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Collusion, antitrust policy, leniency programs, multimarket contact, organizational form

JEL codes:

K42, L22, L41

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November 18, 2024

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1 Introduction

Leniency programs usually grant complete amnesty to a firm that reveals a cartel unknown to competition authorities. However, if an inquiry is underway, the penalty fine reduction hinges on the firm's perceived contribution to the investigation. Hence, firms may have an interest in taking preventive action to slow down the progress of a potential future investigation. This way, if firms seek leniency and cooperate, the information they provide to competition authorities appears more significant. The idea we advocate in this article is that multiproduct firms engaged in collusion across multiple markets simultaneously might benefit from adopting a decentralized organization. This strategy aims to slow down antitrust investigations targeting one of the cartels in which they are involved, granting them the time to seek leniency for the other cartels before competition authorities uncover them. The existence of a leniency program can thus influence the choice of internal organization for firms and encourage them to adopt a decentralized structure.

Our study is not the first to examine the links between collusion across multiple markets and firms' internal organization. However, we introduce a new mechanism. Previous literature has primarily focused on the impact of firms' internal organization on the likelihood of discovering other cartels (Dargaud and Jacques 2015, 2020; Jacques 2023).¹ Decentralization is chosen by firms to try to protect their other cartels by compartmentalizing them, aiming to prolong their existence or avoid multiple convictions. When the goal is to conceal other cartels, the introduction of a leniency program can thwart this attempt at compartmentalization and lead firms to shift from a decentralized to a centralized organization (Dargaud and Jacques 2020). In this article, we obtain the opposite result because decentralization is used for a different purpose. It does not aim to prevent the detection of other cartels but solely to delay it, allowing firms to self-report them.

We consider the interplay between collusion, organizational structure and competition policy, via a model with two firms, two substitute goods and an antitrust authority which seeks to detect and fight collusion through leniency programs. Each firm produces both goods. The firms can choose between two organizational forms: the U-form and the M-form. With the U-form, one manager chooses the price of both goods in order to maximize profit; under the M-form, each manager separately chooses the price of one product to maximize the profit in his division. The U-form thus has the advantage of eliminating competition between the two divisions of the same firm.

Price competition between firms is repeated indefinitely. Firms can exploit this repetition to establish collusion agreements. The theoretical literature has highlighted that multimarket firms could enhance their collusion opportunities by consolidating their various activities into a single collusion agreement (Bernheim and Whinston 1990; Spagnolo 1999; Pénard 2000; Matsushima 2001). This is corroborated by several empirical studies.² However, antitrust authorities incorporate this issue into their procedures and investigate all anticompetitive conducts inside a firm when they detect a collusive agreement.³ In 1999 the US adopted

¹Pénard (2000) demonstrates that firm centralization can facilitate collusion when demand is random and not directly observable. By aggregating information gathered across multiple markets, firms reduce the variance of the signal they observe, thereby reducing the frequency of price wars. This model, which does not include a competition authority, is further from ours.

²See Evans and Kessides (1994) and Ciliberto and Williams (2014) in the field of air transport, Parker and Röller (1997) concerning phones, Fernández and Marín (1998) relating to hotels or Molnar, Violi and Zhou (2013) in the banking sector.

³According to Hammond (2009): "over half of these investigations [involving international cartels] were initiated as a result

amnesty plus programs which consist of reduced fines for a convicted firm if it reports another, undetected, cartel.⁴ Following the adoption of these different measures, firms may no longer necessarily have an interest in consolidating their various collusion activities into a single agreement. On the contrary, they may attempt to compartmentalize them by entrusting their management to different individuals.⁵ This internal decentralization can be adopted for two different reasons. Firms may do so to reduce the probability of other cartels being discovered during an investigation targeting one of their cartels. In this case, firms aim to continue collusion in certain markets or reduce the likelihood of conviction for multiple offenses (Dargaud and Jacques 2015, 2020; Jacques 2023). Firms may also opt for a decentralized organization to slow down antitrust investigations. This delay can be utilized to seek leniency for cartels not yet discovered. Firms can then include more yet-to-be-discovered elements in their leniency application. This increases their likelihood of obtaining leniency and the potential reductions in fines that could be granted. In this study, our focus centers on this second reason.

We now justify this key assumption. When a cartel is either exposed by whistle-blowers or suspected by antitrust authorities, firms are not immediately informed. During this covert investigation, less evidence (especially regarding the existence of a second cartel) is gathered when the cartels are managed by different, unconnected individuals. Authorities can wiretap the firm's line⁶ or meetings can be secretly recorded.⁷ If other offenses are revealed during these meetings, the antitrust authority receives this information even before firms become aware that they are being investigated regarding the first cartel. This risk is reduced if firms choose to compartmentalize their activities. If enough evidence leading to reasonable suspicion has been found, the authority may conduct a raid on the firm, seizing computers or other equipment in order to obtain hard evidence.⁸ When the same individuals manage both cartels, there is a likelihood that authorities will discover evidence of the second cartel. Once this initial investigation phase occurs, firms are fully informed about the inquiry. If the second cartel goes unnoticed during this stage, companies can pursue leniency. The likelihood of being able to apply for leniency is higher if the cartels are managed by unconnected individuals.⁹

To focus on the specific effect we aim to study, we assume that the probability of discovering the second cartel is not dependent on the internal organization of the firms.¹⁰ This organization solely influences the

of leads generated during an investigation of a completely separate market".

⁴The impact of leniency on multimarket collusive firms is specifically investigated in a number of studies discussed in the next section.

⁵Alternatively, they may stagger the different cartels over time and engage in collusion on only one market at a time. This sequential collusion is highlighted by Choi and Gerlach (2013).

⁶Following a press article in 2005, Canadian authorities wiretapped gasoline stations' lines, leading to the detection of several gasoline price-fixing cases. Refer to Clarke and Houde (2013).

⁷An example is the lysine cartel which has been adapted into a film by Steven Soderbergh (*The informant!*).

⁸In 1995, SC Johnson blew the whistle on a cartel. Subsequently, the antitrust authority conducted a raid on a meeting involving the managers and the head offices of the implicated firms. Among these was Colgate-Palmolive, which had previously applied for leniency twice. The first application pertained to the investigated cartel, while the second involved an undetected cartel. When different individuals manage cartels, the risk of swift detection through contagion is reduced.

⁹A counter-argument might suggest that a centralized firm can swiftly gather concrete evidence for both cartels and apply for leniency. However, it seems reasonable to anticipate that this counter-argument is not predominant. Raids and official investigations are often reported by the economic press. Even with decentralization, one division is promptly informed of another division's investigation within the same firm. Furthermore, in this article, we do not consider that CEOs and managers have differing incentives: if leniency is appealing for a firm, managers willingly provide information about the cartels to their CEO. Therefore, it is probable that internal inquiries collect unknown evidence more rapidly than the external investigation conducted by antitrust authorities.

¹⁰We discuss in Section 5 how the results might be affected if this assumption is relaxed.

speed at which this discovery takes place.

Our main finding is that the introduction of a leniency program can incentivize firms to adopt a decentralized organizational structure. In the absence of such programs, firms consistently opt for a centralized structure. The U-form allows for higher collusive prices by eliminating competition between the firm's internal divisions. Conversely, the M-form offers no advantages when leniency programs are absent. The introduction of a leniency program can alter firms' organizational choices. Decentralization enables firms to compartmentalize various collusion agreements, thereby delaying the discovery of subsequent cartels. As a result, firms have more leverage when applying for leniency. However, decentralization has the drawback of introducing competition among the divisions of the firm, leading to lower collusive prices. If the goods produced by the different divisions are sufficiently differentiated, the first effect dominates, and leniency programs encourage the adoption of a decentralized organization.

A decentralized organization of firms leads to lower collusive prices. Competition authorities have an interest in encouraging firms to opt for this type of organization if they are unable to completely deter cartel formation. The leniency program can thus have a marginal deterrent effect on specific cartels by encouraging them to lower their prices.

A French cartel case illustrates our theory: the “pork” cartel fined in July 2020 (Case 20-D-09). The cartel involved twelve companies operating in two sectors (ham and cold meat). It included price agreements on cold meat products and coordinated to present a united front during negotiations with slaughterhouses. These cartels were uncovered due to a complaint filed by a competitive company in September 2012. This complaint revealed unfair competition with very low prices in the pork sector. Subsequently, two groups, Campofrio and Coop, applied for leniency and provided information for the investigation. Each of these companies had several subsidiaries during these collusive periods, indicative of a decentralized organization. However, internal reorganization occurred between the dissolution of the cartels (2013) and the imposition of fines. For example, the Spanish Campofrio food group merged its subsidiaries Aoste and Salaisons Moroni in July 2018, both producing highly substitutable products (raw cold meat products). Similarly, the French Financière Turenne Lafayette group merged two subsidiaries in 2013 (Maison du Jambon and Montagne Noire). Furthermore, Fleury Michon Charcuterie was absorbed into Fleury Michon Traiteur within the same group in 2018. Thus, it can be concluded that after the dissolution of the cartels, several companies reorganized their internal structure and reduced the number of subsidiaries. There is evidence suggesting that the proliferation of subsidiaries was related to collusive agreements.

The paper is structured as follows. Section 2 provides a brief review of the literature related to the topics addressed in our study. Section 3 outlines the model's assumptions. In Section 4, we characterize the various collusion strategies available to firms. Section 5 analyzes the choice of organization. Finally, Section 6 concludes by discussing the robustness of our main findings.

2 Literature review

In this section we briefly review literature on firms' internal organization and the role of leniency programs.

2.1 Internal organization

Optimal organizational design can be influenced by several factors, such as tasks that complement each other (Harris and Raviv 2002; Puschke 2009), firm size and product diversity (Chandler 1962; Aghion and Tirole 1995; Spiegel 2009), the provision of incentives and accuracy in intra-firm performance measurement (Maskin et al. 2000; Besanko et al. 2005; Puschke 2009; Berkovitch et al. 2010), project uncertainty (Qian et al. 2006), etc. If these factors are of minor importance or if they produce opposite effects that cancel each other out, strategic or legal considerations can incentivize firms to alter their internal structures. Some industrial economic papers suggest that competition among divisions within a firm can lead to increased production or prices to influence competitors (Baye, Crocker and Ju 1996; Barcena-Ruiz and Espinosa 1999; Creane and Davidson 2004; Huck, Konrad and Müller 2004; Tan and Yuan 2003; Zhou 2005). In industrial organization, it is commonly believed that firms may adjust their organizational structure strategically. The connection between internal organization and collusion is explored in Cyert, Kumar, and Williams (1995). They suggest that collusion among firms can shift competition away from prices and toward the provision of services to both consumers and other firms. As a result, firms tend toward decentralization to capture market share through non-price competition. However, this shift may reduce the sustainability of collusion: the profits of a local division increase with cartel deviation, while the risk of retaliation decreases due to decentralization. Additionally, consideration of legal factors can influence the selection of organizational structure.¹¹ Dargaud and Jacques (2015) argue that firms have an interest in adopting decentralized organizational structures when engaging in collusion across multiple markets simultaneously, aiming to mitigate the risk that an investigation initiated in one market leads to the discovery of other cartels. Dargaud and Jacques (2020) extend the previous study by incorporating a leniency program into the model. This program may negate the advantage of decentralization by incentivizing firms to disclose other cartels before competition authorities discover them. While this article closely aligns with our study, it attributes a different advantage to decentralization, and arrives at a contrary result regarding the impact of the leniency program on firms' organizational choices. Our study thus complements that of Dargaud and Jacques (2020) by shedding light on an alternate mechanism. Jacques (2023) revisits the notion that decentralization reduces the likelihood of detecting a second cartel. However, the model focuses on the choice between stand-alone firms and conglomerates. The author demonstrates that groups organize as independent firms when engaging in collusion across multiple markets and subsequently form conglomerates after the dissolution of collusion in one of the markets. This dynamic can explain the conglomerate discount observed in certain financial markets. Bageri, Katsoulacos, and Spagnolo (2013) reveal that when expected fines are contingent upon firms' revenues, it creates certain

¹¹Prior to the 9th amendment of the Act against Restraints of Competition (ARC), German cartel members could avoid fines through internal restructuring, as observed in the "sausage case". Firms might evade liability for damages by vertically divesting production tasks (a kind of decentralization) associated with significant occupational risks (Ringleb and Wiggins 1990; Barney, Edwards and Ringleb 1992). Conversely, Brooks (2002) presents evidence suggesting that firms may opt for increased vertical integration as a response to heightened liability.

distortions. If jurisdictions enforce caps on maximum fines proportional to the total firm revenue, specialized firms primarily operating within their core market anticipate lower fines compared to more diversified firms. This discrepancy might influence the organizational decisions made by these firms. Jacques (2024) defends the idea that a conglomerate wishing to collude on several markets may have an interest in splitting into two stand-alone firms to avoid the increased fine applied to recidivist firms. Additionally, Dong, Massa, and Žaldokas (2019) empirically demonstrate that leniency programs impact merger activities, suggesting a potential impact on the internal organizational structure of firms.

2.2 Leniency programs

This paper relates to a second body of literature centered on leniency programs. Since the pioneering work of Motta and Polo (2003), extensive research has studied the impact of leniency.¹² Leniency programs are widely used by firms and represent the primary investigative tool for uncovering cartel activities.¹³ However, some authors point out that a reduced fine might diminish the deterrent effect of penalties or that leniency is primarily used for cartels that might have collapsed internally, diverting attention away from active cartels.¹⁴ The design and effects of these leniency programs remain subjects of an ongoing debate. We now focus on the main papers related to our subject: multimarket collusion or the marginal deterrent effect of leniency.

Multiproduct firms: Some studies delve into the impact of leniency and amnesty plus programs on multimarket colluding firms. Roux and Von Ungern-Sternberg (2007) analyze the effects of amnesty plus within a static framework and identify both procompetitive effects (firms may be incentivized to disclose a second undetected cartel) and procollusive effects (firms might be less inclined to cooperate during initial investigations if revealing the first cartel might lead to disclosing the second). Marx, Mezzeti and Marshall (2015) also use a static framework to study penalty plus programs. When a cartel is convicted, investigated firms are queried about the existence of another collusive agreement. Firms not seeking leniency at this stage are not able to do so later, but the incentive to reveal the second cartel is low since firms are uncertain if they will be investigated. This can lead to penalty plus programs annulling future leniency applications, consequently increasing the anticipated profits of colluding firms. In some cases, firms might create a “sacrificial” cartel to reveal it and sustain other collusive agreements for which leniency applications will be impossible. Using a dynamic framework, Lefouili and Roux (2012) demonstrate that amnesty plus program destabilizes collusive strategies where firms continue collusion after the conviction of the first cartel (procompetitive effect) but facilitates collusive strategies in which firms reveal the second cartel following the conviction of the first one (procollusive effect).¹⁵ Dijkstra (2014) extends the previous work and considers two independent markets with price competition, homogeneous products and three firms¹⁶ and identifies either procollusive

¹²See Spagnolo (2008) and more recently Marvão and Spagnolo (2018) for a literature survey.

¹³See Miller (2009) and Brenner (2009) for empirical studies and Jaspers (2020) for an analysis based on interviews.

¹⁴Harrington and Chang (2015) illustrate how leniency might shift resources from prosecuting active and harmful cartels to failing ones.

¹⁵Brisset, Cochard and Lambert (2019) experimentally investigate results obtained by Lefouili and Roux (2012) and highlight the prevailing procompetitive effect of amnesty plus.

¹⁶Two firms operate in two markets, while the third operates in only one.

or procompetitive effects of leniency and amnesty plus programs. Our study contributes to this literature by highlighting the significant role of firms' internal organization and demonstrating how the design of leniency programs can influence this internal structure. This issue had only been addressed previously by Dargaud and Jacques (2020).¹⁷

Leniency and marginal deterrence: In our article, even when leniency programs fail to deter collusive agreements, they may still decrease collusive prices: this is the marginal deterrent effect. Few articles on leniency consider this effect, as most assume that detection probability and fines remain independent of collusive prices, favoring the prevalence of monopoly prices. Emons (2020) obtains the marginal deterrent effect by considering multimarket colluding firms that determine the extent of collusion. A broader scope of collusion increases the risk of detection. While leniency might not directly impact collusive prices, it can diminish the intensity of collusion. Houba, Motchenkova and Wen (2015) examine the influence of leniency on collusive prices. The likelihood of an investigation opening and the probability of cartel dissolution post-investigation rise with collusive prices. Their study indicates that ex ante leniency applications do not decrease the maximum sustainable cartel price, but ex post leniency can reduce it. Our study unveils a second effect of leniency programs: they might promote the adoption of a decentralized structure, which in turn reduces collusive prices. This additional effect is absent in the previously mentioned articles.

3 Model

We assume that two identical firms, labeled 1 and 2, produce both two differentiated products, A and B. Both firms have identical and zero marginal costs. The firms initially determine their organizational structure, followed by engaging in an infinitely repeated game of price competition. While firms can decide to implement a collusive agreement on one or both products, we introduce a third player: the antitrust authority, tasked with detecting and combating collusion.

Before engaging in price competition, firms cooperatively determine their organizational structure.¹⁸ Each firm can choose between a centralized (unitary) organizational structure (U-form) and a decentralized (multidivisional) structure (M-form). Under the U-form, each CEO sets prices to maximize the overall firm profit, while in the M-form, two divisional managers each set the price for a single product to maximize their respective business unit's profit. In this latter scenario, firms do not internalize the effects of the price on the other product demand.

Once organizational structures have been decided, firms play an infinitely repeated game of price competition. In each period, they can decide to implement a collusive agreement. Collusive outcomes are modeled on the basis of grim trigger strategies (Friedman 1971): as soon as one firm deviates from the agreement, the other plays non-cooperatively forever. Both firms face the same discount factor δ .

¹⁷Refer to the preceding paragraph.

¹⁸The main results are similar if the choice of organization is made non-cooperatively, but the model takes longer to solve.

The demand function for product i ($i = \{A, B\}, j = \{A, B\}$ and $i \neq j$) is¹⁹ (d is a positive parameter reflecting product substitutability):

$$Q^i(p^i, p^j) = \max \left\{ 0, \min \left\{ a - p^i + d(p^j - p^i), \frac{1 + 2d}{1 + d}(a - p^i) \right\} \right\}$$

Collusion among firms or their divisions generates hard evidence which can be found by the authority with probability ρ . Past offenses cannot be detected once firms have reverted to competitive pricing. A deviation from the collusion agreement removes the risk of fines for the deviating firm.²⁰ If a cartel is detected, the authority launches an investigation which always leads to successful prosecution, and a fine F is imposed on each cartel member. Convicted cartels are disbanded, and firms are prohibited from engaging in collusion again within the affected market. During such a single-market investigation, the authority might find, which probability μ ,²¹ actionable evidence of a collusive agreement in the other market, leading to additional fines F for the involved firms. To simplify the presentation of the main results, we assume that $\mu = 1$. The results remain valid for values of μ that are sufficiently high for firms to have an incentive to apply for leniency for the second cartel after an investigation has been opened.

Firms can file leniency requests at two moments. This request may occur before the detection of a cartel. Because we consider a stationary environment, if firms have an incentive to seek leniency before an investigation begins, they would opt not to establish cartels in the first place. Firms will never voluntarily report a cartel they have set up before the launch of an investigation. A firm may also report a cartel if it decides to deviate from the collusion agreement. However, as we assume that deviation removes the risk of fines, this possibility does not influence the firms' strategies. The second opportunity arises during the period between the prosecution of the first cartel and the serendipitous detection of the second.²² However this request is not guaranteed approval. Firms' ability to apply for such leniency depends on their internal organization. A decentralized organization often delays investigations because cartel evidence is scattered across different parts of the firm, and the individuals involved in various cartels are different. We denote q_U , q_M and q_A as the probabilities that the firms have time to file a leniency application for the second cartel after learning that they were under investigation, when both firms operate with a centralized organization (U), when both have a decentralized organization (M), and when the firms adopt different organizational structures (A). Alternatively, these probabilities can be interpreted as the fine reduction awarded to an applicant firm, based on the evidence gathered by the competition authority. The more new evidence the firm provides, the higher the reduction. Our central assumption, vital to the main results, is that $q_U \leq q_A \leq q_M$. Indeed, with decentralized firms, the competition authority's investigation progresses more slowly and the authority has fewer elements raising suspicion about the existence of a second cartel. Firms can then provide more new elements when applying for leniency. Hence, they have a higher probability of obtaining leniency (with

¹⁹The last terms correspond to the demands for each product when the other is priced above its choke price. We include these terms for completeness, but such prices do not arise in equilibrium.

²⁰The opposite hypothesis does not alter the main results, but requires a distinction to be made between the case with and without a leniency program when calculating the incentive constraint not to deviate from the collusion agreement.

²¹In Dargaud and Jacques (2015, 2020) and Jacques (2023), the probability of this event depends on the organizational structure. In this article we remove this assumption since we focus on the investigations slowdown allowed by the decentralization.

²²As we posit that the first cartel is always convicted post-detection, competition authorities have no incentive to offer a leniency program at this stage. A major reason of the leniency application (Motta and Polo 2003)) is then rejected.

the first interpretation of the probabilities q_U , q_M and q_A) or a higher fine reduction (with the second interpretation). To simplify the model, we assume $q_U = q_A$. This leads to the conclusion that firms never choose different organizational structures in equilibrium, allowing us to focus solely on the U and M cases.

If leniency is granted, the fine imposed on the firm for its involvement in the second cartel is: τF , with $\tau \in [-1, 1]$. Only the first firm benefits from the reduced fine. If both firms apply simultaneously, the benefiting firm is randomly chosen. $\tau = 0$ is the total immunity case and $\tau \in]0; 1]$ the partial immunity case. The case $\tau \in [-1; 0[$ corresponds to the existence of an amnesty plus program. Indeed, under this program, a firm that has already been fined for participating in a cartel and subsequently reports another cartel can receive total immunity for the second cartel and a reduced fine for the first one. We can consider in this case that the firm could receive a financial “reward”, modeling by assuming $\tau \in [-1; 0[$. This creates a situation where, by coming forward, the firm not only avoids penalties for future violations but may also receive reimbursement for fines already paid.

The timing of each period is: (1) CEO or managers choose their competitive or collusive prices. Collusion generates hard evidence. Firms may stay on collusive path or deviate from the cartel agreement. (2) The authority suspects an active cartel with probability ρ and launches investigations. (3) During the first-market investigation, firms can seek leniency for the second cartel with probability q_U or q_M (depending on the organizational choice). (4) The competition authority fines cartels that have been discovered and dissolves them definitively.

4 Collusion strategies

Firms have the choice between four strategies. (1) Adopt a centralized organization and collude on both markets simultaneously (U strategy). (2) Adopt a decentralized organization and collude on both markets simultaneously (M strategy). (3) Engage in collusion on one market at a time. Firms start colluding in one market, then collude in the second market once the competition authority has dissolved the first cartel (S strategy).²³ (4) Do not collude (NC strategy). In the absence of collusion, firms engage in price competition with homogeneous goods in each market, leading them to choose prices equal to the marginal production cost then achieving zero profit in each market.

4.1 U Strategy

The detection of the first cartel inevitably leads to the discovery of the second. Consequently, firms are always motivated to seek leniency for the second cartel, provided they have the opportunity, once they become aware that the first cartel has been detected. The profit expectation is therefore equal to:²⁴

$$\Pi_i^U = \pi_i^{cU} - \rho^2 2F - 2\rho(1 - \rho) \left\{ (1 - q_U) 2F + q_U \left[\frac{1}{2} 2F + \frac{1}{2} (F + \tau F) \right] \right\} + \delta (1 - \rho)^2 \Pi_i^U$$

²³This sequential collusion strategy is highlighted by Choi and Gerlach (2013).

²⁴The prices and quantities chosen by the firms in each phase of the collusion agreements are detailed in Appendix A.

$$\Leftrightarrow \Pi_i^U = \frac{\pi_i^{cU} - [4 - 2\rho - (1 - \rho)(1 - \tau)q_U] \rho F}{1 - \delta(1 - \rho)^2}$$

where π_i^{cU} is the profit obtained in each period when the collusion agreement is effective.

If a firm chooses to deviate from the agreement, it is better to do so in both markets at once. The deviation profit is then equal to $2\pi_i^{cU}$. The collusion agreement is sustainable if and only if:

$$\Pi_i^U \geq 2\pi_i^{cU} \Leftrightarrow F \leq F_U \equiv \frac{2\delta(1 - \rho)^2 - 1}{[4 - 2\rho - (1 - \rho)(1 - \tau)q_U] \rho} \pi_i^{cU}$$

4.2 M Strategy

The expressions for the expected profit and the sustainability threshold can be derived from the earlier formulas for the U strategy by substituting q_U by q_M and π_i^{cU} by $2\pi_i^{cM}$, where π_i^{cM} is the profit of each division during each collusion phase. If the firms play the M strategy, the expected profit is equal to:

$$\Pi_i^M = \frac{2\pi_i^{cM} - [4 - 2\rho - (1 - \rho)(1 - \tau)q_M] \rho F}{1 - \delta(1 - \rho)^2}$$

This collusion strategy is sustainable if and only if:²⁵

$$F \leq F_M \equiv \frac{2\delta(1 - \rho)^2 - 1}{[4 - 2\rho - (1 - \rho)(1 - \tau)q_M] \rho} 2\pi_i^{cM}$$

4.3 S Strategy

Firms cartelize in only one of the two markets (named market B), maintaining price competition in the second market. If the cartel is discovered, firms start collusion in the market A. The S strategy can be implemented by centralized or decentralized firms. We will assume that firms select a centralized organization, thereby removing the risk of miscoordination between the two divisions in choosing the first market for collusion. We successively determine equilibrium values in the second market and in the first cartel.

Second cartel: The present discounted value of a colluding firm is given by:

$$\Pi_i^{S2} = \pi_i^{cS} - \rho F + \delta(1 - \rho) \Pi_i^{S2} \Leftrightarrow \Pi_i^{S2} = \frac{\pi_i^{cS} - \rho F}{1 - \delta(1 - \rho)}$$

where π_i^{cS} is the profit of each division during each collusion phase.

This second cartel is sustainable if and only if:

$$\Pi_i^{S2} \geq 2\pi_i^{cS} \Leftrightarrow F \leq F_S \equiv \frac{2\delta(1 - \rho) - 1}{\rho} \pi_i^{cS}$$

²⁵The decision to deviate from the collusion agreement is made by the division managers. However, this does not change the non-deviation constraint, since each term in the inequality is multiplied by 1/2.

First cartel: Each firm's expected payoff associated with collusion is defined as:

$$\Pi_i^S = \pi_i^{cS} - \rho F + \delta(1 - \rho)\Pi_i^S + \delta\rho\Pi_i^{S2} \Leftrightarrow \Pi_i^S = \frac{(1 - \delta + 2\delta\rho)(\pi_i^{cS} - \rho F)}{[1 - \delta(1 - \rho)]^2}$$

If the second phase of the cartel is sustainable, then the first phase is as well. The gains from collusion and the risk of fines are the same in both phases, however, in the first phase, firms recognize that deviating eliminates the possibility of colluding on the second market. The S strategy is therefore sustainable if and only if: $F \leq F_S$.

5 Organization choices

Organization choices: Firms choose their organization cooperatively. They therefore opt for the organization that ensures the highest expected profit.

If $q_M = q_U$, then $\Pi_i^U \geq \Pi_i^M$.²⁶ If $q_M > q_U$, we have:

$$\Pi_i^U \geq \Pi_i^M \Leftrightarrow F \leq F_{UM} \equiv \frac{\pi_i^{cU} - 2\pi_i^{cM}}{(1 - \rho)(1 - \tau)(q_M - q_U)\rho}$$

For firms to prefer M to U , (1) $\pi_i^{cU} - 2\pi_i^{cM}$ must be low and (2) $q_M - q_U$ must be high. If the two goods are only slightly differentiated, intra-firm competition is strong if firms opt for a multidivisional organization, and a collusion agreement only leads to a slight increase in prices. In this scenario, firms are better off choosing a centralized organization, even if it lowers their chances of benefiting from the leniency program, to eliminate intra-firm competition and fully capitalize on the price agreement between the two firms. For decentralization to be an attractive option, the product differentiation must be sufficiently strong. Decentralization must also substantially increase the expected reduction in fines available through the leniency program, that is, the internal organization of firms must significantly affect the speed at which evidence of the second cartel is discovered.

We still need to compare the M and U strategies with the S strategy. Since the profit expectations of the M and U strategies have the same form, we can summarize the two comparisons in a single formula, using a generic letter $X \in \{M, U\}$:

$$\Pi_i^X \geq \Pi_i^S \Leftrightarrow F \leq F_{XS} \equiv \frac{[1 - \delta(1 - \rho)]^2 \pi_i^{cX} - [1 - \delta(1 - \rho)^2](1 - \delta + 2\delta\rho)\pi_i^{cS}}{\left\{ [1 - \delta(1 - \rho)]^2 [4 - 2\rho - (1 - \rho)(1 - \tau)q_X] - [1 - \delta(1 - \rho)^2](1 - \delta + 2\delta\rho) \right\} \rho}$$

This condition is more easily met if the difference between π_i^{cX} and π_i^{cS} is larger. This difference increases as the product differentiation decreases. The sequential collusion strategy only makes sense if there is little competition from the other good (which is priced at its marginal cost), thus the two goods must be highly differentiated. The U and M strategies become more attractive than the S strategy if q_U and q_M increase. If firms anticipate a greater reduction in the fine for the second cartel due to the leniency program, they have less incentive to choose the sequential collusion strategy. The choice between sequential and simultaneous

²⁶This would also be the case if $q_M < q_U$.

collusion strategies also depends on the value of the discount factor (δ). Sequential collusion reduces the gains obtained in each collusion period, but increases the total duration of collusion. As a result, some of the gains from the sequential strategy are obtained later than those from simultaneous collusion strategies. The sequential strategy is therefore more attractive if firms are more patient, and thus if the discount factor is higher. Finally, a higher fine makes the sequential strategy relatively more attractive than the simultaneous collusion strategies, because the second fine is delayed compared to the other two strategies. This second fine is therefore more heavily discounted in the calculation of the earnings expectations associated with each strategy. An increase in the fine thus reduces the profit expectation of the sequential strategy less than for the M and U strategies.

In the absence of a leniency program ($q_M = q_U = 0$), the U strategy always dominates M . U-shaped organization enables firms to eliminate intra-firm competition. It thus enables collusion prices to be set higher than if firms are multidivisional. The M-shaped organization offers no advantage in the absence of a leniency program. The M strategy is therefore never chosen. The firms' choice of strategy is as follows:²⁷

Proposition 1 *Without a leniency program, firms choose the U strategy if and only if $F \leq \min(F_U, F_{US})$. They choose the S strategy if $\min(F_U, F_{US}) < F \leq F_S$. They do not collude if $F > \max(F_U, F_S)$.*

Firms choose the S strategy if the two goods are highly differentiated and if the fine incurred is high. They choose the U strategy if the fine is low or if the goods are slightly differentiated.

With a leniency program, the M strategy dominates the U strategy if $q_M > q_U$ and the product differentiation is very high. In equilibrium, firms opt for the following strategy:

Proposition 2 *If a leniency program is in place, firms choose the U strategy if $F \leq \min(F_{US}, F_U, F_{UM})$, the M strategy if $\min(F_{UM}, F_U) \leq F \leq \min(F_M, F_{MS})$. They do not collude if $F > \max(F_S, F_M, F_U)$. In the other cases, firms choose the S strategy.*

If the fine is high and the goods are highly differentiated, firms choose the S strategy. If the fine is lower or the goods are slightly more differentiated, firms opt for the M strategy. If the product differentiation is low, firms select the U strategy.

A graphical representation helps to visualize the results of Proposition 2. We consider: $a = 10$, $\rho = 0.01$, $q_M = 0.9$, $q_U = 0.1$, $\tau = 0$ and $\delta = 0.95$.²⁸

²⁷The ranking of the different thresholds is specified in Appendix B.

²⁸If δ is high enough for collusion to be sustainable for certain values of F , the overall shape of the figure is minimally affected by the values selected for the other parameters (See Appendix B).

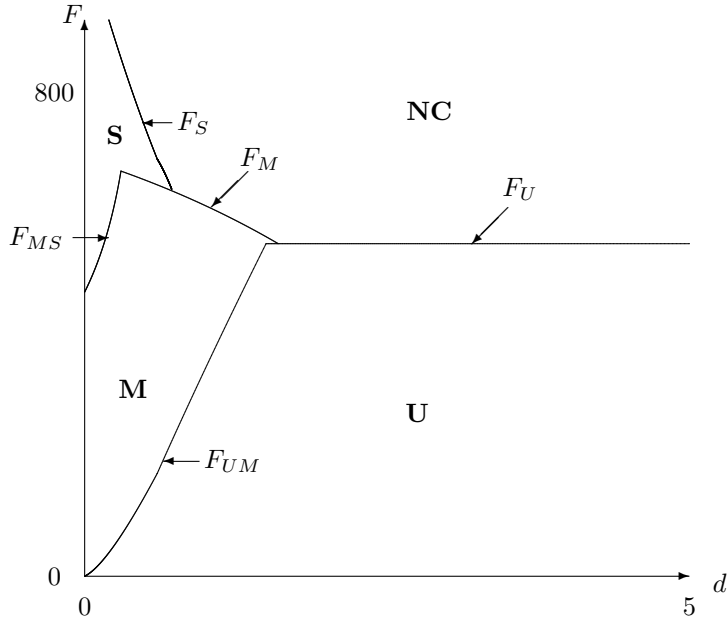


Figure 1: Organizational choice with leniency program

The M strategy is never selected in the absence of a leniency program; however, it may be chosen under certain parameter values when a leniency program is in place. Thus, we have established the central result of this study:

Proposition 3 *Leniency programs encourage the adoption of a decentralized organization when the probability of discovery of the second cartel is high.*

A decentralized organization slows down investigations by competition authorities. It provides firms with more time to apply for leniency for the second cartel, as less evidence has been uncovered when they apply. Consequently, their contribution to the investigation appears more significant, allowing them to secure a larger reduction in their fine. The counterpart is that decentralization introduces competition between the divisions of the same firm, thus lowering the prices charged during the collusion phase. If the differentiation between the two products is high, the first effect dominates the second, and firms adopt a decentralized organization following the introduction of a leniency program.

Comparison with Dargaud and Jacques (2020): We show that, if the probability of detecting the second cartel during an investigation targeting the first is high, leniency programs can encourage firms to opt for a more decentralized organization. Dargaud and Jacques (2020) [DJ] obtain the opposite result. In their study, the introduction of the leniency program encourages firms to abandon a decentralized organization and adopt a centralized one. This difference is due to different assumptions. DJ neglects the impact of firms' organization on their ability to obtain leniency. Formally, they assume $q_U = q_M$. On the other hand, they assume that decentralization reduces the probability of discovery of the second cartel ($\mu_M < \mu_U$). Decentralization can therefore be chosen when it strongly reduces the serendipity probability, and firms hope

to continue colluding in the second market after the first market's dissolution. If the introduction of the leniency program encourages firms to denounce the second cartel, it is no longer in their interest to choose a decentralized organization, and they adopt a centralized one. Our study and DJ's are therefore concerned with different mechanisms, and appear to be complementary. If μ_M is significantly lower than μ_U and if q_U is very close to q_M , we are in the case studied by DJ, and leniency programs encourage the adoption of a centralized organization. If q_M is significantly higher than q_U and if μ_M (and therefore also μ_U) is high, we are in the case analyzed by this article and leniency programs favor decentralized organizations.

Impact of the value of τ : While there is a fairly broad consensus on the usefulness of leniency programs in the fight against cartels, the design of these programs, and in particular their degree of generosity, is still the subject of debate. In our model, the τ parameter is used to vary the degree of generosity of the leniency program. As in many other studies, a variation in this level has ambiguous effects. It can have pro-competitive effects for some parameter values and anti-competitive effects for others.

A reduction of τ corresponds to a higher fine reduction, leading to an increase in F_U and F_M . A leniency program can therefore have an anti-competitive effect by encouraging the formation of new cartels. The reduction in τ also leads to a fall in F_{UM} . The zone where firms choose a decentralized organization grows at the expense of the zone where U is chosen. This organizational change is accompanied by a drop in collusion prices. The leniency program therefore has a marginal deterrent effect. It does not deter some cartels, but encourages them to reduce their collusion prices. Finally, the reduction in τ causes an increase in F_{MS} . It therefore encourages certain cartels to switch from S to M . The impact on social surplus is ambiguous. Collusion lasts less time, but collusion prices are higher.

The optimal value of τ therefore depends on the distribution of industries between these different zones. If in most industries there is little differentiation between goods, it is not advisable to offer generous leniency programs when the probability of discovering the second cartel without a leniency program is high. A higher fine reduction has no impact on firms' organizational choices, and may lead to the emergence of new cartels. On the other hand, if goods differentiation is moderate, a higher fine reduction when leniency is sought may lead to an increase in social surplus. A more generous program may encourage firms to adopt a decentralized organization, leading to a reduction in collusion prices.

6 Conclusion

In this study, we demonstrate that if the probability of discovering the second cartel is high, the introduction of a leniency program may incentivize firms to adopt a decentralized organization. In this case, the leniency program has only a marginal deterrent effect. While it does not prevent the formation of certain cartels, it encourages them to lower their collusive prices.

We focus on the case where the competition authority is certain to detect the second cartel once an investigation into the first cartel has begun, even if the firms do not apply for leniency. This modeling choice

is made to demonstrate our main result using the simplest possible framework. Without this assumption, a broader range of strategies need to be considered. An investigation no longer automatically leads to the discovery of the second cartel, and firms may hope to continue colluding in the second market if the competition authority fails to uncover this cartel. However, they are not always able to do so. For collusion to persist in the second market, the condition $F \leq F_S$ must be met. Typically, this requires that the two goods be sufficiently differentiated for the condition to hold. Therefore, when they are sufficiently differentiated, two cases in the M and U strategies must be distinguished depending on whether or not the firms wish to continue colluding in the second market after the opening of an investigation targeting the first cartel. This therefore increases the number of collusion strategies from three to five, which in turn extends the complexity of solving the model. However, if the serendipity probability is high and the leniency program is sufficiently generous, firms choose to apply for leniency as soon as the competition authority opens an investigation. This automatically leads to the conviction of the second cartel. Then the results obtained under a high probability of serendipity are similar to those assuming this probability equals 1. On the other hand, if this probability is very low, firms never apply for leniency. In this case, a decentralized organization holds no advantage. Firms always choose a centralized organization, whether or not a leniency program is in place. Between these two cases, there are parameter values where firms apply for leniency if they are decentralized but choose not to apply (hoping to continue colluding in the second market) if they are centralized. In these cases, if the leniency program is sufficiently generous, firms move from a centralized to a decentralized organization following its introduction. The main result of our study therefore remains valid. Without a leniency program, firms always opt for a centralized organization. After the introduction of a leniency program, they may opt for a decentralized organization if the probability of detection of the second cartel is sufficiently high. The introduction of a leniency program therefore encourages the adoption of a decentralized organization. The purpose of this organization is not to hide the second cartel in order to continue colluding in the second market (as discussed in Dargaud and Jacques 2015, 2020), but rather to delay the investigation, allowing firms time to apply for leniency and to increase the amount of undiscovered evidence for a greater fine reduction.

The implications that firms may choose to compartmentalize activities to delay investigations are broader than just the analysis of collusion. Other firm behavior can be analyzed in this context, such as tax evasion or standard (environmental or other) infringement. An interesting topic for future research is to introduce the major assumption of this article into static model of self-reported crimes (Kaplow and Shavell 1994; Innes 2000; Feess and Walzl 2004; Landeo and Spier 2020).

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Appendix

Appendix A: Prices and quantities

U Strategy: Solving the individual maximization program for each firm, we obtain the following equilibrium values ($i = 1, 2$; $Y = A, B$):

	Collusion	Deviation	Punishment
Price	$p_i^Y = \frac{a}{2}$	$p_i^{dY} = \frac{a}{2} - \varepsilon$	$p_i^{pY} = c = 0$
Quantity	$q_i^Y = \frac{a}{4}$	$q_i^{dY} = \frac{a}{2}$	$q_i^{pY} = \frac{a}{2}$
Profit	$\pi_i^{cU} = \frac{a^2}{4}$	$\pi_i^{dU} = \frac{a^2}{2}$	$\pi_i^{pU} = 0$

M Strategy: We obtain the same equilibrium prices under the M strategy as in the duopoly case with differentiated products (each firm producing only one product). For each period we obtain:

	Collusion	Deviation	Punishment
Price	$p_i^Y = \frac{a}{2+d}$	$p_i^{dY} = \frac{a}{2+d} - \varepsilon$	$p_i^{pY} = c = 0$
Quantity	$q_i^Y = \frac{1+d}{2+d} \frac{a}{2}$	$q_i^{dY} = \frac{1+d}{2+d} a$	depends on the price in the other market
Profit of a division	$\pi_i^{cM} = \frac{1+d}{2(2+d)^2} a^2$	$\pi_i^{dM} = 2 \frac{1+d}{2(2+d)^2} a^2$	$\pi_i^{pM} = 0$

A deviating division reduces its price ($p_i^Y - \varepsilon$) in order to absorb the global market. But this price reduction is not computed in order to absorb the consumers buying the other product since the collusive price is the best response to the other market price.

S Strategy: Firms cartelize in only one of the two markets (named market B), maintaining price competition in the second market. If the cartel is discovered, firms start collusion in the market A. In the market without collusion, equilibrium prices equal marginal cost: $p_1^B = p_2^B = c = 0$. In the market A firms act as a monopoly. The best-response function of a firm monopolizing the market A is: $p^A = \frac{a+dp^B}{2(1+d)}$. Setting $p^B = 0$, we obtain:

$$p_i^A = \frac{a}{2(1+d)} \quad , \quad q_i^A = \frac{a}{4} \quad \text{and} \quad \pi_i^{cS} = \frac{a^2}{8(1+d)}$$

Appendix B: Ranking of different thresholds

Independent products: If $d = 0$ then: $\pi_i^{cU} = 2\pi_i^{cM}$ and $\pi_i^{cS} = \pi_i^{cM}$. These conditions imply that:

- 1) $F_{UM} = 0$ then $F_U > F_{UM}$ if δ is sufficiently high for U to be sustainable.
- 2) $F_M > F_U \Leftrightarrow q_M > q_U$
- 3) $F_S > F_M \Leftrightarrow 4\delta - 2 + q_M(1-\tau)[1-2\delta(1-\rho)] > 0$

This condition is verified in $d = 0$. Indeed, we must have $1 - 2\delta(1 - \rho) < 0$ so as to $F_S > 0$. We therefore have: $4\delta - 2 + q_M(1 - \tau)[1 - 2\delta(1 - \rho)] > 4\delta - 2 + [1 - 2\delta(1 - \rho)]$. The right-hand term is rewritten as:

$4\delta - 2 + [1 - 2\delta(1 - \rho)] = 2\delta - 1 + 2\delta\rho$. $2\delta - 1 + 2\delta\rho > 0$ if $\delta > \frac{1}{2}$, which is a necessary condition for collusion to be sustainable.

We conclude that $F_S > F_M > F_U > F_{UM} = 0$ if $d = 0$.

The ranking of F_M and F_{MS} in $d = 0$ depends on the value of δ . If δ is high, $F_M > F_{MS}$ (as in the graph shown in the text). If δ is lower, $F_M < F_{MS}$.

Substitutable products ($d > 0$): F_U does not depend on d . F_M is a decreasing function of d and F_{UM} is an increasing function of d . F_U will therefore intersect F_M and F_{UM} . We want to order these two intersections.

We denote by d_1 and d_2 the values of product substitutability verifying the following two equalities, respectively:

$$F_U = F_{UM} \Leftrightarrow 2\pi_i^{cM} = \left\{ 1 - \frac{[2\delta(1-\rho)^2 - 1](q_M - q_U)(1-\tau)(1-\rho)}{[2\rho + (1-\rho)(4 - q_U + \tau q_U)]} \right\} \pi_i^{cU} \text{ for } d = d_1.$$

$$F_M = F_{UM} \Leftrightarrow \frac{2\delta(1-\rho)^2 - 1}{[2 + (1-\rho)(2 - q_M + q_M\tau)]\rho} 2\pi_i^{cM} = \frac{2\delta(1-\rho)^2 - 1}{[2\rho + (1-\rho)(4 - q_U + \tau q_U)]\rho} \pi_i^{cU} \text{ for } d = d_2$$

To show that the intersection of F_U and F_{UM} lies to the left of the intersection of F_U and F_M , we show that $\frac{F_M}{F_U} > 1$ in $d = d_1$. We have:

$$\frac{F_M}{F_U} = \frac{[2\rho + (1-\rho)(4 - q_U + \tau q_U)] 2\pi_i^{cM}}{[2 + (1-\rho)(2 - q_M + q_M\tau)] \pi_i^{cU}}$$

For $d = d_1$ then:

$$\frac{F_M}{F_U} = \frac{[2\rho + (1-\rho)(4 - q_U + \tau q_U)] - [2\delta(1-\rho)^2 - 1](q_M - q_U)(1-\tau)(1-\rho)}{[2 + (1-\rho)(2 - q_M + q_M\tau)]} > 1 \Leftrightarrow 1 > \delta(1-\rho)^2$$

This condition is necessarily verified. We conclude that $d_1 < d_2$.