On the Nature of Private Information in Corporate Leniency

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Introduction

Since the US Department of Justice introduced new leniency policies in 1993 (the Corporate Leniency Policies) to improve the effectiveness of successfully detecting and prosecuting cartels, leniency programs have become a crucial part of cartel prosecution worldwide. While differing within certain parameters and guidelines, leniency programs all offer a reduced fine to one or more firms that are willing to provide evidence on an illegal collusion they are involved in. This reduced fine serves as an incentive for colluding firms to report to the competition agency (CA).

The implementation of leniency programs was accompanied by a broad range of literature on the behavior of firms under the new conditions. The first paper directly focusing on corporate leniency and proposing a first model to identify incentives and motives of involved parties was Motta and Polo (2003). This first model only allowed for leniency application as an collusive decisions of cartels. The following literature then introduced models where spontaneous reporting can

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occur. These results are collected in Spagnolo (2008). In most of these models, firms have complete information on the leniency program, their own profits and all related probabilities. As a result, they will either not form a cartel at all because cartel profits are not high enough anymore, or if they form will never use leniency programs because they have no incentive to risk the high cartel profit.

Harrington (2008) aims to solve this contradiction by allowing the probability of getting caught and convicted to change over time. Cartels might then establish at one point but apply for leniency later. This however results in the so called 'Rush to the Courthouse-Effect' where either no firm applies or all firms try to outpace each other in applying.

The theoretical work on corporate leniency is accompanied by experiments that aim at getting an undisturbed view on firm behavior. One experiment conducted by Bigoni et al. (2010) suggests that players who are presented with a constant product of a probability of conviction and a fine, tend to apply more often when facing a high fine. This means that, independent from the likelihood of a successful prosecution, players fear the high fine. In Harrington (2012) this behavior is interpreted as firms being afraid of a possible leniency application of other cartel members and modeled by allowing firms to have private information on the likelihood of getting caught and convicted by the CA. Already in Pinna (2010), Sauvagnat (2010) and Silbye (2010) private information is included in a model for either the CA or the colluding firms. Harrington's approach differs in that it concludes on a Bayes-Nash equilibrium where one firm might turn its partner in without this partner 'rushing' behind to get a chance to apply as well.

While this thesis aims at a similar equilibrium that allows for asymmetric behavior of firms, it is based on a different interpretation of private information in cases of collusion. Firms will have private information on the amount and quality of evidence, which they collected during the period of collusion. The model of

Harrington (2012) will then be adjusted to the new assumptions.

Private Information in Corporate Leniency

Harrington (2012) supposes that firms receive a private signal that gives them information on the likelihood of the CA convicting the cartel without any firm applying for leniency. Given their own signal, they then form expectations on the signal of the other firm. This definition implies that firms' signals are based on information on CA behavior. Only having different information on the CA will give firms different signals on the likelihood of conviction.

The CA generates information on all its activities and their probable impact on the success of prosecution. In many countries the CA not only waits for cartel members to come forward, but also actively investigates certain sectors to detect possible cartels and, if there is sufficient evidence, also starts an investigation. [1] Therefore the CA does indeed create information that might affect firms' leniency decision.

However CAs are public organizations and, following the nature of public organizations, CAs underlie certain guidelines of transparency and publicity. [2] Every individual person can inform himself/herself about CA activities and firms that are involved in cartels naturally have an even higher interest in getting to know about every detail of the CA's work. Therefore the following part of this thesis will argue that there is no private or secret information generated by the CA but all its activities are openly known by all cartel members.

In addition to the information on the CA, firms themselves will also create information in the form of evidence over the period of collusion. This evidence

[1] Germany as an example conducts sector inquiries and collects information by other market participants that can lead to further investigation, in Bundeskartellamt (2010). *The Bundeskartellamt in Bonn – Organisation, Tasks and Activities.* p. 22 and 42

[2] Again referring to the example of Germany, the CA is only able to search the premises of the involved firms after instituting fine proceedings which is a public procedure, in Bundeskartellamt (2012). *Effective cartel prosecution - Benefits for the economy and consumers.* p. 20

includes all the material that in case of court proceedings could be used against them. All colluding firms know how much evidence could have been collected at a maximum but it is privately known by each firm how much evidence it actually created and kept. The idea of giving firms private information on their own evidence was already introduced by Silbye (2010) who proposed a model where the CA offers a leniency rate based on this evidence to encourage the high-evidence firm to apply first. While the leniency rate itself is kept fixed in the following model, certain other features of Silbye's model will be included in the model set up by Harrington (2012).

Modeling Private Evidence

General Set-up

The following model describes a situation where a cartel between two firms has already ended and firms have to decide if they apply for a leniency program or not. If a firm applies it will have to pay the leniency share θ of the total fine F. If no firm applies for leniency the CA might still be able to uncover the cartel and make both firms pay a fine F. At this point firms learn about their collected evidence λ_i, $\lambda_i \in [\underline{\lambda}, \bar{\lambda}] \subseteq [0, 1]$.

In line with the work of Silbye (2010) this model will assume that the evidence one firm provides when applying will determine the likelihood of the other firm getting convicted, meaning that if firm i decides to make use of the leniency program firm j will be convicted with probability λ_i.

Having stated this, the range of $[\underline{\lambda}, \bar{\lambda}]$ can be described more specifically. The upper end of this range, namely $\bar{\lambda}$, will be very close or equal to 1 because the highest amount of evidence possibly collected will lead to a very high probability of conviction if revealed to the CA. The lower end $\underline{\lambda}$ on the other hand is very unlikely to be 0 as for colluding firms it is not possible to communicate without leaving any kind of evidence.

The evidence described in the variable λ will be positively correlated among firms. The more evidence they find for themselves, the more evidence the other firm could have collected. Taking the position of firm i firm j's evidence will follow a cumulative distribution function of $G(\lambda_j|\lambda_i)$ for which the following holds:

AI *$G(\lambda_j|\lambda_i)$ $(j \neq i)$ is continuously differentiable in λ_i and λ_j. If $\lambda'' > \lambda'$ then $G(\bullet|\lambda_i = \lambda'')$ strictly first-order stochastically dominates (FOSD) $G(\bullet|\lambda_i = \lambda')$.*

The probability of conviction, λ_0, derives from a degree of evidence that is available to the CA without any firm applying. Colluding firms will not be able to control and hide all evidence. Obvious changes in prices or the arrangement of meetings among partners in neutral places are examples for this openly available evidence. In addition, the CA can also gain information from other market participants who might be able to observe collusive patterns earlier than the CA. Firms refer to this risk of open evidence as $E[\lambda_0|\lambda_1, ..., \lambda_n]$, or $E[\lambda_0|\lambda_1, \lambda_2]$ for the case of $n = 2$ that is analyzed in the model. For this expectation on openly available evidence, assume that firms expect a high λ_0 for a high level of own evidence and by applying for leniency firms will contribute an amount of evidence greater than λ_0:

AII *$E[\lambda_0|\lambda_1, ..., \lambda_n]$ is continuously differentiable for every $i \in [1, ..., n]$, $\frac{\partial E[\lambda_0|\lambda_1,...,\lambda_n]}{\partial \lambda_i} \geq 0 \ \forall \ i$, and $E[\lambda_0|\lambda_1, ..., \lambda_n] \leq \lambda_i \ \forall \ i$.*

Public Evidence

When it is public knowledge to both firms how much evidence the other firm holds, then $E[\lambda_0|\lambda_1, \lambda_2]$ is obviously the same for both firms. The one stage decision problem of firms can be illustrated in a static game structure, as in Table 1 where firm 1 plays rows and firm 2 plays columns. In a first step, which is not displayed here, the actual values of λ_1 and λ_2 are realized. It is a dominant strategy for both firms to apply for leniency whenever $E[\lambda_0|\lambda_1, \lambda_2] > \theta$, which means that for a sufficiently high risk of getting convicted firms always strictly prefer to apply[3]. It is also a dominant strategy for firm i to remain silent whenever $E[\lambda_0|\lambda_1, \lambda_2] \leq \theta$ and $\lambda_j < \theta$.

For $E[\lambda_0|\lambda_1, \lambda_2] \leq \theta$ and $\lambda_1, \lambda_2 > \theta$ there are two equilibria and firms are essentially interested in choosing the same action as the other firm. If at least one's firm evidence is below θ, the other firm will strictly prefer to remain silent which accordingly leads to both firms rejecting leniency as they want to copy each other's actions.

So only for the case limited to $E[\lambda_0|\lambda_1, \lambda_2] \leq \theta$ and $\lambda_1, \lambda_2 > \theta$ is the behavior of firms not determined by dominant strategies. The tie between the two equlibria will be broken by selecting the Pareto-efficient equilibrium, which minimizes the expected fines for firms. Note that in the considered case

$$E[\lambda_0|\lambda_1, \lambda_2]F \leq \theta F < \frac{\lambda_2 + \theta}{2} F$$

for firm 1, which means that the expected fine from the equilibrium of both applying is higher than the expected fine from the equilibrium of none applying. The same is true for firm 2. So the Pareto-efficient equilibrium is given by the set of all pairs of (λ_1, λ_2) for which $E[\lambda_0|\lambda_1, \lambda_2] \leq \theta$, in other words it is Pareto-efficient for both to remain silent whenever this symmetric behavior is an equilibrium.

Summarizing these considerations for public evidence, the symmetric optimal strategy profile for firms is

$$\phi(\lambda_1, \lambda_2) = \begin{cases} \text{Apply} & \text{if } E[\lambda_0|\lambda_1, \lambda_2] > \theta \\ \text{Not apply} & \text{if } E[\lambda_0|\lambda_1, \lambda_2] \leq \theta. \end{cases} \tag{1}$$

[3]The second condition for this being a dominant strategy is actually $\lambda_2 > \theta$ for firm 1 (and $\lambda_1 > \theta$ for firm 2), but due to AII this condition is automatically fulfilled.

Private Evidence

Under evidence being private each firm faces a higher degree in uncertainty when evaluating the risk of being caught. Following Harrington (2012) this model will assume them to solve this uncertainty by acting according to a cut-off strategy. They do not apply for low values of evidence but prefer to apply when they observe high values of evidence because they deem it too risky to stay silent. The symmetric strategy profile can be formulated as

$$\phi(\lambda_i) = \begin{cases} \text{Apply} & \text{if } \lambda_i \in (x, \bar{\lambda}] \\ \text{Not Apply} & \text{if } x \in [\underline{\lambda}, x]. \end{cases} \tag{2}$$

Given this strategy the set of symmetric cut-off Bayes-Nash equilibria will be defined by certain values of x for which it is optimal for firms to follow the strategy ϕ whenever the other firm does the same.

If firm 2 commits to the cut-off strategy, applying for leniency will imply an expected fine for firm 1 as follows:

$$G(x|\lambda_1)\theta F + (1 - G(x|\lambda_1)) \left(\frac{E[\lambda_2|\lambda_1, \lambda_2 > x] + \theta}{2} \right) F. \tag{3}$$

The first part of this expected fine is the probability of firm 2 not applying, which is the case whenever $\lambda_2 \leq x$, multiplied by the leniency reduced fine that firm 1 will receive for sure in this case. In the second part firm 2 is applying as well and both firms have an equal chance of being the first and of receiving leniency.

On the other hand, the expected fine from not applying can be calculated in the same way and is

$$G(x|\lambda_1)E[\lambda_0|\lambda_1, \lambda_2 \leq x]F + (1 - G(x|\lambda_1))E[\lambda_2|\lambda_1, \lambda_2 > x]F. \tag{4}$$

Again the first part displays the expected fine if firm 2 does not apply for leniency, in which case both firms only face the risk of getting convicted due to openly available evidence, and the second part is the expected fine if firm 2 applies for leniency, which means that firm 1 will be convicted with probability $E[\lambda_2|\lambda_1, \lambda_2 > x]$.

Summing up the previous equations, firm 1 strictly prefers to apply whenever the expected fine from applying is lower than the expected fine from not applying, which is true whenever expression (4) is greater than expression (3) or

$$E[\lambda_0|\lambda_1, \lambda_2 \leq x] - \theta > -\left(\frac{E[\lambda_2|\lambda_1, \lambda_2 > x] - \theta}{2}\right)\left[\frac{1 - G(x|\lambda_1)}{G(x|\lambda_1)}\right]. \quad (5)$$

The difference between the risk due to openly available evidence and the leniency rate must be sufficiently large to make applying an optimal choice. According to this condition, applying is the optimal choice if the left hand side of the equation is positive (then the right side is negative due to AII) or if both sides are negative but the difference between the risk due to available evidence and the leniency rate is sufficiently small. For all other cases firm 1 will prefer to remain silent, especially for the case $E[\lambda_2|\lambda_1, \lambda_2 > x] < \theta$. So the optimal strategy profile can be rewritten as

$$\phi(\lambda_i) = \begin{cases} \text{Apply} & \text{if } \lambda_i \in (x, \bar{\lambda}] \text{ and } E[\lambda_2|\lambda_1, \lambda_2 > x] \geq \theta \\ \text{Not Apply} & \text{if } x \in [\underline{\lambda}, x] \text{or } E[\lambda_2|\lambda_1, \lambda_2 > x] < \theta. \end{cases} \quad (6)$$

For further analysis on the relevant cut-off values define

$$\Delta(\lambda_1, x) \equiv E[\lambda_0|\lambda_1, \lambda_2 \leq x] - \theta + \left(\frac{E[\lambda_2|\lambda_1, \lambda_2 > x] - \theta}{2}\right)\left[\frac{1 - G(x|\lambda_1)}{G(x|\lambda_1)}\right]. \quad (7)$$

Now it will be optimal to for firms apply for $\Delta(\lambda_1, x) > 0$. This function is increasing in λ_1[4] and therefore it is possible to determine x through the function $\Delta(x, x)$. If $\Delta(x, x) \geq 0$ then firm 1 will apply for every $\lambda_1 > x$ because then $\Delta(\lambda, x)$ will be positive for all values of $\lambda_1 > x$. With the same argumentation it holds that the firm will not apply for every value of $\lambda_1 < x$ iff $\Delta(x, x) \leq 0$. Therefore, x will be an equilibrium cut-off iff $\Delta(x, x) = 0$. For a better interpretation of the relevant values of x consider

$$\begin{aligned} \Phi(x) &= G(x|x)\Delta(x,x) \quad (8) \\ &= G(x|x)(E[\lambda_0|\lambda_1, \lambda_2 \leq x] - \theta) + \frac{E[\lambda_2|\lambda_1, \lambda_2 > x] - \theta}{2}(1 - G(x|x)). \end{aligned}$$

Again, applying will be preferred for $\Phi(x) > 0$, but this expression has the advantage that it gives a good illustration for when x takes the extreme values of $\underline{\lambda}$ or $\bar{\lambda}$. For the lower end $G(x|x)$ will be 0 which means that the difference between $E[\lambda_2|\lambda_1, \lambda_2 > x]$ and θ is essential when determining whether $\underline{\lambda}$ is an equilibrium cut-off. When the highest possible amount of evidence is considered as a possible threshold, then the opposite is the case and the difference between $E[\lambda_0|\lambda_1, \lambda_2 \leq x]$ and θ becomes essential for determining an equilibrium cut-off. In conclusion, the behavior of firms can be summarized as follows:

- If $\Phi(x) = 0$, x is an optimal symmetric cut-off value for firms when they follow a symmetric cut-off strategy. They will apply when they observe evidence with a value above this threshold and they will refrain from applying when their evidence is below this threshold.

- $\underline{\lambda}$ will be an equilibrium cut-off iff $E[\lambda_2|\lambda_1, \lambda_2 > \underline{\lambda}] \geq \theta$. Under public evidence firms apply whenever $E[\lambda_0|\lambda_1, \lambda_2] > \theta$. Due to AII the condition

[4] The sign of the derivative actually depends on the term $E[\lambda_2|\lambda_1, \lambda_2 > x] - \theta$, but after adjusting the strategy profile only the case of a positive derivative remains relevant for the further analysis of when firms are applying for leniency.

stated here under private signals is a weaker one. Note that if $\underline{\lambda}$ is not an equilibrium cut-off the only feasible equilibrium threshold will be $x = \bar{\lambda}$.

- $\bar{\lambda}$ will be an equilibrium cut-off iff $E[\lambda_0|\lambda_1, \lambda_2 \leq \bar{\lambda}] \leq \theta$, which is similiar to the condition for remaining silent under public evidence.

At this point it is not possible to strictly determine whether public or private evidence lead to more leniency applications. This would depend on how firms form their expectations on λ_0 and on the evidence of the other firm as can be seen by comparing $E[\lambda_0|\lambda_1, \lambda_2] - \theta > 0$ to condition (5). These inequalities capture the condition for applying and public and private evidence respectively. If firms strictly underestimate the evidence of the other firm ($E[\lambda_2|\lambda_1, \lambda_2 > x]$) the case of private evidence might even lead to less leniency applications. Nonetheless, the model under private evidence captures firms' fear of the other firm applying first and delivering its evidence to the CA. It also holds the possibility for an asymmetric behavior of firms, where one firm wishes to apply and the other to stay silent, if they receive different signals.

Conclusion and Discussion

The main purpose of this thesis was to get a better understanding on the kind of information that is private to each firm and to shed some light on what impact this might have on firms' behavior. Similar to the results of Hamilton (2012) this model does not make quantitative predictions on the effect of private evidence but incorporates the possibility of an asymmetric behavior of firms given their evidence. Furthermore the introduction of private evidence holds some potential for future research.

Private evidence provides a good starting point when thinking about transferring the model into a dynamic setting with several periods. The amount of evidence firms possess will naturally build up during periods of collusion, which means that actually an increase in λ_i can be expected until it reaches a critical point. Such a setting has the potential to explain firms' behavior as observed in the real world. Besides this, the model can also capture actions of the CA to influence firms' behavior as have been suggested in the literature.

In Silbye (2010) the CA makes use of private evidence by conditioning the leniency rate on the amount of evidence. In the present model it would also be possible to introduce a leniency scheme based on firms' evidence to reward high evidence firms. This would not only encourage firms to keep evidence but would also encourage high evidence firms and discourage others. That would enable the CA to reach the cartel member with the highest evidence and hence to increase its chances on convicting all cartel members.

Sauvagnat (2010) suggests the CA to have some private information on the probability of a successful conviction. He allows the CA to 'bluff' in some cases where conviction without leniency is highly unlikely. This would affect firms' expectations on λ_0 because the start of an investigation then means that with some probability the CA already has enough evidence for a conviction.

Finally Harrington (2012) proposes a more active behavior of the CA, in which it purposely leaks information to only one firm to actively create private information among firms. Here this would result in different values of $E[\lambda_0|\lambda_1, \lambda_2]$ among firms.

These examples show that the model developed in this thesis might serve as a framework for future leniency analysis. It enables the incorporation of several real-world features, that can potentially lead to well-founded policy implications.

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Appendix

Tables

	apply	not apply
apply	$\frac{\lambda_2+\theta}{2}F,\ \frac{\lambda_1+\theta}{2}F$	$\theta F,\ \lambda_1 F$
not apply	$\lambda_2 F,\ \theta F$	$E[\lambda_0\vert\lambda_1,\lambda_2]F,\ E[\lambda_0\vert\lambda_1,\lambda_2]F$

Table 1: Game illustration for public signals in the modified model