On leniency and markers in antitrust

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Abstract
We investigate the impact of marker system on the effectiveness of leniency programs to deter unlawful collusion. Assuming that the likelihood of conviction is increasing in the number of reporting firms, optimal cartel deterrence requires the competition authority to obtain all the available evidence. Then we show that the introduction of the marker system has an ambiguous impact on cartel deterrence. In relation to the manner that the marker is secured and the cartel-related evidence is allocated, we derive the conditions under which allowing the first applicant to secure a marker enhances cartel deterrence. If the marker is again available once its holder failed to complete the leniency application, the introduction of a marker never enhances cartel deterrence. In the contrary, if the marker is permanently lost following a denial to report by the first marker recipient, such a system may act as a mechanism that facilitates reporting by cartel members.

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1. Introduction

Leniency Programs (hereafter LPs) aim to improve cartel deterrence by offering fine reductions to cartel members that either voluntarily self-report before there is even an investigation, or report and cooperate during investigation. Post-investigation leniency aims to evidence acquisition for an already spotted cartel to be convicted. It has also an important impact on the pre-investigation stability of the cartel, affecting firms’ decision to enter in a collusive agreement.

The marker system allows a number of reporting parties to reserve their position in queue for a specified period of time. The marker removes the uncertainty for the leniency applicant about the existence of other informants and its exact position in reporting line. According to OECD (2014) the majority of jurisdictions of OECD countries seem to have some kind of marker system. Most of them (including EC) restrict the availability of markers to the first reporting party, while others (including Canada, France, Germany, UK etc) offer this possibility to subsequent applicants as well.

A common assumption in the related literature is that cartel members possess similar evidence, thus even when one participant reveals, the infringement is convicted with certainty. This implies the uselessness of any additional reporting to strengthen the Antitrust Authority’s (AA) ability to prove the putative infringement. However, as Blatter et al. (2017) points out, firms may have incomplete pieces of evidence with the total evidence to be cumulative and each single reporting to render conviction only more likely. In addition, OECD (2012) states that “authorities are likely to find themselves in situations where, while aware of the existence of a cartel as a result of a leniency application by the first applicant, they are not yet in a position to prove the infringement”.

In this paper, we assume that the evidence brought by additional informants has some added value, rather than being a mere corroboration of the evidence offered by the first informant. This assumption has some interesting implications. Inducing a single firm to report does not imply that all its partners have also sufficient incentives to do so, as well. If the leniency is not generous enough, some firms may prefer to remain silent and avoid reporting in an attempt to restrain the conviction likelihood. We show that cartel deterrence requires the LP to provide incentives for universal reporting, i.e. the AA should obtain all the available evidence.
The impact of marker system on the effectiveness of LP is studied in Blatter et al. (2017). Assuming imperfect and asymmetric evidence in a duopoly and restricting leniency to the first informant, they show that under the marker system only one firm reports with the second in line to retreat and Antitrust Authority (AA) not to obtain all the available evidence. They show that the marker system increases the deterrence cost unless firms possess sufficiently asymmetric evidence.

Here, we show that the impact of the marker system on the effectiveness of a LP to deter cartel activity crucially depends on the manner that the marker is available. We show that if the marker is available once its holder failed to complete the leniency application, the introduction of a marker never enhances cartel deterrence. In the contrary, if the marker is permanently lost following a denial to report by the first marker recipient, such a system may act as a mechanism that facilitates reporting by cartel members.

The rest of the paper is organized as follows: The model is described in the next section. In section 3 we analyze the benchmark case in the absence of marker system. In section 4 we introduce the marker. Section 5 concludes.

2. The model

Consider \( N \) symmetric firms producing a homogeneous good and competing in prices for an infinite number of periods. Each firm maximizes the expected sum of future discounted profits using a common discount factor \( \delta \in (\frac{1}{2}, 1) \).\(^1\) In each period firms choose between competing and colluding

- If all firms cooperate setting the collusive price, each one earns \( \pi = 1 \).
- When one firm unilaterally deviates from the agreed price, it receives \( N \) while the others get zero.
- The competitive profits are zero.

The Antitrust Authority (AA) investigates each industry with probability \( \alpha \in (0, 1) \).\(^2\) The launch of an investigation does not necessarily imply that guilty firms are convicted; conviction demands a sufficient amount of evidence to be gathered.

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\(^1\) For \( \delta < 0.5 \) collusion is not sustainable even in the absence of antitrust policy.

\(^2\) Using data from DoJ price-fixing cases, Bryant and Eckhart (1991) estimated the probability of cartel detection to be between 0.13 and 0.17 in a given year. Combe et al. (2008) estimated the same probability over a European sample to be around 0.13.
Concentrating only on cases where firms have indeed formed a cartel, we assume that, despite the infringement, the prosecution outcome is uncertain, with the probability of conviction being non-decreasing in the amount of available evidence. We measure evidence by the change in probability of conviction that it induces. Any evidence that is a mere repetition of evidence already in the possession of the AA does not increase the probability of conviction; it is therefore considered as redundant.

The total amount of cartel-related evidence is decomposed in two parts: common evidence, denoted by \( z \), possessed by every participant, and pieces distributed symmetrically among firms, each one possessing an amount \( \Delta \rho = \frac{1-z}{N} \). We assume that AA’s actions unveil only a part of each type of evidence. This evidence determines the probability of conviction when no firm confesses:

\[
\rho_0 = \lambda_1 z + \lambda_2 N \Delta \rho \quad \text{with} \quad 0 \leq \lambda_h \leq 1, \ h = 1,2.
\]

For simplicity, we assume that \( \lambda_1 = \lambda_2 \), i.e. that the evidence unveiled by the AA’s efforts consists of equal portions of both common and firm-specific evidence.\(^3\)

Following a successful investigation each convicted firm is pays a fine \( \mu \), where \( \mu \geq 1 \).\(^4\) An LP allows a cartel participating firm to provide evidence related to the existence of the cartel after the investigation opening, in exchange for a fines reduction. The common share of the additional evidence is provided only once by the firm that is the first in line to testify. The latter increases the probability of conviction by \( (1 - \rho_0)z \), in addition to any exclusive piece the first informant may present. When more firms confess, one’s exclusive evidence renders the conviction more likely by \( (1 - \rho_0) \Delta \rho \). Hence, when \( n \in [1, N] \) firms report, the probability of conviction becomes:

\[
\rho_n = \rho_0 + (1 - \rho_0)(z + n \Delta \rho)
\]

When confessing, eligible-for-leniency firms receive a fine reduction proportional to their individual contribution to cartel prosecution, i.e. the reduced to full rate fine is:

\[\text{3 Assuming that } \lambda_1 \neq \lambda_2 \text{ produces qualitatively similar results.}\]

\[\text{4 Bageri et. al (2013) shows that fines on revenues result in higher collusive prices that fines on illegal gain. Further, Katsoulakos et al. (2015) shows that fines based on illegal profits are welfare superior to fines on revenues. The US (federal) fines correspond to no more than double damages while other jurisdictions allow for up to treble damages, see Harrington (2014). A reasonable assumption for the value of } \mu \text{ is that } \mu \in [2,3].\]
\[ y_1(k) = \frac{1 - \rho_0 - k(1 - \rho_0)(z + \Delta \rho)}{1 - \rho_0} = 1 - k(z + \Delta \rho) \]

for the first informant

\[ y(k) = \frac{1 - \rho_0 - (1 - \rho_0)z - k(1 - \rho_0)\Delta \rho}{1 - \rho_0 - (1 - \rho_0)z} = \frac{N - k}{N} \]

for any subsequent eligible applicants. Both \( y_1 \) and \( y \) lie between 0 and \( \mu \), i.e. we exclude any possibility for rewards. The parameter \( k \) measures how additional information is valued by the AA, and thus determines the generosity of the leniency offered to each eligible informant.\(^5\)

A firm’s decision on whether to come forward and provide evidence crucially depends on that firm’s perception about its position on the priority line. The accuracy of this perception depends in turn on the AA’s information-diffusion policy. With respect to the latter, we examine two alternative systems: in the first, as the investigation goes on no firm is aware of its position on the priority line. Hence, when deciding on whether to come forward and provide evidence, any firm is uncertain about the treatment it will receive. If it decides to confess, it expects to be the first eligible-for-lenience with some positive probability less than one.

In the second system, called “marker”, the arrival of the first applicant is public knowledge while subsequent applicants know only that they will not occupy the first position. In relation to the latter, a marker could be or could be not transferred to another potential applicant, once a previous one has refused to confess. Here we consider all the aforementioned cases.

The timing of the game is as follows:
- Each firm chooses whether to collude or not
- If a cartel agreement is in effect, each firm chooses between staying loyal or defecting from it
- A deviation from the collusive price implies that the market will be competitive ever after
- The AA investigates the industry with probability \( a \)
- In case of investigation, each cartel participant chooses between reporting or not.

\(^5\) As we restrict leniency to non-negative fines the parameter \( k \) is bounded from above: \( y_1(k) \geq 0 \) \( \iff k \leq \bar{k} \equiv \frac{N}{1 + z(N - 1)}. \)
The reporting decision may be simultaneous, when the AA follows the full-secrecy system, or sequential in a random order, when the AA follows a marker system. Focusing on the deterrent impact of leniency policies, we make the simplifying assumption that the start of investigation implies the definite dissolution of the collusive agreement, regardless of the outcome of the inspection. Therefore, following an investigation, firms compete forever.\(^6\)

- Finally, the cartel is convicted with probability \(\rho_n\).\(^7\)

### 3. Benchmark: no marker

In this section we investigate the incentives of firms to collude under the benchmark -no marker- regime. Following the launch of an inspection, firms decide whether to remain silent or to report the agreement and the reporting decision is taken simultaneously by all firms.\(^8\) If a firm thinks that a number, say \(n - 1\), others are about to come forward and decides to withhold evidence, it expects to pay the full fine and no fine with probability \(\rho_{n-1}\) and \((1 - \rho_{n-1})\) respectively. Reporting, on the other hand, reduces that period’s profit by a percentage \(\rho_n \bar{g}_n\), with \(\bar{g}_n = \frac{\gamma_1 + (n-1)}{n}\) to represent the expected fine in case of confession. The latter is the best reply to \(n - 1\) other firms choosing to report when:

\[
1 - \rho_n \mu \bar{g}_n \geq \rho_{n-1}(1 - \mu) + 1 - \rho_{n-1}
\]

**Lemma 1** In case of investigation, for every \(n \in [2, N]\) the incentive to report is monotonically decreasing in the number of other informants.

**Proof**

See Appendix. ■

Rearranging (2) yields that \(n\) firms report when the expected leniency is sufficiently generous:

\(^6\) Alternatively, assuming that the permanent interruption of the illicit activity requires successful prosecution produces qualitatively similar results.

\(^7\) Whether the investigation leads to conviction or not, we assume that the AA monitors the investigated market for an infinite number of periods, forcing firms to compete for ever after.

\(^8\) Simultaneous reporting is meant to represent that before deciding whether to confess, a firm must “guess” how many others are about to report. “Guessing” correctly is equivalent to assuming that during the reporting process each potential whistleblower is notified about the number of the other reporting parties and taking this into account decides its action. At the end of the reporting phase, the names of those eligible for leniency are determined randomly.
Lemma 2 An equilibrium of the subgame where $n \in [2, N]$ firms report exists when:

$$k \geq k_n^0 \equiv \frac{Nn(1 - z)}{[1 + (n - 1)z][n(1 - z) + N(z + \theta)]}$$

with $\theta = \frac{\rho_0}{1 - \rho_0}$

According to lemma 1 a firm’s incentive to report is reduced when the number of other firms that this firm thinks they also have decided to come forward increases. However, lemma 1 does not apply to the unique informant: Because the first informant offers all the common evidence the effect in terms of conviction probability are greater. When the latter creates a sufficiently strong disincentive, universal non-reporting is equilibrium. If a firm reports assuming that no other does so, it expects to pay the reduced fine with probability $\rho_1$, and to receive nothing thereafter. If it chooses to remain silent, it expects to pay the full fine with probability $\rho_0$ and no fine otherwise. Reporting is the best reply to all other firms remaining silent when:

$$1 - \rho_1\gamma_1(k) \geq (1 - \rho_0) + \rho_0(1 - \mu)$$

(3)

Rearranging (3) yields the minimum $k$ above which a firm chooses to confess as the unique informant:

Lemma 3 Universal non-reporting is equilibrium of the investigation subgame when:

$$k < k_1^0 \equiv \frac{N(1 - \rho_0)}{1 + (N - 1)(z + \rho_0 - z\rho_0)}$$

The above is the minimum amount of leniency that makes reporting the best reply to all others remaining silent. If the LP provides sufficient incentives for a single informant to come forward, reporting by additional informants is not certain: as they possess pieces of evidence not available to the first informant and therefore conviction likelihood is not 1, others may decide to withhold their exclusive piece of information.

Lemma 4 For $k = \max\{k_1^0, k_0^0\}$ at least $n$ firms reveal under investigation.

Proof

See Appendix.

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9 When thinking that no other firm has decided to confess, a firm may decide not to come forward even if it would have done so under the assumption that some another firm has already decided to confess.
As the valuation of the provided information will be equal for all firms that simultaneously report, when $k^0_i \geq k^0_N$, i.e. when

$$z \geq z_a \equiv \frac{\sqrt{4N-3+4(N-1)((N-1)\rho_0-(1-\rho_0))}-2(N-1)\rho_0-1}{2(N-1)(1-\rho_0)} \text{ or } \rho_0 \leq \bar{\rho}_0 \equiv \frac{z[1+(N-1)z]}{(1-z)^2(N-1)}$$

offering $k = k^0_N$ is not be enough to induce universal reporting. In such case setting $k = k^0_i$ for the first in line induces reporting by every cartel participant. This implies that when evidence brought by the first comer increases significantly the conviction rate, inducing the unique informant to come forward is enough to trigger a race to report by all firms. Otherwise, even if some firms report, others may find it preferable to hold back.

**Corollary** Inducing the unique informant to report triggers reporting by every firm when

$$\rho_0 \leq \bar{\rho}_0 \text{ or when } z \geq z_a$$

Otherwise the same outcome requires $k = k^0_N$ to be offered.

Consider that $k^0_N > k^0$, therefore the AA needs to offer $k = k^0_N$ in order to induce post-investigation reporting by $n$ parties. Initially, each participant expects to earn the collusive profits and, in case of successful -with probability $\rho_n$- investigation, to pay the full fine with probability $\frac{N-1}{N}$ or the reduced fine with probability $\frac{1}{N}$. Therefore, the value of collusion where $n$ firms report under investigation is:

$$V^0_n = \frac{1 - a^2/\mu_2(k^0_n)}{1 - \delta(1 - a)}$$

with $\hat{\gamma}(k^0_n) = \frac{r_1(k^0_n)+1}{N}$

The following lemma determines the optimal number of firms induced to report under investigation:

**Lemma 5** Optimal ex-ante deterrence requires the AA to obtain all the available evidence.

*Proof*

See Appendix.

Let us now define strategy $C$ of the entire game as the usual trigger strategy with the additional feature of dictating to remain silent in case of investigation. A firm that plays $C$ expects with probability $1 - a$ to keep receiving the collusive profits, and
with probability $a \rho_0$ to pay the fine $\mu$, and keep receiving the competitive profit for an infinite number of periods. The value of $C$ is therefore:

$$V^C = (1 - a)(1 + \delta V^C) + a[(1 - \rho_0) + \rho_0(1 - \mu)]$$

Solving for $V^C$ yields:

$$V^C = \frac{1 - a \rho_0 \mu}{1 - \delta(1 - a)}$$

When $k_1^0 \geq k_n^0$ promising $k = k_n^0$ to the first reporting firm, is not enough to induce any reporting: as $V^C > V_n^0$ holds for every $n \in [1, N]$, firms select to coordinate on the most profitable $C$ which entails that no one confesses under investigation. Hence, when $z \geq z_\alpha$, offering $k = k_1^0 > k_N^0$ to the first informant induces reporting by every participant. In this case the value of the cartel becomes:

$$\tilde{V}_N^0 = \frac{1 - a \mu y_1(k_1^0) + (N - 1)}{1 - \delta(1 - a)}$$

4. Marker

Consider that the first-to-door can be aware of its position in line, while all subsequent firms are aware of the existence of at least one informant but they are not able to infer their precise position. We distinguish two sub-cases. In the first, if a marker holder denies confessing, the marker is transferred to the next in the priority line. Second, a reluctant-to-confess marker holder implies the permanent loss of the marker for the particular reporting process.\textsuperscript{10}

4.1Scrolling marker

Let us describe the case where the marker is transferred to the next applicant when a previous holder chooses to remain silent. Assuming that reporting by one party becomes common knowledge, the existence of subsequent applicants requires that some lenient treatment should be expected for the $n - 1$ remaining informants. Each one of them has sufficient incentives to report when the value of reporting, given that it receives lenient treatment with equal likelihood, exceeds the value of remaining silent. When the latter occurs each one expects that it will pay the full fine with probability $\rho_{n-1}$:

\textsuperscript{10} Further, we assume that when the marker holder denies confessing, this firm has no possibility to report later in the reporting process.
\[ \rho_{n-1} \geq \rho_n \frac{\gamma(k) + (n-2)}{n-1} \]

which yields

\[ k \geq k_n \equiv \frac{N(n-1)(1-z)}{[n(1-z) + N(z + \theta)]} \]

Observe first that \( k_n \) always decreases with \( z \) which implies that when additional reporting has less impact on the conviction rate, less leniency should be awarded. Second, that as for \( \gamma(k) \geq 0 \), \( k \leq N \) must hold and \( k_n \leq N \) always holds, just offering \( k = k_n \) to one subsequent applicant, is enough to induce reporting by the targeted number of informants.

The following lemma defines the necessary treatment for the marker recipient to report:

**Lemma 6** Assuming a regime that offers a transferrable marker to the first-to-door applicant, the latter requires at least \( k = k^0_1 \) in order to come forward.

**Proof**

See Appendix. ■

When enough incentives are given for \( n \) firms to report under investigation, each one anticipates, at the time of decision regarding the participation in the infringement, that with probability \( \frac{1}{N} \) it will be the first to confess and with probability \( \frac{1}{N} \) that it will be the subsequent eligible applicant. The value of collusion where \( n \) firms report under investigation is:

\[ V_n^1 = \frac{1 - a\rho_n\mu\gamma(k^0_1, k_n)}{1 - \delta(1-a)} \]

with \( \gamma(k^0_1, k_n) = \frac{\gamma_1(k^0_1) + \gamma(k_n) + (N-2)}{N} \)

The next proposition states that the transferable marker always decreases the overall expected fine, a fact that hurts deterrence compared to the benchmark:

**Proposition 1** Consider that the AA offers a transferable marker to the first in line applicant:

i. In order to improve ex-ante cartel deterrence, it is always optimal to offer sufficient incentives that induce reporting by all firms, i.e. the AA should obtain all the available evidence. Necessary for the latter is to offer sufficient leniency to at least one subsequent applicant.
ii. *It is always superior in terms of cartel deterrence to maintain the uncertainty among cartel participants, regarding their position in reporting line.*

Proof

See Appendix.

Despite that \( \gamma(k_n) < \mu \), i.e. the total amount of fines is decreased in order to induce multiple firms to confess, the increase of the conviction rate outweighs this effect and the value of collusion is lower when \( n \) firms report than when only one does the same, i.e. \( V_n^i \leq V_1^i \). Further, we show that it is optimal to set \( n = N \) which yields a value of collusion equal to \( V_N^i \).

The above provides an argument that supports the European system’s practice to extend the eligibility to subsequent applicants. The DoJ’s LP restricts the eligibility to the first informant which implies that only a single firm’s evidence is obtained. On the other side, the European system manages to detach evidence from multiple firms, a fact that seems to improve not only the cartel detection and the collection of fines but cartel deterrence as well.

The previous analysis also implies that the more a potential whistleblower knows about its position in reporting line, the more expensive its testimony becomes. Thus, the no marker regime requires a lower level of leniency in order to achieve the same outcome, i.e. universal reporting: preventing firms to predict the reporting outcome enhances ex-ante deterrence and firms have lower incentives to form a cartel at first.

4.2 Non-scrolling marker

Let us now analyze the case where the marker is withdrawn once the marker holder denies confession. Assume that the AA provides the incentives to the \( n - 1 \) subsequent parties to come forward, following a confession by the first in line, i.e. \( k = k_n \) is offered to one additional applicant.

**Lemma 7** Assuming a regime that offers a non-transferable marker to the first-to-door applicant; inducing universal reporting is always optimal.

Proof

See Appendix.

\( ^{11} \)The latter holds for every positive \( k \) and \( k_n \) is always positive.
Note that $k_N > k_1^{0}$ and $k_N > k_N^0$ hold for

$$z < z_b = \frac{N - 2 + \sqrt{N^2 + 4 + N - 8(1 - \rho_0) - 4\rho_0 - 2(N - 1)\rho_0}}{2(N - 1)(1 - \rho_0)}$$

and

$$z > z_e = \frac{1}{(N - 1)^2}$$

respectively. The following proposition compares the deterrent impact of the marker and the no marker systems once the marker is lost after its holder’s decision to withhold the evidence it possesses:

**Proposition 2** Consider a non-transferable marker system:

i. for $z_e < z < z_a$, the no marker and marker systems produce similar results in terms of ex-ante deterrence

ii. for $z_a < z < z_b$, the marker system enhances ex-ante deterrence compared to the no marker system

iii. for $z_b < z$ the no marker system is superior in terms of ex-ante deterrence compared to the marker system

**Proof**

See Appendix.

The minimum $k$ that makes the first to come forward when $z > z_b$ ($k_N^{1'} = \frac{N(1 - \rho_0)}{1 + z(N - 1)}$) is always higher than $k_N^1 = \frac{(1 - z)(1 - \rho_0)}{1 + z(N - 1)}$ which induces confession by the marker holder when $z < z_b$. At the same time per unit valuation of evidence for any subsequent informant is larger than $k_N^1$ and the expected fine for any subsequent applicant is equal to that of the first:

$$y_1(k_N^{1'}) = \frac{y(k_N) + (N - 2)}{N - 1}$$

Therefore, the actual reduced fine that each eligible subsequent applicant pays is always lower to that of the marker holder, when $z < z_b$. The certainty that the marker

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12 The threshold $z_b$ defines the level of $z$ above which subsequent firms, that face a situation where the marker recipient denies to report, select between two types of equilibria: first an equilibrium where everyone but one confesses and second the universal non-reporting equilibrium.
creates for the latter renders this applicant less demanding in terms of the necessary leniency.

All the previous analysis implies that if the probability of unassisted conviction is not very low the marker holder has strong incentives to come forward, when all the others are going to do the same regardless of what the first in line decides. If further \( z_a < z \), which implies that under the no marker regime the first-to-door requires \( k_1^0 > k_N^0 \) to come forward, the marker acts as a mechanism that induces this firm to compromise with a lower level of leniency, that is \( k_N^1 \). This results in a value of collusion which is lower under the marker system. When \( z_b < z \) the marker holder recognizes the gravity of its reporting, as remaining silent implies universal non-reporting: confession by this firm needs a more generous treatment to be offered, a fact that raises the value of collusion, reducing the overall level of expected fines and finally stabilizing the collusive agreement.

Furthermore, we consider useful to briefly discuss the robustness of the last result with respect to the assumption that \( k_n \) is offered to each subsequent applicant, even when the marker holder has decided to remain silent. If instead we suppose that \( k_{N-1}^0 \) or \( k_1^0 \), depending on the level of \( z \), is offered to one informant in the latter case, everyone of the \( N-1 \) others is induced to confess following the marker recipient’s denial. Hence, \( k_N^1 \) is always enough to persuade the marker holder to report and the marker regime produces at least equal deterrent results with the no marker system. In fact, for every \( z > z_a \) the former always dominates in terms of ex-ante deterrence while for \( z \leq z_a \) both systems are equivalent.

In the graph below the black, dashed and dotted lines represent the value of the cartel under the no marker, the non-scrolling and the scrolling marker system respectively, for the following values of the parameters: \( a = .15, \mu = 2, \delta = .9, N = n = 4 \) and \( \rho_0 = .7 \). The common share of evidence \( z \) is on the horizontal line. For \( z < z_a = .38 \) the value of collusion under the no marker, the non-scrolling marker systems coincide. For \(.38 < z < z_b = .64 \) the value of the cartel under the non-scrolling marker is lower, while for \( z > .64 \) the no marker system is superior. Comparing the two marker systems, the non-scrolling results in higher deterrence when \( z < .64 \). For every \( z \) the scrolling marker produces worse deterrent results compared to the no marker.
5. Concluding remarks

Transparency and certainty have been highlighted as crucial parameters that should be taken into consideration for the implementation of the LP. ICN (2014) mentions that “a leniency applicant needs to be able to foresee with a high degree of certainty how it will be treated if it reports anticompetitive conduct and what the consequences will be if it does not come forward”.

The adoption of a marker system succeeds to eliminate the uncertainty, at least for the first-to-come applicant, reserving for the latter a position in line that secures its eligibility for a given lenient treatment. Here we show that offering information to applicants about the availability of leniency affects the effectiveness of the LP, depending on the way that the marker is secured: if the latter is repeatedly obtainable, regardless of the reporting decision by the holder, the marker system requires higher level of fine reductions. This increases the profitability of collusion and therefore it hurts deterrence. Otherwise, a marker that is not transferable in case of failed-reporting by the holder could induce universal reporting with the first applicant to require leniency equal to the expected leniency offered to any subsequent informant. In such case the marker acts as a mechanism that induces confession in instances where in the absence of it reporting would require more generous fine reductions to be offered.

References

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### Appendix

**Proof of lemma 1**

Subtracting the RHS of (2) from the LHS and simplifying we obtain:

\[ \varphi = (1 - \rho_n \mu \hat{y}_n) - (1 - \rho_{n-1} \mu); \]

Substituting \( \rho_n \) and \( \hat{y}_n \) into \( \varphi \) yields

\[ \varphi = \mu \frac{k[1 + (N - 1)z][N(z + \rho_0 - z\rho_0) + n(1 - z)(1 - \rho_0)] - Nn(1 - z)(1 - \rho_0)}{N^2 n} \]

Taking the derivative with respect to \( n \) yields

\[ \frac{\partial \varphi}{\partial n} = \frac{-k \mu [1 + (n - 1)z][\rho_0 + (1 - \rho_0)z]}{N^2 n} < 0. \]

**Proof of lemma 4**

When \( k_1^0 \geq k_n^0 \) holds, offering \( k = k_n^0 \) implies that either \( n = 0 \) or \( n \) firms confess. As we will show later when presenting the equilibrium of the game, the cartel with no reporting parties is always more profitable than any other cartel. Assuming that firms
select the most profitable collusion, reporting by \( n \) parties requires \( k = k_1^0 \) to be offered. When \( k_1^0 < k_n^0 \), the latter is not sufficient and \( k = k_n^0 \) should be offered for the same outcome to be achieved.

Proof of lemma 5
Substituting for \( \gamma_1(k_n^0) \) and \( \gamma(k_n^0) \) into \( V_n^0 \) yields
\[
V_n^0 = \frac{N^2[1 - a\mu(z + \rho_0 - z\rho_0)] - an(1 - z)\mu(1 - \rho_0)(N - 1)}{N^2[1 - \delta(1 - a)]}
\]
Note that \( \frac{\partial V_n^0}{\partial n} = -\frac{a(N-1)\mu(1-z)(1-\rho_0)}{N^2[1-\delta(1-a)]} < 0 \), i.e. the value of the cartel is decreasing in the number of reporting firms. Hence, it is always optimal to set \( n = N \), i.e. to induce reporting by every cartel participant.

Proof of lemma 6
Consider that \( N - 1 \) marker holders have already denied to confess. Also, the incentive to report for a marker holder always increases with the number of other reporting parties:
\[
\frac{\partial(\rho_{n-1} - \rho_n\gamma_1)}{\partial n} = \frac{k\mu(1-z)(1-\rho_0)[1+(n-1)z]}{n^2}
\]
The \( N^{th} \) firm that has the opportunity to benefit from the marker confesses if (3) is satisfied. Otherwise, it remains silent and every previous marker recipient knows that its reporting implies a conviction rate at least equal to \( \rho_1 \) while remaining silent entails a conviction rate equal to \( \rho_0 \). Hence, if the last in line is not to report as the unique informant, no other has any incentive to come forward as a marker holder. If \( k \geq k_1^0 \) is offered to this applicant, every previous marker holder has no incentive to withhold its evidence, even if the action of its reporting entails a probability of conviction equal to \( \rho_n \). Therefore, \( k = k_1^0 \) is necessary for at least one informant to exist and sufficient to persuade any marker holder to confess.

Proof of proposition 1
Substituting for \( \gamma_1(k_n^1) \) and \( \gamma(k_n^1) \) into \( V_n^1 \) and taking the derivative with respect to \( n \) yields
\[
\frac{\partial V_n^1}{\partial n} = \frac{a(1-z)(1-\rho_0)[-N(1+(N-3)x)-(N-2)(N-1)(1-z)+2(1-z-\rho_0)]}{N^2[1-\delta(1-a)][1+(N-1)(x+\rho_0-z\rho_0)]} \leq 0
\]
As the value of the cartel reduces with the number of reporting parties, it is always optimal to set \( N = n \), i.e. to induce reporting by all firms. At the same time \( V_1^i > V_1^n \) holds for every \( \rho_0 \in [0,1] \). Then, it can be easily inferred that \( V_1^n < V_N^n \) and \( V_1^n < V_{N-1}^0 \).

**Proof of lemma 7**

If the marker holder decides to come forward the cartel is convicted with probability \( \rho_n \). In the contrary, if it remains silent and assuming that no marker is available, at most \( N - 1 \) firms are induced to come forward. Under the rationale of the previous section the best case in terms of deterrence is all but one to report with the value of the cartel to be equal to \( V_{N-1}^0 \).

Reporting by the marker holder implies conviction rate equal to \( \rho_n \), while if remaining silent conviction takes place with probability \( \rho_{n-\nu} \), with \( \nu \in [0,n] \). Therefore the marker holder has enough incentives to confess when:

\[
1 - \rho_n \gamma_1(k) \geq (1 - \rho_{n-\nu}) + \rho_{n-\nu}(1 - \mu)
\]

which is equivalent to

\[
k \geq k_{1,n}^n = \frac{\nu N (1 - z)}{(1 + z (N-1)) [n (1 - z) + N (z + \theta)]}
\]

Substituting \( k = k_{1,n}^n \) into \( \gamma_1(k) \), we obtain the corresponding value of the cartel:

\[
V_{1,n}^n = \frac{1 - a \rho_n \gamma_1(k_{1,n}^n) + \gamma(k_n) + (N - 2) \mu}{1 - \delta (1 - a)}
\]

As \( \frac{\partial V_{1,n}^n}{\partial n} = - \frac{a (N-1) (1-\rho) (1-\rho_n)}{N^2 (1-\delta (1-a))} < 0 \) and \( V_{1,n}^n < V_{N-1}^0 \) it is optimal to provide \( k = k_{1,n}^n \) for the marker holder and \( k_n \) to one subsequent applicant.

**Proof of proposition 2**

First, \( z_e < (>) z_a < (>) z_b \) holds for \( \rho_0 > (\leq) \frac{1}{N(N-2)z} \). Also \( k_N \geq k_{N-1}^0 \) holds for every \( z \in [0,1] \), thus the \( N - 1 \) subsequent confess even if the marker holder remains silent. Consider that \( \rho_0 > \frac{1}{N(N-2)z} \). For \( z < z_b \) the marker holder knows that remaining silent implies that \( N - 1 \) others are going to report and its incentive to confess is:

\[
(1 - \gamma_1(k)\mu) \geq (1 - \rho_{N-1}) + \rho_{N-1}(1 - \mu)
\]

which yields
\[ k \geq k_N^1 = \frac{(1 - z)(1 - \rho_0)}{1 + z(N - 1)} \]

For \( z_e < z < z_b \) the value of the cartel becomes

\[ 1 - a\mu\hat{y}(k_N^1, k_N) \]

\[ \frac{1}{1 - \delta(1 - a)} \]

with \( \hat{y}(k_N^1, k_N) = \frac{\gamma_1(k_N^1) + \gamma(k_N) + (N-2)}{N} \), which coincides with \( V^0_N \). Therefore, under the scrolling marker the collusive value is equal to the value of the cartel under the no marker regime for \( z < z_b \). For \( z_a < z < z_b \) the collusive value under the no marker system is \( \tilde{V}_N^0 > V^0_N \).

If \( z > z_b \) the unique marker holder recognizes that remaining silent implies that firms will coordinate on the most profitable \( V^c \) and that the conviction probability will be \( \rho_0 \). The marker holder confesses only if

\[ 1 - \gamma_1(k)\mu \geq 1 - \rho_0 + \rho_0(1 - \mu) \]

which yields

\[ k \geq k_N^{1f} = \frac{N(1 - \rho_0)}{1 + z(N - 1)} \]

with the value of the cartel to be

\[ \tilde{V}_N^{1f} = \frac{1 - a\mu\hat{y}(k_N^{1f}, k_N)}{1 - \delta(1 - a)} \pi \]

with \( \hat{y}(k_N^{1f}, k_N) = \frac{\gamma_1(k_N^{1f}) + \gamma(k_N) + (N-2)}{N} \), which is always higher than both \( \tilde{V}_N^0 \) and \( V^0_N \).