]_{M,\{n-1\}}$ holds for any $n \geq \frac{1}{2} + \sqrt{1-4f(1-\phi)}/2 < 1$ when compared with $\phi f/(n(n-1+(1-\phi)f))$. As the other value for $\bar{\kappa}$, i.e. $(1-\hat{\mu})/(n\hat{\mu})$, is either even lower or not relevant, we can conclude that all members of the cartel blow the whistle if one firm has deviated. ■

Equations (23) and (24) highlight the fact that a ringleader or a cartel member that deviates appropriates the whole industry profit Π. However, they expect a different total fine. A cartel member is able to apply for leniency and hence expects a fine of $(1-\lambda)\Pi\rho\mu_{n-1}f\psi_{n-1}/(n-1)$. Since a convicted ringleader always has to pay the full fine, it expects a fine of $\lambda\Pi\rho\mu_{n-1}f$.

Then, the critical discount factors for the ringleader as well as the members are given by

$$\bar{\delta}_{RL,\{n-1\}} \geq \frac{1-\lambda}{(1-\lambda\rho\mu_{n-1}f)(1-\rho\mu_{n-1})} \tag{29}$$

and

$$\bar{\delta}_{M,\{n-1\}} \geq \frac{1-\lambda-(n-1)}{((1-\lambda)\rho\mu_{n-1}f\psi_{n-1}-(n-1))(1-\rho\mu_{n-1})}. \tag{30}$$

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

$$\lambda = \frac{1}{2\rho\mu_{n-1}f(1-\psi_{n-1})}\Big(2\rho\mu_{n-1}f(1-\psi_{n-1}) + (1-\rho\mu_{n-1}f)n - \\ - \sqrt{(1-\rho\mu_{n-1}f)((1-\rho\mu_{n-1}f)n^2 + 4\rho\mu_{n-1}f(1-\psi_{n-1})(n-1))}\Big). \tag{31}$$

Having a closer look at the profit-sharing rule reveals the following:

Lemma 3 *The profit-sharing rule increases with the probability of review, i.e.* $\frac{\partial\lambda}{\partial\rho} > 0$*, if firms choose the AW strategy.*

Proof The derivative is given by $\partial\lambda/\partial\rho = (2\rho\mu_{n-1}f(1-\psi_{n-1})(n-1) + (1-\rho\mu_{n-1}f)n^2 - n\sqrt{(1-\rho\mu_{n-1}f)((1-\rho\mu_{n-1}f)n^2 + 4\rho\mu_{n-1}f(1-\psi_{n-1})(n-1))})/(2\rho^2\mu_{n-1}f(1-\psi_{n-1})\sqrt{(1-\rho\mu_{n-1}f)((1-\rho\mu_{n-1}f)n^2 + 4\rho\mu_{n-1}f(1-\psi_{n-1})(n-1))})$. From equation (31), one can show that $\lambda > 1$ for all $\rho > 1/(\mu_{n-1}f)$. Furthermore, the denominator of $\partial\lambda/\partial\rho$ is always non-negative for all $\rho \leq 1/(\mu_{n-1}f)$. The numerator is equal to zero if and only if $\rho = 0$ and is always negative if $\rho \geq \frac{1}{\mu_{n-1}f}\frac{n^2}{n^2-4(1-\psi_{n-1})(n-1)} \Leftrightarrow \frac{1}{\mu_{n-1}f}\frac{n^2}{n^2-4\phi}$

HIER STIMMT ETWAS NICHT BEI DER UMFORMUNG!? $\rho > ...$???

which is always larger than $1/(\mu_{n-1}f)$ for any $n > 2$. Thus, $\partial\lambda/\partial\rho > 0$ for all $\lambda \leq 1$. ■

Making use of the above results, we can state the following proposition:

Proposition 1 *If all firms blow the whistle in the case of an industry review and ringleader discrimination, ordinary cartel members always have an incentive to shift collusive 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 $\bar{\delta}_{M,\{n-1\}} \geq -\frac{1-\lambda-(n-1)}{n-1}$. Consequently, the profit-sharing scheme amounts to $\lambda = \frac{1}{n}$. Together with *Lemma 3* we get $\lambda > \frac{1}{n}$ if $\rho > 0$. ■

Lemma 3 and *Proposition 1* imply that a ringleader's per-period profit 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. It will become clear from the discussion of the SW and NW strategies below that these results indeed depend on the AW strategy.

4.2 Whistleblowers and silent firms

Again, we have to take into account that κ affects the strategy choice of the cartel members. Since the ringleader will never blow the whistle independently of κ, we only have to consider the incentives of the cartel members. We start the analysis again with the SW strategy where at least one member does not have an incentive to blow the whistle.

4.2.1 Some firms blow the whistle (SW)

Due to the one-stage deviation principle, a cartel member that does not blow the whistle while the other members do has a collusive firm value of

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

if the collusive industry is reviewed. Not blowing the whistle means that the 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 $V^{+}_{M,\{n-2\}} \geq V^{+}_{M,\{n-1\}}$ which holds if

$$\bar{\delta}_{\{n-2\}} \geq \frac{((1+\kappa(n-1))\phi - \kappa(n-1))f}{((1+\kappa(n-1))(1-\rho\hat{\mu}(1+\kappa(n-2)))\phi - \kappa(n-1))f + \kappa(n-1)}. \quad (33)$$

Comparing (33) to the analogous critical discount factor in the symmetric case (expression (12)) shows that both only differ in $-\kappa$, the additional value of the

probability of conviction which is missing 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 $n-1$.

WARUM WIRD HIER LAMBDA NICHT BERECHNET – UNTEN ABER SCHON (WIEDER)???

4.2.2 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

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

Note that the new profit-sharing rule $\tilde{\lambda}$ differs from the profit-sharing rule λ firms choose in the AW strategy. However, $\tilde{\lambda}$ is different from the symmetric sharing rule too. Since no ordinary cartel member blows the whistle under the NW strategy, ringleaders and cartel members have the same collusive firm value. On the other hand, due to our finding in *Lemma 2* that cartel members always blow the whistle if one firm has deviated, a ringleader has a lower firm value from deviation and thus a lower incentive to deviate. Since this results in a lower critical discount factor, the profit has to be shifted in the other direction than in the AW strategy, i.e. from the ringleader to the ordinary cartel members. Then, the collusive firm value of a ringleader amounts to

EIGENTLICH SCHÖNER PUNKT: KANN MAN DA EVTL. NOCH MEHR DARAUS MACHEN???

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

To calculate $\tilde{\lambda}$, we have to calculate the new critical discount factors for the ringleader and for the cartel members denoted by $\bar{\delta}_{RL,\{0\}}$ and $\bar{\delta}_{M,\{0\}}$, respectively. From (35) and (34) and from *Lemma 2*, we get

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

and

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

Since $\bar{\delta}_{RL,\{0\}} = \bar{\delta}_{M,\{0\}}$ has to hold at the margin, the new profit-sharing rule is given by

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

DEN FOLGENDEN ABSCHNITT VERSTEHE ICH NICHT; WOFÜR BRAUCHEN WIR DAS??? KANN MAN NICHT EINFACH LAMBDATILDE EINSETZEN UND DANN BEKOMME ICH DOCH AUCH DEN KRITISCHEN DISKONT.FAKTOR

A cartel member deviates from the SW strategy if its firm value is larger when blowing the whistle if the collusive industry is reviewed while no other firms do so. Such a member would have a collusive firm value of

$$V^{+}_{M,\{1\}} = \frac{(1-\tilde{\lambda})\Pi}{n-1} + (1-\rho)\,\delta V^{+}_{M,\{1\}} + \rho\left(-\hat{\mu}(1+\kappa)\frac{(1-\tilde{\lambda})\Pi f(1-\phi)}{n-1} + (1-\hat{\mu}(1+\kappa))\,\delta V^{+}_{M,\{1\}}\right). \quad (39)$$

At least one cartel member would choose to deviate from NW if $V^{+}_{M,\{1\}} \geq V^{+}_{M,\{0\}}$. To calculate the corresponding critical discount factor, we rearrange equation (34) to

$$V^{+}_{M,\{0\}} = \frac{(1-\tilde{\lambda})\Pi}{n-1}\left(\frac{1-\rho\hat{\mu}f}{1-\delta(1-\rho\hat{\mu})}\right). \quad (40)$$

Thus, the critical discount factor above which no firm would blow the whistle if the industry is reviewed is then given by

$$\bar{\delta}_{\{0\}} \geq \frac{((1+\kappa)\phi-\kappa)f}{((1+\kappa)(1-\rho\hat{\mu})\phi-\kappa)f+\kappa}. \quad (41)$$

Interestingly, expression (41) is equal to the corresponding boundary of the symmetric case (expression (16)). This means in turn, that the incentive if one firm blows whistle while the other firms do not is independent of the outcome of the profit-sharing rule at the margin.

4.3 Comparison with the no-discrimination case

Consider a situation where the antitrust authority has chosen an enforcement policy such that indeed AW would maximize the number of industries which are able to sustain collusion. Note that this does not mean that the leniency program has a strictly adverse effect. It just excludes those cases where for a relatively high κ, firms would be able to collude for a larger ρ through the use of NW.[12] WORAUF BEZIEHT SICH DAS FOLGENDE "doing so"??? Doing so, the boundaries of switching from strategy AW to SW and from SW to NW only affect the strategy through which firms sustain collusion 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.

As far as the AW strategy is concerned, however, the effects of discriminating ringleaders on the sustainability of collusion may be ambiguous. Consider again the

[12] Technically, this means $\bar{\delta}_{\{0\}} < \bar{\delta}_{\{n\}} \gtreqless \bar{\delta}_{RL,\{n-1\}} = \bar{\delta}_{M,\{n-1\}}$. We will not go into detail but numerical simulations suggest that this condition does not hold if κ is so large (a single whistle-blowing firm is very valuable) that excluding the ringleader from the leniency program would unambiguously increase the sustainability of collusion, i.e. $\bar{\delta}_{\{n\}} \geq \bar{\delta}_{RL,\{n-1\}} = \bar{\delta}_{M,\{n-1\}}$.

numerical example from section 3. Plugging the parameter values into the profit-sharing rule (expression (31)) results in

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

Using this value to calculate the critical discount factors for the asymmetric case ($\bar{\delta}_{RL,\{n-1\}} = \bar{\delta}_{M,\{n-1\}}$) and all other relevant discount factors described above, i.e. $\bar{\delta}_{\{n\}}, \bar{\delta}_{\{n-1\}}, \bar{\delta}_{\{n-2\}}$, and $\bar{\delta}_{\{0\}}$, gives *Figure 3* in the numerical example:

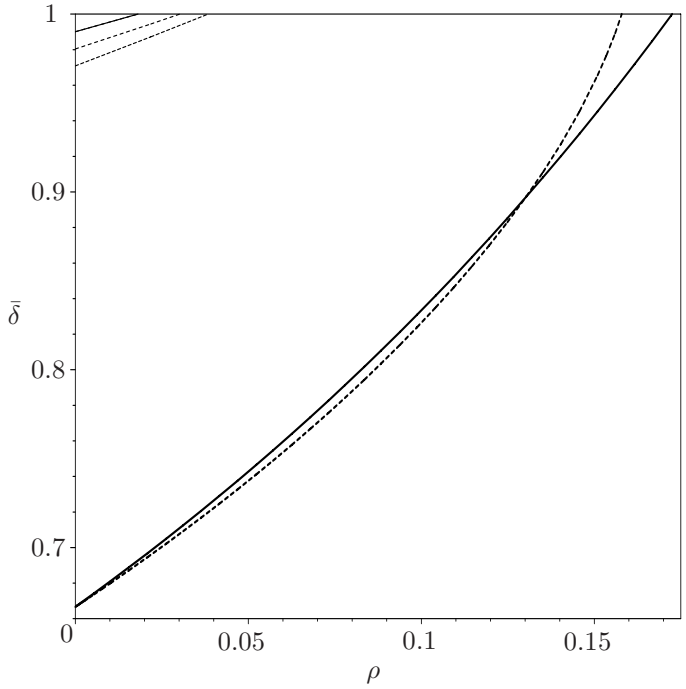

Figure 3: Comparison of both regimes ($\kappa = 1/10$).

Again, the solid line represents the critical discount factor for the regimes where all firms are able to benefit from the leniency program and firms share the monopoly industry profit equally. The dotted line gives the critical discount factor for the asymmetric case under the adjustment of the ringleader and the member per-period profit through $\lambda^*(\rho)$. As becomes obvious from the figure, there exists an intercept point.

If ρ is small, a regime where the ringleader is not discriminated against always results in a lower sustainability of collusion. This results from the lower probability of conviction when the antitrust authority excludes the ringleader. We know from *Proposition 1* that for $\rho \to 0$, firms have less incentives to shift profits from the cartel members to the ringleader, i.e. $\lambda \to 1/n$. Due to this and because of the small probability of review, the collusive per-period profit share and the expected profit from deviation of the ringleader and of an ordinary cartel member are 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. Consequently, an antitrust authority which can only commit to review an industry with a relatively small probability will always be better off when allowing ringleaders to benefit from leniency programs. One may argue that the additional evidence the ringleader can reveal to the antitrust authority may make up for the low investigation probability and thus help increase the detection probability. In this situation, evidence is very valuable.

On the other hand, as ρ increases, we know that $\lambda \to 1$. If the probability that the industry is reviewed becomes higher, the ringleader will obtain a greater share 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 thus increases their incentives to deviate and to obtain the whole monopoly industry profit. As can be seen in *Figure 3*, this effect on the sustainability of collusion may be so strong such that the sustainability-reducing (VERSTEHE ICH NICHT WIRKLICH; EIGENTLICH JA "enhancing" – SONST ERGIBT SICH JA KEIN WIDERSPRUCH, D. H. ER MUSS NICHT "exceeded" WERDEN!?) effect of a larger probability of conviction is exceeded by the asymmetry effect.

SOLLTE MAN HIER EVTL. NOCH EINMAL STÄRKER DIE 3/4 EFFEKTE ANSPRECHEN, DIE IN VERSCHIEDENE RICHTUNGEN GEHEN?!?

We summarize the above considerations in the following proposition:

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

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

As mentioned in the proposition, the effect of a more asymmetric cartel does not necessarily outweigh the effect of a higher probability of conviction. *Figure 4* gives an example where κ is sufficiently large such that excluding the ringleader would always result in more collusive industries. Compared to the situation before, as κ becomes larger, the antitrust authority forgoes valuable information by excluding the ringleader. A large κ would increase the probability of conviction so much that no ringleader discrimination would be always superior in the relevant parameter space.

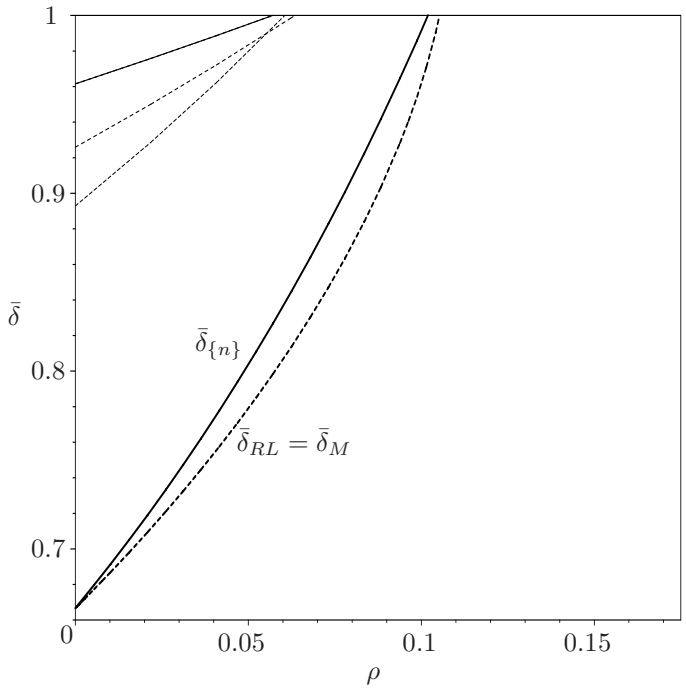

Figure 4: Ringleader exclusion fares always worse (c.p. κ increased from 1/10 to 2/5).

Figure 5 illustrates the impact of a change in the amount of evidence every firm may pass on to the antitrust authority on the critical review policy $\tilde{\rho}$. It reveals that there is a non-monotonous relationship between κ and $\tilde{\rho}$. Broadly speaking, if the antitrust authority has only limited resources to investigate a specific industry, then no ringleader discrimination seems to be the better option as κ increases. In this case, the evidence every firm has may be viewed as a substitute for the low probability of review (see above) . Then, as κ increases, this means that no discrimination is optimal for a broader range of ρ. However, if a review is very likely, an increase in the evidence each firm has is less important if firms already possess a lot of evidence. As a result, an antitrust authority would rather want to exclude the ringleader from the leniency program in order to increase the asymmetry between the firms. As a consequence, $\tilde{\rho}$ decreases. Thus, for certain values of ρ, the optimality of one regime or the other is not clearcut and crucially depends on κ.

EIGENTLICH SOLLTE MAN JA HIER NOCH ALS ERKLÄRUNG ANFÜHREN, DASS MIT HOHEM KAPPA AUCH DIE KURVEN STEILER WERDEN [LAUFEN SCHNELLER IN 1 HINEIN] – UND DEMNACH SICH DER SCHNITTPUNKT NACH LINKS BEWEGEN MUSS; WARUM STEILER??? MUSS DER KDF BEI RHO=1 ZWANGSLÄUFIG BEI >= 1 LIEGEN: IMMER UNTERSUCHEN HEIßT JA NICHT ZWANGSLÄUFIG IMMER ÜBERFÜHREN???

Table 1: Comparative statics on $\tilde{\rho}$.

x	κ	ϕ	f	$\hat{\mu}$	n
$\frac{\partial \delta}{\partial x}$	> 0	< 0	> 0	> 0	> 0
$\frac{\partial \tilde{\rho}}{\partial x}$	$\lessgtr 0$	< 0	< 0	< 0	> 0

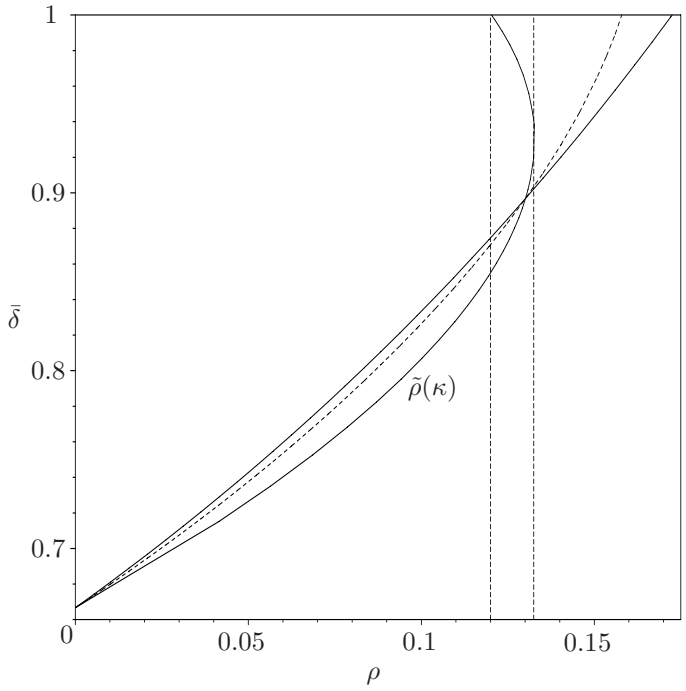

Figure 5: Impact of κ on $\tilde{\rho}$.

Beside κ, all other relevant parameters, i.e. the scope of the leniency program ϕ, 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 slope of the critical discount factors on the one hand—and thus the probability of review that would be sufficiently high to prevent any collusive activities. On the other hand, these parameters also affect the degree of convexity of both curves—and thus the existence of $\tilde{\rho}$.

Numerical simulations based on the example from section 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*.

FEHLT: ERKLÄRUNGEN (ZUMINDEST KURZ)???

In the introduction, we also mentioned that Leslie (2006) argues that the negative effect of ringleader exclusion with respect to cartel deterrence could be compensated for by levying a higher fine on the ringleader side. In our model, one could think of doing so by introducing a fine load of $(1 + l)f$ 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 given in *Proposition 2* should hold as the basic reasoning still applies.

5 Conclusions

In this paper, we focus on whether ringleaders of illegal cartels should be given the chance to apply for leniency or not. We identify the different forces at work which make one regime appear more favorable than the other. We find that both approaches may be a useful means to curb cartel activity. Indeed, we find 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 then faces a higher expected fine which needs to be accounted for when deciding how to split profits. The resulting asymmetry between the firms reduces the sustainability of the cartel.

Our analysis is based on specific assumptions concerning the functioning and the homogeneity of the cartel firms. The model assumes that firms are symmetric and that one of these firms takes on the role of a ringleader. As a result, under ringleader discrimination, firms become asymmetric as they are treated differently. However, as mentioned in the introduction, whereas 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 certainly be interestingly to analyze which characteristics will make cartel leadership more likely and how they finally affect collusive stability. Clearly, introducing heterogeneous firms into the model means that there is an a priori asymmetry in the market which negatively affects the sustainability of collusion from the start. Depending on the ringleader's characteristics, granting access to the benefits of the leniency programs only to ordinary cartel members may have the desired effect and lead to an even greater asymmetry among firms.

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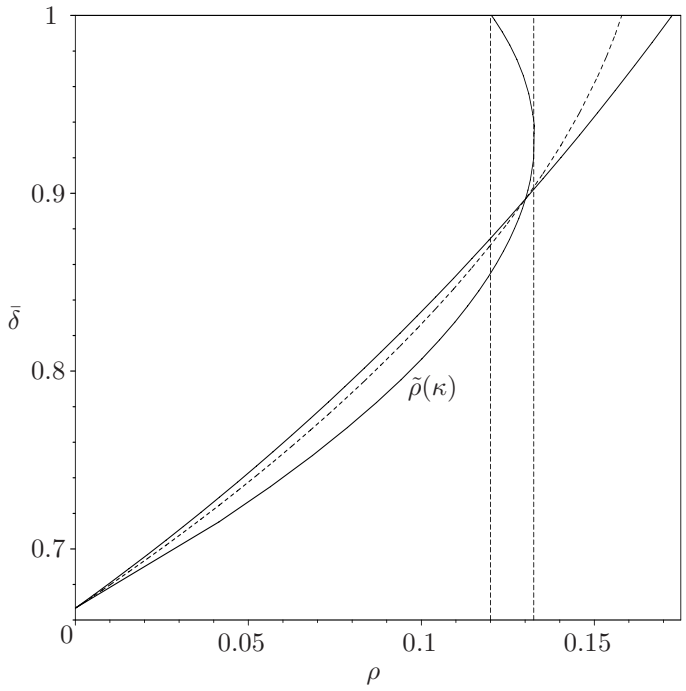

Figure 6: Comparison of both regimes ($\kappa = \frac{1}{10}$).

nicht so viel auf asymmetrie herumreiten sondern auf den gg.läufigen effekten (s. vortrag)
proportionale strafe ja nur an periodengewinn orientiert, d.h. evtl. gar nicht so hoch – lassen sich ρ und f zs.fassen bzw. sollte man darauf achten, dass $\rho f \geq 1$??

muss fine reduction immer proportional sein??? realität???

warum haben wir eigentlich keine nash bargaining solution?? ist unsere aufteilungsregel in dem sinne optimal, dass sie sich tatsächlich nur auf die stabiltät konzentriert? eigentlich ja, da der disagreement payoff ja für alle gleich 0 ist!?

wer sollte RL sein? 2 firmen, unterschiedliche kosten: wo ist krit. df am geringsten? einfluss auf gewinne wg. anreizen (nbs?)? abgrenzung von papier hier: nur betrachtung des falles mit diskriminierung/fine load für RL noch dazu (dann machen wohl beide fälle wieder sinn)? lässt sich das hier einfügen

SCHINKEL: *(i) RL discrimination hat keinen einfluss auf die aufdeckungswkt., obwohl das von behörden gerne angenommen wird; (ii) was passiert, wenn alle beweise vom RL zs.gehalten werden?? (iii) ist in europa full leniency für RL wirklich möglich ('aggravating circumstances' – einfach zu integrieren)*

(grafiken noch verinheitlichen hinsichtlich beschriftung!!)

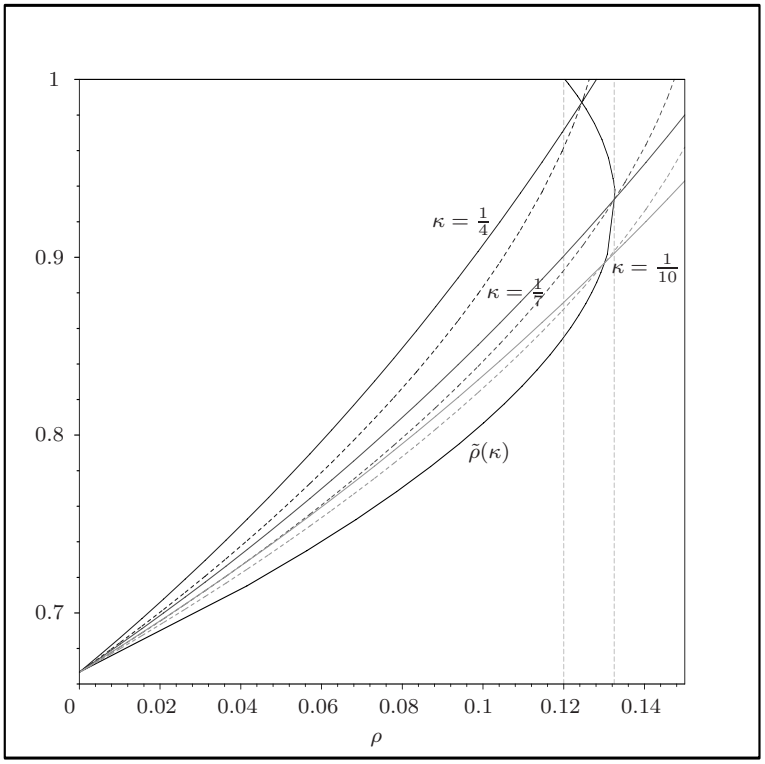

Figure 7: Ringleader exclusion fares always worse (c.p. κ increased from $\frac{1}{10}$ to $\frac{4}{10}$).

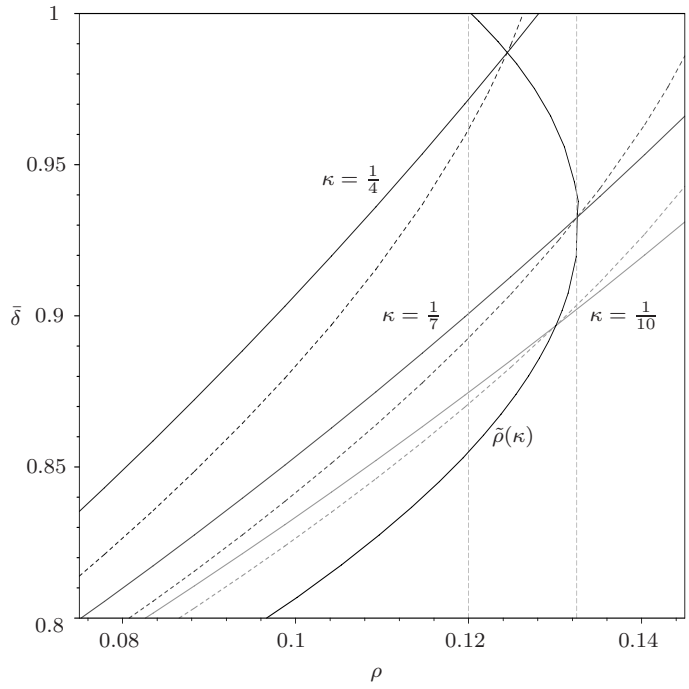

Figure 8: Ringleader exclusion fares always worse (c.p. κ increased from $\frac{1}{10}$ to $\frac{4}{10}$).