

# Hidden collusion by decentralization: firms' organization and antitrust policy\*

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**Abstract:** This paper develops a theory concerning the centralization degree of firms involving in multimarket collusive agreements. We examine the impact of exogenous organizational structures on collusive strategy. We then go on to consider the endogenous case. A centralized organization (unitary or U-form) allows price coordination on several markets whereas a decentralized one (multidivisional or M-form) decreases the probability that the antitrust authority will find evidence of collusion on one market during an investigation in the other. We show that this trade-off depends to a great extent on product substitutability and upon the instruments used by the antitrust authority.

**JEL classification:** L22; L41; K42

**Keywords:** antitrust policy; collusion; organizational design; M-form; U-form.

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# 1 Introduction

At the end of June 1995, agents from the FBI raided the head office of a firm based in the United States called ADM. The FBI was investigating a cartel which became known as the lysine cartel; they took away documents and conducted extensive interviews. The press coverage was also extensive. Such enforcement activity led to the successful prosecution of the participants in this international cartel.<sup>1</sup> The documents taken also revealed other wrongdoing. It appeared that ADM was not only involved in an amino acid cartel but was also involved in a citric acid cartel and one relating to a gluconic acid salt.<sup>2</sup> All three cartels were effectively brought to an end. According to Hammond (2009): *"over half of these investigations [involving international cartels] were initiated as a result of leads generated during an investigation of a completely separate market."* Multiproduct firms which simultaneously engage in several different cartels run some risk of being caught participating in one cartel whilst being investigated in relation to another. A rational response to this danger is to segregate cartels and managers so that neither part of a business nor manager of it can be implicated in any more than its or his own specific area of business. This may lead to decentralized business, which, itself may be a clue that cartel activity is being conducted or is being contemplated. Akzo Nobel N.V., for instance had many subsidiaries, which were directly or indirectly 100% owned by the group's parent company. One of its subsidiaries was implicated in the gluconic acid salt cartel in mid 1995.<sup>3</sup> Two other different subsidiaries - within the same group - continued to participate in a food additive (choline chloride) cartel until 1998.<sup>4</sup>

This article considers this means of behavior and suggests that previous works concerning the facilitation of collusive outcomes may need qualification. Theoretical work has often worked on the assumption that inter firm contact may facilitate collusion<sup>5</sup> and so one might expect that firms would, in effect, have a cartel department which would collude with the corresponding departments of other firms. Other studies suggest that it is rational that

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<sup>1</sup>Case COMP/36.545/F3

<sup>2</sup>Cases COMP/E-1/36.604 and COMP/E-1/36.756

<sup>3</sup>Case COMP/E-1/36.756

<sup>4</sup>Case COMP/E-2/37.533

<sup>5</sup>particularly if the markets are asymmetric (Bernheim and Whinston (1990)), or firms' objective functions are concave (Spagnolo (1999)), or if the demand is random (Mat-sushima (2001)).

cartels ought to be managed by the same manager at the highest level. In particular Pénard (2000) shows that when firms face random and unobservable demands and have a multitude of contacts, then centralization is more conducive to collusion than decentralization. Furthermore Cyert, Kumar and Williams (1995) suggest that price wars are more likely to occur in markets where price decisions are decentralized. Finally Harrington (2006) notes that centralization can be adopted to keep non-participant employees not only in the dark but also in line. He suggests that ADM and Christie’s pricing strategy was deliberately maintained at a high management level once cartels had been established.<sup>6</sup> All of these studies conclude that centralization may assist firms to sustain collusion and the positive outcomes for firm welfare it entails.

In our framework, centralization for colluding firms has advantages and disadvantages from the point of view of effective cartel conduct. If firms sustain simultaneous collusive outcomes in different markets, then each subsidiary could be managed by one agent to defeat the risk of a single investigation ending up as a multiple investigation. Hence multiproduct firms could choose to separate their collusive activities.<sup>7</sup>

The existing trade-off between coordination on the one hand and maintaining a discrete set of possibly legally insulated activities on the other was studied by Baker and Faulkner (1993) in social organizations. They reconstructed the intra firm communication networks involved in three major conspiracies in the heavy electrical equipment industry in the United States and found that centralization was primarily driven by the need for inter firm coordination. Some works dealing with organized crime and terrorism examine the role which information exchange plays along with the risk of detection,<sup>8</sup> but to the best of our knowledge, none of the economic papers dealing with the structure of firms engaging in cartel activity studies the trade-off between intra firm coordination and diversification of the ad-

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<sup>6</sup>Connor (1997) also points out that ADM is a very centralized firm: “*For a company of its size and diversity, ADM is managed by a remarkably small number of managers*”.

<sup>7</sup>Thomas and Willig (2006) consider an other drawback of two linked collusive agreements: firms’ payoffs can be lower assuming that information is perfect in one market but imperfect in the other. Under imperfect information, temporary price wars must be used to discipline the firms (as in Green and Porter (1984)), but this extends to the other market if collusive agreements are linked. Thomas and Willig (2006) show that the two collusive agreements may be insulated to prevent from the risk of contagion of prices wars. In ours, they may be separated to avoid the risk of contagion of antitrust authority’s investigations.

<sup>8</sup>See Garoupa (2007) or Baccara and Bar-Isaac (2008)

ministration (and insulation) of each cartel to distinct internal administrative or product divisions. Here we hope to contribute to the rapidly flourishing literature on the choice of organizational structure.

With such things in mind optimal organizational design can depend upon a number of factors, including: which tasks compliment each other (Harris and Raviv (2002); Puschke (2009)), the firm's size and its product diversity (Chandler (1962); Aghion and Tirole (1995); Spiegel (2009)), the provision of incentives and the precision of the intra firm performance measures (Maskin, Qian and Xu (2000); Besanko, Régibeau and Rockett (2005); Puschke (2009); Berkovitch, Israel and Spiegel (2010)), the uncertainty of the projects (Qian, Roland and Xu (2006)) or the firm's strategic behavior (Baye, Crocker and Ju (1996); Tan and Yuan (2003); Zhou (2005)). To our knowledge, however, there is no work which explores the question of whether it is necessary from the firms perspective, to protect internal information from investigations by outside agents in order to avoid serendipity arising.

The closer paper in this spirit is Aubert, Kovacic and Rey (2006). They study the impact of leniency programs and reward programs for informants. They show that if the antitrust authority gives rewards to self-reporting employees, then colluding firms have to increase employees compensation. Firms should also reduce turn-over and restructuring in order to avoid such compensation for new employees. In this way the antitrust policy may increase the inertia of internal organization for a firm.

To study the interplay between collusion, organizational structure and competition policy, we consider a framework with two firms, two substitute goods and an antitrust authority. Firms can choose between two organizational forms: the U-form and the M-form. In the U-form structure, one manager chooses the price of the two goods with a view to profit maximization. In the M-form organization, prices are decided by two managers, each one choosing the price of one product to maximize the profit of his own division. Our main argument is that the M-form organization compartmentalizes collusive agreements into different divisions and then reduces the probability that the authority will find hard evidence of several infringements when it investigates in only one market. In contrast, in the U-form model, collusive agreements are centralized under the supervision of a single manager and once the authority has successfully dealt with one cartel, there is a clear likelihood that others may be discovered. A trade-off exists between the coordination among the two prices and the compartmentalization of the evidence of collusion. When a firm infringes antitrust

laws on several markets, it may choose to be a decentralized organization so as to reduce the possibility for the authority to find evidence of several infringements when it investigates a single offense.

Remark: these observations happen to favor an alternative interpretation. The two firms could be considered as multidivisional, each division producing one product. The initial choice between the U-form and the M-form organizations can be reinterpreted as a decision made by the chief executive officer (CEO) as to whether to carry out the price decision himself or to assign it to another manager (M-form). The organizational choice is no longer about the internal structure of a firm but rather is about cartel organization. Firms initially choose to create two independent cartels subject to the authority of division managers and concerning only one product or alternatively a unique cartel put under the immediate authority of a CEO and concerning both products.<sup>9</sup>

Choi and Gerlach (2009) focus on different questions but their model is close to ours. They study the impact of antitrust policy on collusion structure when two firms interact on markets with demand linkages. If the goods are close substitutes, collusion can be sustained only if the firms simultaneously collude in the two markets and revert to competitive equilibrium once at least one cartel has been successfully dealt with, because collusion is not sustainable in only one market, and thus antitrust policy has a *knock-on effect* so far as concerns enforceability. If the goods are strong complements, the firms can almost obtain monopoly rents even if they collude in only one market. Firms start by colluding in one market and once detected, they collude in the other market. In this case, antitrust policy has a *waterbed effect* where a depression or depressing event in one region leads to a raise on another. The authors also study the possibility that the authority may increase its investigation capacity to ensure that detection of one cartel implies the detection of the second. This case is similar to our U-form case. Our framework has a similar basis structure, but some hypothesis are different (we detail this in a footnote after the presentation of our model). Moreover our focus departs from theirs by concentrating on the organizational design of firms.

Our main results are the following. When firms have no choice but to act under the U-form or the M-form model, centralization may help a firm to sustain collusive outcomes if the antitrust fine is low, but decreases the collusive power of firms in the opposite case.

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<sup>9</sup>Harrington (2006) distills some information about cartel's organizational structures and notes that these are uneven among the cartels.

Under endogenous structure choice, firms face a trade-off between coordination and compartmentalization. By compartmentalizing collusive agreements, the M-form organization reduces the probability that antitrust authority uncovers inculpatory evidence of several infringements when it investigates only the one market. If the two products are close substitutes, competition between the two divisions of an M-firm results in low collusive prices which leads firms to choose the U-form structure despite the increased risk of a fine. If products are weak substitutes, firms need less coordination and compartmentalization favors the M-form structure.

Finally this paper investigates the effects of varying key parameters such as the discount factor value, the probability of cartel detection or the level of the antitrust fine. The paper also shows how results vary with imperfect compartmentalization.

The paper is organized as follows. In section 2, we describe our basic framework. Section 3 characterizes the collusive strategies under the U-form organization. Section 4 does likewise under the M-form structure. In section 5, we analyze the impact of organizational structure on collusive strategies when subject to exogenous constraints. Section 6 endogenizes the choice of organizational structure. Section 7 extends the results and the conclusion follows in section 8.

## 2 The Model

We consider a simple framework consisting of an antitrust authority and two identical firms 1 and 2 both producing two differentiated products A and B, each produced with the same constant marginal cost  $c$ , which is for simplicity assumed to be zero.

Firms play a two-stage game: they firstly choose an organizational structure<sup>10</sup> inside the strategy space [M-form, U-form] and, second, play an infinitely repeated game of price competition. Firms can decide to reach a collusive agreement. The collusion outcomes are modeled on a grim trigger basis: as soon as a firm deviates from the agreement, all other firms will play non-cooperatively forever.

Collusion requires communication between firms and generates hard evidences, which can be found by the authority with an exogenous probability. Both firms have the same discount

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<sup>10</sup>except in the exogenous structure case (see Section 5).

rate  $\delta \in (0, 1)$ .

The demand functions for products A and B are:<sup>11</sup>

$$Q^A(p^A, p^B) = \max \left\{ 0, \min \left\{ a - bp^A + d(p^B - p^A), \frac{\frac{a}{b} - p^A}{\frac{b+d}{b(b+2d)}} \right\} \right\}$$

$$Q^B(p^A, p^B) = \max \left\{ 0, \min \left\{ a - bp^B + d(p^A - p^B), \frac{\frac{a}{b} - p^B}{\frac{b+d}{b(b+2d)}} \right\} \right\}$$

The parameter  $d$  is a measure of product substitutability ranging from zero (independent products) to infinity (perfect substitutes). As the values of  $a$  and  $b$  do not play a major role, we assign specific values:  $a = 10$  and  $b = 1$ .

## 2.1 Organizational design

In the first stage firms determine their organizational form. Firstly, each firm may adopt a centralized or unitary organizational structure (U-form) in which a manager chooses the prices of the two products maximizing the overall profit for the firm. Second, they can select a decentralized or multidivisional structure (M-form) in which two divisional managers, maximizing the profit of their own divisions, determine each one the prices of a single product.

Once firms have selected their organizational structure they can reach collusive agreements. If they adopt the same organizational form, then they select a symmetric collusive agreement. In the opposite case, one manager wants to maximize the overall profit of his firm whereas in the other firm two managers seek to maximize only their own divisional profit. Equilibrium prices should reflect these two different objectives. In the next subsection we simplify our analysis by choosing assumptions which guarantee that the U-form organization is the best reply to itself and thus the two firms will always select the same organizational structure in a pure strategy Nash perfect equilibrium. We assume that when the first stage of the game has two pure strategy Nash equilibria, firms are able to coordinate on the one

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<sup>11</sup>Belleflamme, Picard and Thisse (2000) describe how these demand functions can be derived from a quadratic utility function. The demand for each product has a kink at a critical price for which consumers stop buying one of the product and demand a quantity  $(\frac{a}{b} - p) / (\frac{b+d}{b(b+2d)})$  of the other product,  $p$  referring to the product for which the quantity is positive (See Vives, 1999).

with the highest expected profits.<sup>12</sup>

## 2.2 Antitrust policy

The policies adopted by the antitrust authority are intended to deter collusion. At the end of each collusive period, the authority can suspect collusion in a market with a probability denoted by  $\rho$ . Then it commences an investigation which leads to a successful prosecution with a probability of  $\mu_1$  and a fine  $F$  is imposed on each member of the cartel. Moreover during this one-market investigation, the antitrust authority may find cogent evidence of a collusive agreement in the other market. The probability of this depends on the organizational structure of the firms: it is equal to  $\mu_2$  if the two firms are centralized,  $\mu_3$  if they are decentralized and  $\mu_4$  if we consider an asymmetric organizational structure. In the case of a successful prosecution by the authority, firms must pay a second fine  $F$ . We suppose that convicted cartels revert to non-cooperative behavior forever after.

We intuitively assume that:  $\mu_2 \geq \mu_4 \geq \mu_3$ . It is easier for an antitrust authority to find cogent evidence of collusion in one market during an investigation in the other if firms act in a centralized way. The relevant assumption  $\mu_2 \geq \mu_3$  requires more justification. Hammond (2009) analyzes the implementation of the US antitrust division and notes that: *"The Division will target its proactive efforts in industries where we suspect cartel activity in adjacent markets or which involve one or more common players from other cartels. When we are able to identify culpable executives, we begin digging deeper to determine whether they had pricing authority on other products over time and then for indicia of collusion in those products as well. [...] We will ask executives [...] not just about their knowledge of price fixing in the market under investigation, but whether they have any information of any cartel activity in other markets as well."* We can therefore expect a weaker probability that the authority finds cogent evidence of a collusive agreement in the non-investigated market if each agreement is managed by single decision maker without intermarket linkage. This assumption is also employed in the social organization studies undertaken by Baker and Faulkner (1993) where they stress that: *"Decentralization or 'compartmental insulation' limits exposure, making it difficult to uncover an entire network [...]"*. Finally, we assume

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<sup>12</sup>This assumption is used to remove the well-known problem of equilibrium selection in coordination game theory. Alternatively, we could assume that the organization's choice is cooperative or that firms sequentially choose their organizational design.



the only interesting case:  $\mu_2 > \mu_3$  as the opposite case would yield the U-form as a dominant strategy.

To simplify the exposition and to highlight the main effects, we assume that:<sup>13</sup>

$$\mu_1 = \mu_2 = \mu_4 = 1 > \mu_3 \equiv \mu$$

We first focus on the case  $\mu = 0$  and postpone the study of the case  $\mu > 0$  until section 7. The hypothesis  $\mu_2 = \mu_4$  implies that the asymmetric case may be disregarded in this paper as it is always dominated by the U-form symmetric case.

If a firm deviates from a collusive agreement by cutting its price(s), the authority can still find collusion during this deviation period, but a past offense can not be detected any more once firms have reverted to competitive pricing. In section 7, we consider the possibility of a higher fine for repeat offenders. Formally, the first time the firms are successfully prosecuted, the imposed fine is  $F$  whereas the sanction is increased by  $\theta$ , with  $\theta \geq 1$ , in the event of repeated offense. We fix  $\theta = 1$  until section 7.

We treat all these policy parameters as exogenous. The exogenous assumption about the parameters  $\rho$  and  $F$  eliminates several potential effects of the antitrust policy. If  $\rho$  was dependent on the firms' prices then the cartel could adopt complex price patterns (Harrington (2004b and 2005); Harrington and Chen (2006)). If  $F$  was dependent on the seriousness, firms could choose to lower prices below the monopoly level to decrease the expected fine (Besanko and Spulber (1989); Souam (2001)) and may choose higher post-cartel prices if they were used to estimate damage (Harrington, 2004a). In this paper, we choose to disregard these effects so as to simplify the model and focus on the other interesting effects of antitrust policy.

Since  $\rho$  and  $F$  are exogenous parameters, colluding firms should set price at the monopoly level. Although products are differentiated in our paper, properties concerning collusive agreements are comparable to that of price competition models with homogeneous products as both firms sell both goods and firms are not differentiated. If  $\rho = 0$  we obtain the same results as previously demonstrated in the literature: in equilibrium, if the monopoly price is sustainable then any price between the competitive and the monopoly price can be sustained.

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<sup>13</sup>Choi and Gerlach (2009) mainly study the case  $\mu_1 = 1$  and  $\mu_2 = 0$ . They also study an extension in which the antitrust authority can increase its investigation capacity leading to  $\mu_2 = 1$ .  $\mu_3$  and  $\mu_4$  are irrelevant in their framework.

In the opposite case no higher price than the competitive one is sustainable. If  $\rho > 0$  and if a higher price than the competitive one is sustainable then the monopoly price is sustainable too (but the reciprocity is wrong).

In sum, the firms observe the exogenous antitrust policy. At that point they then choose an organizational structure among:  $\{U - form, M - form\}$ . Hence firms can reach a collusive agreement or compete on price. If they adopt a unitary organizational structure, then collusive agreements are managed by the top-managers of the firm. Under the decentralized structure, two divisional managers maximize the collusive profit of their own divisions and the agreements are independent. We use the subgame perfect Nash equilibria as the solution concept of this infinitely repeated game.

### 3 The U-form organization

Centralized firms have two different cartel options. The first is to simultaneously collude in the two markets ( $U_{sim}$  strategy). The second is to initiate a cartel concerning one market and then initiate collusion in the other market once the first cartel has been detected ( $U_{seq}$  strategy).<sup>14</sup>

ADM, which simultaneously colludes on the lysine, citric acid and gluconate markets offers an example of the  $U_{sim}$  strategy.<sup>15</sup> A further example concerns the car glass producers:<sup>16</sup> Saint-Gobain, Pilkington, etc. where surprise inspections in 2005 at several sites of car glass producers in Europe permitted the authorities to discover and fine the cartel participants, including several differentiated products such as glass for windcreens, sidelights, backlights and sunroofs.

ENI and Shell (or their respective subsidiaries) can both be considered as an example of the  $U_{seq}$  strategy as they were implicated in 1986 (Polypropylene<sup>17</sup>) and 1994 (PVC<sup>18</sup>) for

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<sup>14</sup>If  $\theta > 1$ , there is a third possibility: collude in only one market and stop colluding once firms are fined ( $U_{one}$  strategy). When  $\theta = 1$ , this third strategy is always dominated by the  $U_{seq}$  strategy: if firms benefit from colluding in only one market, then they also benefit to collude in the second one once the first cartel has been discovered and fined as the first and second cartels generate the same profits.

<sup>15</sup>Cases COMP/36.545/F3, COMP/E-1/36.604 and COMP/E-1/36.756

<sup>16</sup>Case COMP/39125

<sup>17</sup>Case IV/31.149

<sup>18</sup>Case IV/31.865

cartel activities but re-engaged in collusive behavior in the paraffin wax sector<sup>19</sup> after having received the Commission Decisions for the two previous cases.

### 3.1 Simultaneous cartels in both markets ( $U_{sim}$ strategy)

Assuming that firms simultaneously collude in both markets, the U-form organization implies that the detection of one-market collusion leads to successful detection in the other market. In this case, the antitrust authority imposes a fine of  $2F$  and firms engage in repeated price competition forever after.

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

	Collusion	Deviation	Punishment <sup>20</sup>
Price	$p_i^X = 5$	$p_i^{dX} = 5 - \varepsilon$	$p_i^{pX} = c = 0$
Quantity	$q_i^X = \frac{5}{2}$	$q_i^{dX} = 5$	$q_i^{pX} = 5$
Profit	$\pi_i^{cU} = 25$	$\pi_i^{dU} = 50$	$\pi_i^{pU} = 0$

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

$$\Pi_i^{U_{sim}} = \pi_i^{cU} - [1 - (1 - \rho)^2] 2F + \delta (1 - \rho)^2 \Pi_i^{U_{sim}} \Leftrightarrow \Pi_i^{U_{sim}} = \frac{25 - 2\rho(2 - \rho)F}{1 - \delta(1 - \rho)^2}$$

Deviations are punished with eternal Nash reversion involving this current gain:

$$\Pi_i^{dU_{sim}} = 50 - 2\rho(2 - \rho)F$$

Collusion in both markets is sustainable if and only if one shot defection followed by punishment leaves less profits than staying on a collusive path, this requires:

$$\Pi_i^{U_{sim}} \geq \Pi_i^{dU_{sim}} \Leftrightarrow F_{U_{sim}} \equiv 25 \frac{\delta(1 - \rho)^2 - \frac{1}{2}}{\delta(1 - \rho)^2 \rho(2 - \rho)} \geq F$$

<sup>19</sup>Case COMP/39181

<sup>20</sup>During the punishment phase, firms set price equal to marginal cost (i.e. equal to zero). Equilibrium quantity is arbitrarily set to 5 in the table (such value is the quantity for which price is strictly equal to 0), but results would be the same considering higher values of equilibrium quantities.

This threshold value increases with  $\delta$ , decreases with  $\rho$ , but is independent of  $d$ .

**Remark:** We assume that colluding firms choose the monopoly price. It is straightforward to show that it is the best strategy for firms. If such firms choose a price strictly less than the monopoly price (and higher than competitive price), then  $\Pi_i^{U_{sim}}$  decreases and the scope for which a collusive agreement can be sustainable is narrower.<sup>21</sup> This remark should be regarded as pervasive throughout this paper.

### 3.2 Sequential collusion ( $U_{seq}$ strategy)

In this section firms engage in cartel activity in only one of the two markets (market B), maintaining price competition in the second market until the cartel is discovered, at which point collusion is commenced in the second market (market A). We successively determine equilibrium values in the second and in the first cartels.

#### 3.2.1 Second cartel

In market B, the cartel has been discovered and equilibrium prices equal marginal cost:  $p_1^B = p_2^B = c = 0$ . In market A, firms behave monopolistically. The best-response function of a firm monopolizing the market A is:  $p^A = \frac{10+dp^B}{2(1+d)}$ . Setting  $p^B = 0$ , we obtain:

$$\tilde{p}_i^A = \frac{5}{1+d} \quad , \quad \tilde{q}_i^A = \frac{5}{2} \quad \text{and} \quad \tilde{\pi}_i^c = \frac{25}{2(1+d)}$$

The present discounted value of a firm in collusion is given by:

$$\tilde{\Pi}_i = \tilde{\pi}_i^c - \rho F + \delta(1-\rho)\tilde{\Pi}_i \Leftrightarrow \tilde{\Pi}_i = \frac{\frac{25}{2(1+d)} - \rho F}{1 - \delta(1-\rho)}$$

whereas deviation profit is given by:

$$\tilde{\Pi}_i^d = 2\tilde{\pi}_i^c - \rho F = \frac{25}{1+d} - \rho F$$

Consequently, collusion is sustainable if and only if:

$$\tilde{\Pi}_i \geq \tilde{\Pi}_i^d \Leftrightarrow \tilde{F} \equiv \frac{2\delta(1-\rho) - 1}{\delta\rho(1-\rho)} \frac{25}{2(1+d)} \geq F$$

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<sup>21</sup>A change in equilibrium price would decrease the value of  $F_{U_{sim}}$  by replacing the first term (25) by a smaller value.

$\tilde{F}$  decreases as  $d$  and  $\rho$  increase or  $\delta$  decreases. If the value of  $d$  is high the one-market collusive profit is low as the competition between products is fierce and thus collusion is sustainable as long as  $\delta$  is high and  $\rho F$  very small.

### 3.2.2 First cartel

In market B, equilibrium prices and quantities are the same as in the previous case and each firm's per-period payoff associated with collusion is given by:  $\tilde{\pi}_i^c = \frac{25}{2(1+d)}$ , leading to this expected payoff of the collusive firm:

$$\Pi_i^{U_{seq}} = \tilde{\pi}_i^c - \rho F + \delta(1-\rho)\Pi_i^{U_{seq}} + \delta\rho\tilde{\Pi}_i \Leftrightarrow \Pi_i^{U_{seq}} = \frac{(1-\delta+2\delta\rho)\left(\frac{25}{2+2d} - \rho F\right)}{[1-\delta(1-\rho)]^2}$$

The current gain from deviation is given by:

$$\Pi_i^{dU_{seq}} = 2\tilde{\pi}_i^c - \rho F = \frac{25}{1+d} - \rho F$$

Then collusion is sustainable if and only if:

$$\Pi_i^{U_{seq}} \geq \Pi_i^{dU_{seq}} \Leftrightarrow F_{U_{seq}} \equiv \frac{-1+3\delta-2\delta\rho-2\delta^2(1-\rho)^2}{[1-\delta(1-\rho)^2]\delta\rho} \frac{25}{2(1+d)} \geq F$$

Intuitively, this condition is easier to sustain than:  $F \leq \tilde{F}$ . Indeed, the per-period collusive and deviation profits are equal in the first and in the second cartels. However, the collusive expected payoff is higher in the first cartel because account is taken of the expected collusive outcome in the second cartel.

### 3.3 Strategy's choice

**Comparison of the two cartel options:** When both cartels are sustainable, the simultaneous case dominates sequential cartels if and only if:

$$\Pi_i^{U_{sim}} \geq \Pi_i^{U_{seq}} \Leftrightarrow F_1 \equiv 25 \frac{[1-\delta(1-\rho)]^2 - [1-\delta(1-\rho)^2](1-\delta+2\delta\rho)\frac{1}{2+2d}}{[3-2\rho-\delta\rho+(3\rho-6)\delta(1-\rho)+3\delta^2(1-\rho)^2]\rho} \geq F$$

$F_1$  is an increasing function of the value of the substitutability between products.

**Comparison of fine threshold levels:** To determine the equilibrium strategy of firms, we must compare the threshold values for which the two collusive strategies are sustainable.

$$\tilde{F} > F_{U_{sim}} \Leftrightarrow \frac{2\delta(1-\rho)^2 - 1 + \rho}{1+d} > \frac{2\delta(1-\rho)^2 - 1}{2-\rho}$$

If  $d = 0$ :  $\tilde{F} > F_{U_{sim}}$ ; if  $d$  is relatively high, then  $F_{U_{sim}} > \tilde{F}$ , implying that the two curves intersect one time.

**Proposition 1:** *When firms act as U-form organizations, they choose a sequential cartel model when product substitutability is very weak and competition policy is strict ( $\tilde{F} > F > \min(F_1, F_{U_{sim}})$ ). Firms will choose a simultaneous option if competition policy is not strict ( $F < \min(F_1, F_{U_{sim}})$ ). Finally firms do not collude if the antitrust fine is very high ( $F > \max(\tilde{F}, F_{U_{sim}})$ ).*

**Graphical representation:** We plot the sustainability threshold values and the previous conditions in a  $d$ - $F$  diagram to identify different regions representing the various organizations of collusion. We choose:  $\rho = 0.01$  and  $\delta = 0.8$ . Three different regions, bounded by the border lines in full line, appear in the graph:  $U_{seq}$ ,  $U_{sim}$  and *No Collusion*.

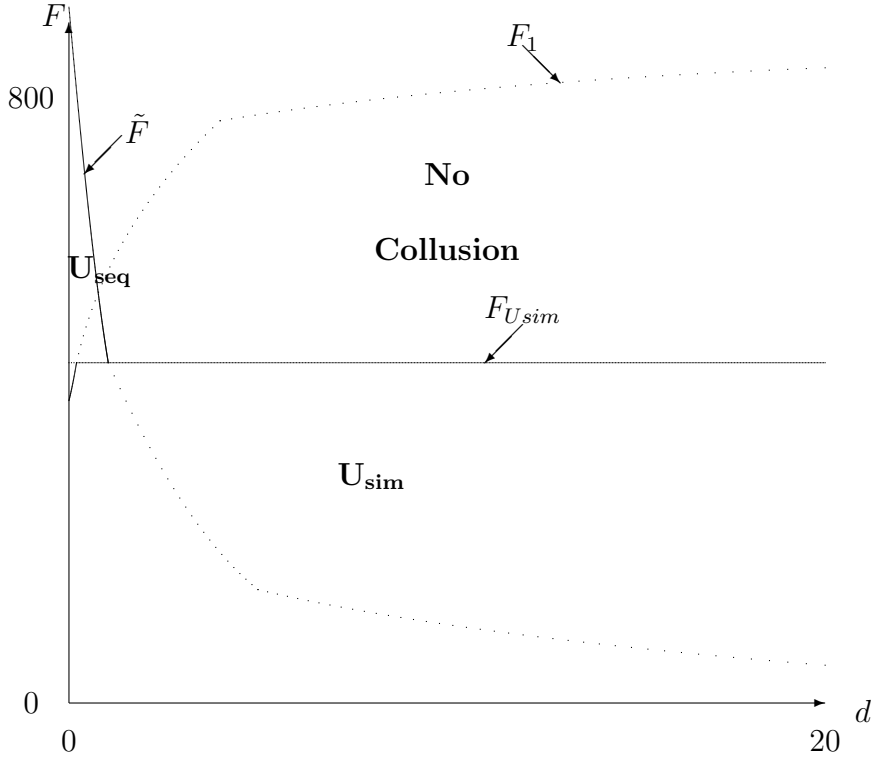


Figure 1: Collusive equilibria in the U-form organization

If products are sufficiently strong substitutes, then the  $U_{seq}$  strategy yields low equilibrium prices and thus firms simultaneously collude in the two markets unless the fine is high, and if it is, firms will revert to a competitive equilibrium. If products are sufficiently weak substitutes and  $F$  is not too high, the  $U_{seq}$  strategy can be easier to sustain than the  $U_{sim}$ , which thus dominates, even if this latter strategy is sustainable. If  $F$  is high, sequential collusion is still sustainable while simultaneous collusion is not. Finally, if  $F$  is very high or  $d$  is increased, then neither strategy is sustainable.

The comparison between the  $U_{seq}$  and  $U_{sim}$  areas demonstrates two effects. First, the  $U_{sim}$  strategy yields higher per-period profits than the  $U_{seq}$  strategy. Second, cartels are longer-lasting in the  $U_{seq}$  strategy than in the  $U_{sim}$  strategy. In our paper, the date of cartel dissolution is determined to follow a geometric distribution. The expected cartel life duration under the  $U_{sim}$  strategy is  $\frac{1}{(2-\rho)\rho}$  whereas it is equal to  $\frac{1}{\rho}$  for each cartel under the  $U_{seq}$  strategy. Moreover under the  $U_{seq}$  strategy, fines are paid later and so all other things being equal, the present value of the fine is lower. Henceforth, there exists a trade-off

among lower equilibrium prices but longer-lasting agreement under the  $U_{seq}$  strategy when compared with the other cartel option.

## 4 The M-form organization

In this section we assume that both firms exhibit the M-form organizational behavior. Four strategies can be studied. Suppose both firms simultaneously collude in the two markets, then when a cartel has been successfully detected in only one market, firms can either continue to collude in the other market (designed by  $Mc$  strategy) or can stop (designed by  $Ms$  strategy). Firms can also choose to collude in only one market and once discovered, they commence collusion in the second market, but this strategy is the same as the  $U_{seq}$  strategy in the previous section. Finally, they can choose to collude in only one market and stop colluding once detected. This is the same scheme as the  $U_{one}$  strategy defined in the previous section which is once again dominated by the  $U_{seq}$  strategy (since  $\theta = 1$ ). The assumption  $\mu = 0$  implies that the  $Mc$  strategy dominates the  $U_{seq}$  one. The only advantage of this latter strategy is that a detection of one cartel does not necessarily imply the detection of the other; this is true for  $\mu > 0$ . If  $\mu = 0$ , it is better for firms to collude simultaneously in the two markets in order to be able to set higher prices without decreasing the expected duration of the second cartel. Consequently only simultaneous cartels are relevant for decentralized firms when  $\mu = 0$ .

The Japanese and Korean companies Ajinomoto and Cheil Jedang Ltd, involved in the lysine price-fixing conspiracy<sup>22</sup> can be seen as an example of the  $Mc$  strategy. Once the cartel was detected, collusion continues in the nucleotide cartel until 1998.<sup>23</sup> The very decentralized Akzo Nobel group is another convincing real-life example.<sup>24</sup> Akzo Nobel N.V, a subsidiary of the group, was fined after an investigation by the Commission which established that it

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<sup>22</sup>Case COMP/36.545/F3

<sup>23</sup>Case COMP/E-1/C.37.671

<sup>24</sup>"Since 1993-1994, the Akzo Nobel group has been organized on the basis of a two layer structure: a "corporate centre" and directly underneath approximately 20 Business Units ("BUs"). The corporate centre co-ordinates the most important tasks with regard to general strategy of the group, that is to say finance, legal affairs and human resources. The BUs each have their own General Manager, management team and supporting services responsible for the entire operational management of the BU." EC (Case COMP/F/38.620 – hydrogen peroxide and perborate).



operated a secret sodium gluconate cartel from 1987 until 1995.<sup>25</sup> Therefore this did not deter other subsidiaries from continuing with illegal activities.<sup>26</sup> Obviously the *Ms* strategy can not be experienced in antitrust decisions because the second cartel is never detected.

#### 4.1 The collusion stops (*Ms* strategy)

On the two markets, the two divisions agree to determine collusive prices maximizing joint profit. However, divisions belonging to different markets compete on price. Equilibrium prices are the same when considering two firms competing with differentiated products (one firm producing only the product A, the other firm the product B).

We obtain the following equilibrium per-period values for collusion, deviation and punishment strategies:

	Collusion	Deviation	Punishment
Price	$p_i^X = \frac{10}{2+d}$	$p_i^{dX} = \frac{10}{2+d} - \varepsilon$	$p_i^{pX} = c = 0$
Quantity	$q_i^X = 5\frac{1+d}{2+d}$	$q_i^{dX} = 10\frac{1+d}{2+d}$	depends on the other market price
Profit of a division	$\pi_i^{cM} = 50\frac{1+d}{(2+d)^2}$	$\pi_i^{dM} = 100\frac{1+d}{(2+d)^2}$	$\pi_i^{pM} = 0$

On deviation strategy, a division sets a lower price ( $p_i^X - \varepsilon$ ) in order to supply one entire market. But it is not desirable for firms to reduce the price still further to win some customers from the other market, because the collusive price is the best response to the other market price.

The present discounted value of a division from colluding is given by:

$$\Pi_i^{Ms} = \pi_i^{cM} - \rho F + \delta(1 - \rho)^2 \Pi_i^{Ms} \Leftrightarrow \Pi_i^{Ms} = \frac{50\frac{1+d}{(2+d)^2} - \rho F}{1 - \delta(1 - \rho)^2}$$

<sup>25</sup>Case COMP/E-1/36.756

<sup>26</sup>EKA Chemicals AB operated a cartel in the market of hydrogen peroxide and its downstream product sodium perborate until 1999 (Case COMP/F/38.620), but also in the sodium chlorate until 2000 (Case COMP/38.695). Another subsidiary (Akzo Nobel Chemincals SpA) participated in the choline chloride agreement until 1998 (Case COMP/E-2/37.533).

The current gain from deviation is given by:

$$\Pi_i^{dMs} = 100 \frac{1+d}{(2+d)^2} - \rho F$$

Collusion is sustainable if and only if:

$$\Pi_i^{Ms} \geq \Pi_i^{dMs} \Leftrightarrow F_{Ms} \equiv \frac{2\delta(1-\rho)^2 - 1}{\delta(1-\rho)^2 \rho} 50 \frac{1+d}{(2+d)^2} \geq F$$

## 4.2 The collusion continues (*Mc* strategy)

In the first phase of the cartel agreement (firms collude in both markets), equilibrium values of each division are the same as with the *Ms* strategy. In the second phase (firms collude in only one market), prices, quantities and profits are the same as the results obtained in section 3.2.1.

The present discounted value of a division from colluding is given by:

$$\begin{aligned} \Pi_i^{Mc} &= \pi_i^{cM} - \rho F + \delta(1-\rho)^2 \Pi_i^{Mc} + \delta(1-\rho) \rho \tilde{\Pi}_i \\ \Leftrightarrow \Pi_i^{Mc} &= \frac{50 \frac{1+d}{(2+d)^2} - \rho F + \delta(1-\rho) \rho \tilde{\Pi}_i}{1 - \delta(1-\rho)^2} \end{aligned}$$

The current gain from deviation is given by (deviation occurs in the first phase):

$$\Pi_i^{dMc} = 2\pi_i^{cM} - \rho F = 100 \frac{1+d}{(2+d)^2} - \rho F$$

Collusion is sustainable if and only if the two following conditions hold:

$$\Pi_i^{Mc} \geq \Pi_i^{dMc} \Leftrightarrow F_{Mc} \equiv \frac{[1 - \delta(1-\rho)] [2\delta(1-\rho)^2 - 1] \frac{50(1+d)}{(2+d)^2} + \delta(1-\rho) \rho \frac{25}{2+2d}}{[1 - \delta(1-\rho)^2] \delta(1-\rho) \rho} \geq F$$

and

$$F \leq \tilde{F}$$

The first condition is less restrictive than the second one:  $F_{Mc} > \tilde{F}$ .<sup>27</sup>

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<sup>27</sup>If  $\mu > 0$ , the most restrictive condition depends on the degree of product differentiation.

### 4.3 Strategy choice

Equilibrium profits are the same under the *Ms* or *Mc* strategies before the antitrust authority detects one of the collusive agreements. After this, *Ms* strategy's profits equal to 0 involving that firms choose the *Mc* strategy if of course it is sustainable (this unavoidably implies positive profits after the detection of the first collusive agreement).

Intuitively,  $F_{Mc} > F_{Ms}$  if  $F \leq \tilde{F}$ . It is easier for firms to sustain the first phase if firms can collude once more once a first cartel has been detected.

We must compare  $F_{Ms}$  and  $\tilde{F}$ :

$$F_{Ms} > \tilde{F} \Leftrightarrow \frac{2\delta(1-\rho)^2 - 1}{4 + 4d + d^2} > \frac{2\delta(1-\rho)^2 - 1 + \rho}{4 + 8d + d^2}$$

For  $d = 0$ :  $\tilde{F} > F_{Ms}$ . If  $\rho$  is sufficiently lower than  $d$ , then  $\tilde{F} < F_{Ms}$ .

**Proposition 2:** *When firms are constrained to choose the M-form organization, they choose the Mc strategy if  $F \leq \tilde{F}$ ; the Ms strategy if  $F \leq F_{Ms}$  and  $F > \tilde{F}$ ; and they do not collude if  $F > \max(F_{Ms}, \tilde{F})$ .*

## 5 Impact of the organizational structure on collusion

Before going into detail about the choice of organizational structure, it is interesting to study the impact of organization on collusion whilst considering exogenous organizational structures. Consideration of high synergies among tasks or incentives can constrain the organization<sup>28</sup> and dominate the advantage of better protection against illegal activities.<sup>29</sup> In this case, collusive opportunities does not influence the structural organization of firm but the opposite is true.

We must compare these two threshold values:

$$F_{Ms} > F_{U_{sim}} \Leftrightarrow \frac{4 + 4d}{4 + 4d + d^2} > \frac{1}{2 - \rho}$$

<sup>28</sup>Maskin, Qian and Xu (2000), Harris and Raviv (2002), Besanko, Régibeau and Rockett (2005), Puschke (2009).

<sup>29</sup>Akzo Nobel provides once again an example. The EKA subsidiary contains several collusive agreements probably due to the synergies between products.

If  $d = 0$ :  $F_{Ms} > F_{U_{sim}}$ . If  $d$  is sufficiently high:  $F_{Ms} < F_{U_{sim}}$ .

The following graphical representation indicates the impact of organizational structure on collusive opportunities.

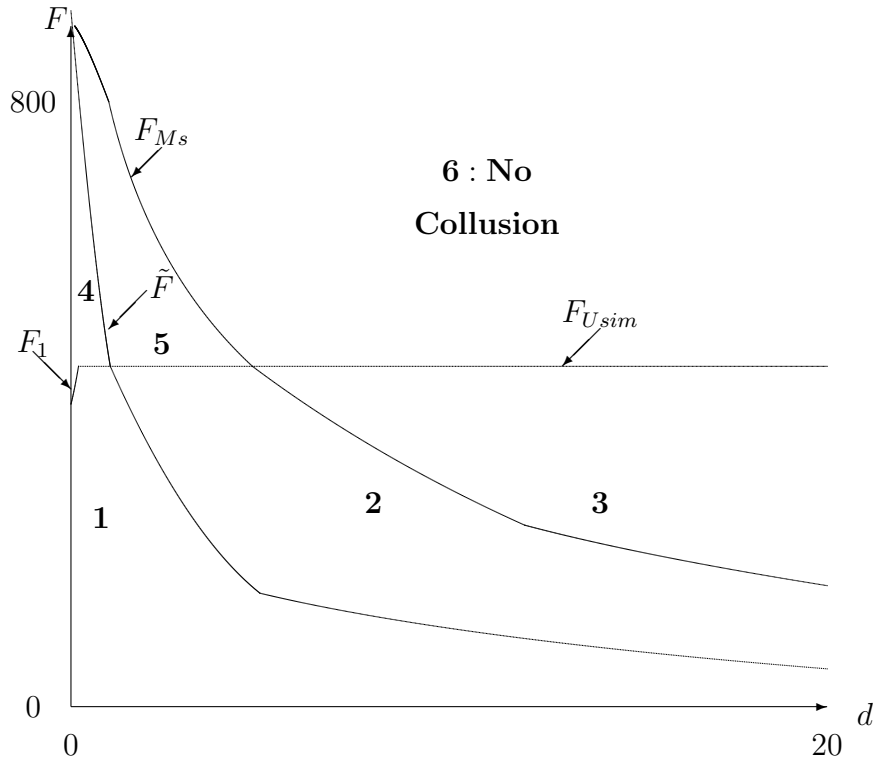


Figure 2: Impact of organizational structures on collusion

Six areas appear. In zone 1 firms choose to collude in the two markets whatever the organizational structure is, but with differences involving the structure of firms. Firstly, collusive prices are higher when firms are centralized (except in the limit case  $d = 0$ ). Second, a cartel is longer-lasting if firms are decentralized because collusion continues in the second market after the detection in the first, this is not the case with centralization. The zone 2 depicts the area where firms simultaneously collude and stop collusion once at least one cartel has been discovered. In zone 3 collusive agreements are sustainable only if firms are centralized.<sup>30</sup> In zones 2 and 3, collusive opportunities are reinforced by centralization

<sup>30</sup>Cyert et al. (1995) consider that this result applies if product differentiation is weak and describe real-life examples which provide that the decentralization yields the dissolution of the collusive agreement.

which admits higher prices than with decentralization.

Results change if expected fines are higher. In zone 4 decentralized firms simultaneously collude in the two markets whereas centralized firms choose sequential collusive strategy, in this case collusive prices are higher when firms are decentralized. The zone labeled 5 described an area where collusive agreements are sustainable only if firms are decentralized. Finally in the sixth zone collusion is never sustainable.

Our analysis focuses on the impact of organizational structures on collusion and the following proposition can now be stated:

**Proposition 3:** *Centralization may help firms to sustain collusive outcomes whenever the antitrust fine is low but decreases the collusive power of firms in the opposite case.*

## 6 Organizational choice

We now assume an endogenous model for the choice of organizational structure. Without any competition policy ( $\rho = 0$ ), firms choose the U-form organization and collude if  $\delta$  is sufficiently high.<sup>31</sup> But if the antitrust authority is fierce, centralization does not always dominate over decentralization.

### 6.1 Comparison of the two organizational structures

As noted in section 4, the *Mc* strategy dominates the *U<sub>seq</sub>* one if  $\mu = 0$ . So we have to compare the *U<sub>sim</sub>* strategy with the *Mc* and *Ms* strategies.

If the two conditions  $F \leq \tilde{F}$  and  $F \leq F_{U_{sim}}$  hold, the *U<sub>sim</sub>* and the *Mc* strategies are both sustainable. Firms will adopt the *U<sub>sim</sub>* strategy if and only if:

$$\Pi_i^{U_{sim}} \geq 2\Pi_i^{Mc} \Leftrightarrow F_2 \equiv 25 \frac{[1 - \delta(1 - \rho)] \left( \frac{1}{2} - \frac{2+2d}{(2+d)^2} \right) - \delta(1 - \rho)\rho \frac{1}{2+2d}}{(1 - \delta)(1 - \rho)\rho} \geq F$$

If  $d = 0$ :  $F_2 = -\frac{25}{2} \frac{\delta}{1-\delta} < 0$ . If products are perfectly independent, equilibrium price coordination provides no added value and so the M-form always dominates the U-form. As  $F_2$  is increasing with  $d$ , firms choose the U-form as long as  $d$  is sufficiently high.

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<sup>31</sup>Although the model is different we obtain analogous results to those of Pénard (2000).

If  $F_{Ms} \geq F > \tilde{F}$  and  $F \leq F_{U_{sim}}$ , the relevant comparison is between  $Ms$  and  $U_{sim}$ . If a cartel is successfully detected in one market, then collusion in the other market is deterred too, whatever the organizational structure is. However, the expected fines differ in these two organizational forms: in the U-form organization, the fine is simply  $2F$  whereas in the M-form, firms must pay the basic fine  $F$  and a double fine only if the two cartels are simultaneously detected. Firms adopt the  $U_{sim}$  strategy instead of the  $Ms$  strategy if and only if:

$$\Pi_i^{U_{sim}} \geq 2\Pi_i^{Ms} \Leftrightarrow F_3 \equiv \frac{\frac{25}{2} - 50\frac{1+d}{(2+d)^2}}{(1-\rho)\rho} \geq F$$

If  $d = 0$ :  $F_3 = 0$ .  $F_3$  is increasing with  $d$ .

Comparison of the fine threshold values yields  $F_3 > F_2$  (in the relevant zones). The advantage of decentralization structure tends to be favored by the possibility of firms to collude in the second market once the first cartel has been detected.

## 6.2 Equilibrium organization choice

### Proposition 4:

- If  $\tilde{F} > F > F_2$ , firms choose the *Mc* strategy.
- If  $F_{Ms} > F > \max(\tilde{F}, \min(F_3, F_{U_{sim}}))$ , firms choose the *Ms* strategy.
- In the other cases where  $F < F_{U_{sim}}$ , firms choose the *U<sub>sim</sub>* strategy.
- Firms do not collude if  $F > \max(\tilde{F}, F_{Ms}, F_{U_{sim}})$ .

**Corollary:** *If products are weak substitutes, firms adopt M-form organization. If products are strong substitutes and the fine is low, they adopt U-form organization. When the fine is high, collusion is deterred and firms are indifferent towards their organizational structures.*

In the following figure, the organizational structures are compared in  $(d, F)$  space. We choose these axes because if  $\delta$  is sufficiently high and  $\rho$  sufficiently small in order for  $\tilde{F}$ ,  $F_{Ms}$  and  $F_{U_{sim}}$  to be positive, the graphical representation has the same general shape which is independent from the exact values of  $\delta$  and  $\rho$ . We assume:  $\rho = 0.01$  and  $\delta = 0.8$ .

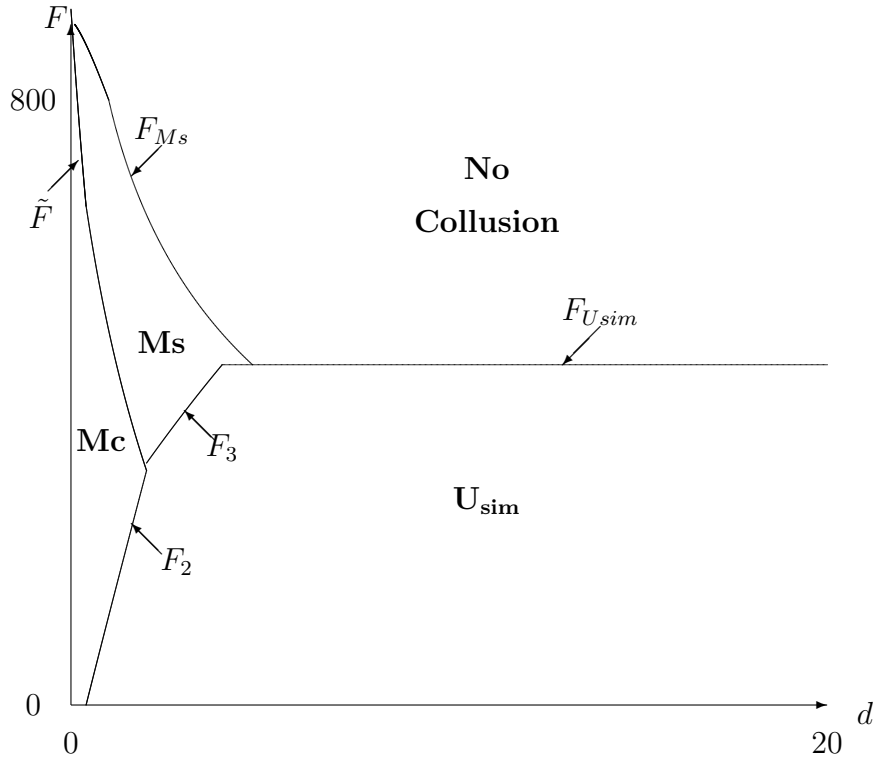


Figure 3: Equilibrium organizational structures

If goods are independent ( $d = 0$ ), firms adopt M-form organization even if the fine is nil. In this case, there is no impact on equilibrium prices by the absence of coordination between divisions, and firms still collude in one market if a cartel has been discovered in the other.

If goods are substitutable, the M-form organization yields competition between divisions of the same firm, therefore equilibrium prices and profits are lower on the collusive path. If  $d$  is sufficiently high, competition becomes too fierce and firms switch to U-form organization. The threshold value of  $d$  for which a firm is indifferent between U-form and M-form organizations increases as the fine increases. An increased fine constrains firms to choose M-form organization because the compartmentalization between divisions prevents it from being fined twice.

If the condition  $F > F_{U_{sim}}$  holds, simultaneous collusion under centralized organization is not sustainable. Consequently, firms choose M-form organization, if it is still sustainable.

Under imposed U-form organization, some firms may prefer the  $U_{seq}$  strategy depending on the values of parameters, whereas if firms can adopt M-form organization, the  $U_{seq}$  area disappears. In this area, firms select the  $Mc$  strategy. Consequently, the *waterbed effect* (ceasing a cartel activity triggers cartel formation in the other market) disappears when firms can select the M-form organization.

If condition  $F > \tilde{F}$  holds, the  $Mc$  strategy is no more sustainable. Thus, firms may adopt the  $Ms$  strategy. Therefore, antitrust policy can have a *knock-on effect*: successful prosecution in one market leads to the dissolution of the cartel in the other market.

### 6.3 Impact of some parameters

It is useful to analyze how the results vary with  $\delta$  and  $\rho$  values.

**Impact of the discount factor ( $\delta$ ):** In  $(F, d)$  space the general shape is not affected by the values of parameters if  $\delta$  is sufficiently high to sustain collusion. If we consider  $(F, \delta)$  space the general shape depends on product substitutability: firms choose centralized organization if  $d$  is sufficiently high and adopt a decentralized one in the opposite case. For these two extremes,  $\delta$  does not affect organizational structure but only influences the ability of firms to collude. By contrast for intermediate values of  $d$ ,  $\delta$  may lead to a change in the choice of organizational structure. We illustrate this point by plotting equilibrium structures in  $(F, \delta)$  space considering two cases:  $d = 1$  and  $d = 3$ .



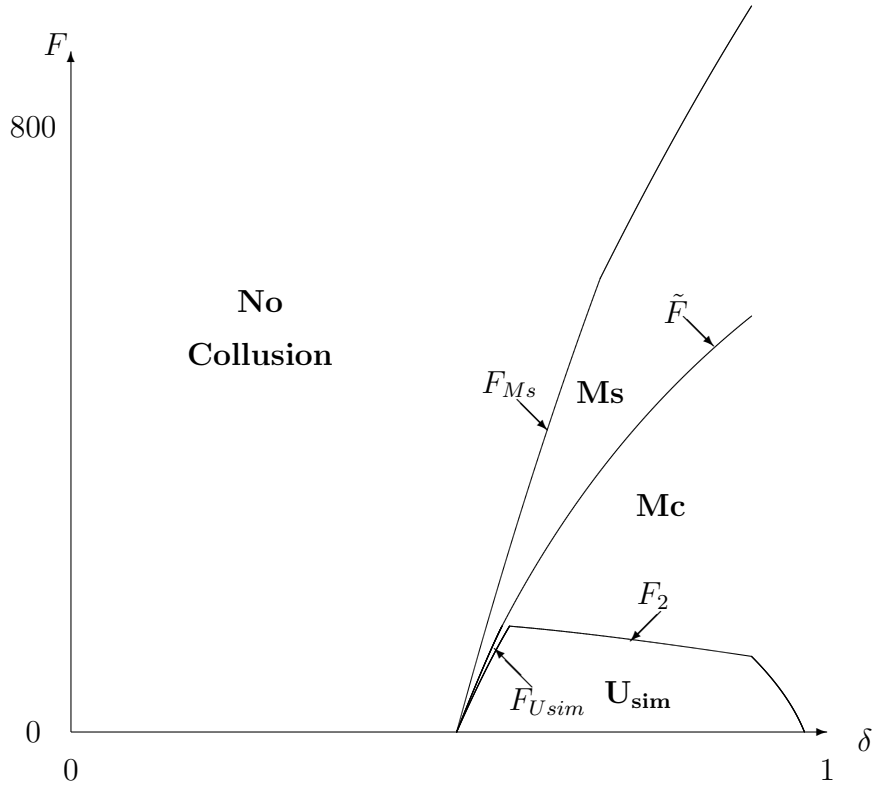


Figure 4: Impact of the discount factor ( $\rho = 0.01$  and  $d = 1$ )

If  $d = 1$ :  $F_{Ms} > \tilde{F} > F_{U_{sim}}$  and  $F_2$  is decreasing with  $\delta$ . Firms choose the  $Ms$  strategy for values of  $\delta$  slightly higher than 0.51 because it is the only sustainable strategy. They choose the  $Mc$  strategy for a higher value of  $\delta$ . If  $F$  is sufficiently high a greater increase in  $\delta$  does not impact upon collusive strategy. But for low  $F$  a greater increase in  $\delta$  drives firms to move from the  $Mc$  strategy to the  $U_{sim}$  one when the latter becomes sustainable. If  $\delta$  is very high firms revert to the  $Mc$  strategy because this strategy encourages collusive agreement on one market once the other cartel has been detected; this advantage taking place after a number of periods. So the  $Mc$  strategy advantage compared to the  $U_{sim}$  strategy increases with the value of  $\delta$ . For low values of  $F$  and  $d$  the degree of centralization for a firm is a non-monotonic function of  $\delta$ . An increased value of  $\delta$  first increases the centralization level and then decreases it.

For a higher value of  $d$  ( $d = 3$ ):  $F_{Ms} > F_{U_{sim}} > \tilde{F}$  and  $F_2 > \tilde{F}$ . In this case the *Mc* strategy is never selected at equilibrium<sup>32</sup> and the graphical representation of equilibrium organizational structures is simpler. An increased value of  $\delta$  may drive firms to adopt a more centralized organization when  $\delta$  increases.

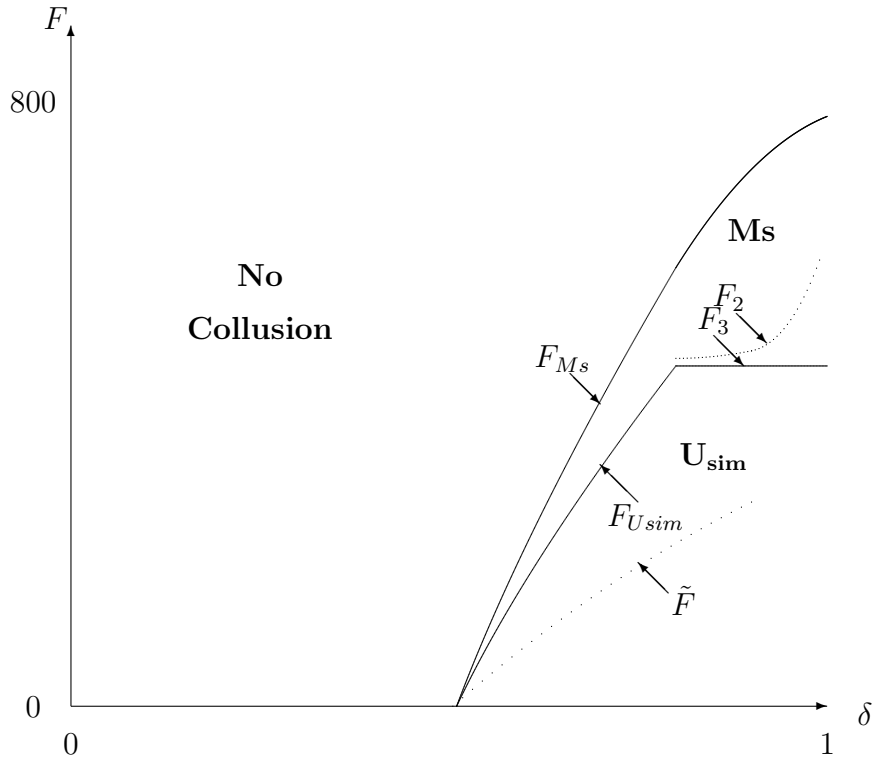


Figure 5: Impact of the discount factor ( $\rho = 0.01$  and  $d = 3$ )

For even higher values of  $d$ :  $F_{U_{sim}} > F_{Ms}$  and  $F_3 > F_{Ms}$ , then U-form is the only one equilibrium strategy and  $\delta$  does not impact anymore on the organizational choice.

**Proposition 5:** (a) *If  $\delta$  is high enough to warrant sustainable collusion irrespective of internal organization, an increased value of  $\delta$  can only imply a switch toward a more*

<sup>32</sup> $F_2$  is now an increasing function of  $\delta$ . The major advantage of the *Mc* strategy compared with the  $U_{sim}$  one is to allow collusive agreement on one market once the other cartel has been detected; advantage which is more effective when  $\delta$  increases. But this advantage is lower for high values of  $d$  since product substitutability affects the prices of one-market collusion. Another advantage is that the second fine is paid later in the *Mc* strategy, this advantage is weakened if  $\delta$  increases. For high values of  $d$  this second effect dominates the first and  $F_2$  evolves into an increasing function of  $\delta$ .

decentralized structure. (b) If  $\delta$  is low and collusion is only sustainable under the  $M$ -form internal structure, an increased value of  $\delta$  can encourage firms to choose a more centralized structure.

**Impact of the probability of detection ( $\rho$ ):**  $\tilde{F}$ ,  $F_{Ms}$ ,  $F_{U_{sim}}$ ,  $F_2$  and  $F_3$  are decreasing functions of  $\rho$ . As  $F_2$  and  $F_3$  decrease with higher values of  $\rho$  an increase in  $\rho$  can only lead to more decentralization on the assumption that sustainable collusion can be achieved whatever the internal organization is. This increase can also yield firms to choose the  $Ms$  strategy instead of the  $Mc$  one since the latter is no longer sustainable. This could be the case if  $F_{Ms} > \tilde{F}$  as  $\tilde{F}$  decreases with  $\rho$ . Also there may be a switch from the  $U_{sim}$  strategy to the  $Ms$  or  $Mc$  ones because the first strategy is no longer sustainable (even if profits would be higher). Therefore if  $\rho$  increases firms never leave a decentralized structure to switch to the  $U_{sim}$  strategy.

**Proposition 6:** *An increased probability of detection can only provide stronger incentives to choose a more decentralized structure.*

## 7 Extensions

In this section we briefly highlight the impacts of  $\theta > 1$  and  $\mu > 0$ . The expression of  $F_{U_{sim}}$  is the same whereas the expressions of the other threshold values are somewhat more complex.<sup>33</sup>

$$\begin{aligned}\tilde{F} &= \frac{2\delta(1-\rho) - 1}{\delta\rho\theta(1-\rho)}\tilde{\pi}_i^c & ; & \quad F_{Ms} = \frac{2\delta(1-\rho)^2 - 1}{\delta(1-\rho)^2[1+(1-\rho)\mu]}\pi_i^{cM} \\ F_{Mc} &= \frac{[1-\delta(1-\rho)][2\delta(1-\rho)^2 - 1]\pi_i^{cM} + \delta(1-\rho)\rho(1-\mu)\tilde{\pi}_i^c}{\{\rho(1-\mu)\theta + [1-\delta(1-\rho)](1-\rho)[1+(1-\rho)\mu]\}(1-\rho)\delta\rho} \\ F_2 &= \frac{[1-\delta(1-\rho)]\left(\frac{\pi_i^{cU}}{2} - \pi_i^{cM}\right) - \delta(1-\rho)\rho(1-\mu)\tilde{\pi}_i^c}{[1-\delta(1-\rho) - \delta\rho\theta](1-\mu)(1-\rho)\rho} & ; & \quad F_3 = \frac{\frac{\pi_i^{cU}}{2} - \pi_i^{cM}}{(1-\rho)(1-\mu)\rho}\end{aligned}$$

<sup>33</sup>Details are reported in Dargaud and Jacques (2010)

## 7.1 Imperfect compartmentalization ( $\mu > 0$ )

We now turn to the case of imperfect compartmentalization under decentralized organization. If a cartel is successfully detected in one market, the antitrust authority may find cogent evidence of a collusive agreement in the other (if firms collude in both markets) with probability  $\mu > 0$ . An increase in  $\mu$  only impacts the profits of decentralized firms, involving increased values of  $F_2$  and  $F_3$ . The values of  $F_{Mc}$  and  $F_{Ms}$  decrease. If  $d$  is very low then a new region in the graph is created where firms may choose the  $U_{seq}$  structure for some values of  $F$ .

**Proposition 7:** *An increase in  $\mu$  provides stronger incentives to choose U-form design.*

The following figure serves to illustrate the organizational choice under imperfect compartmentalization. We assume that  $\mu = 0.5$  and keep the values of the other parameters unchanged. We also plot on the graph the border lines of benchmark case values ( $\mu = 0$ ) with dots for comparison.

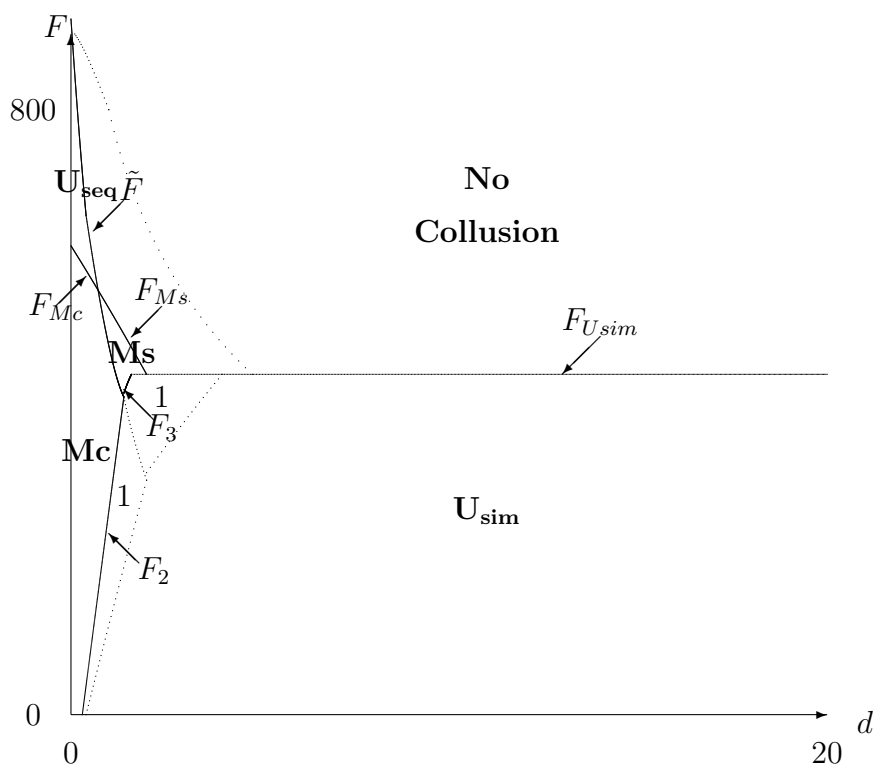


Figure 7: Imperfect compartmentalization

The two border lines between the  $U_{sim}$  and  $Mc$  areas and the  $U_{sim}$  and  $Ms$  areas move to the left. Firms switch to U-form organization if  $\mu$  is increased (zone "1"). This leads to a price increase in the collusive path. The maximum value of the antitrust fine which allows the  $Ms$  strategy and the first phase of the  $Mc$  strategy to be sustained decreases. The first border line moves downward and consequently the  $Ms$  strategy is less likely to occur in consideration of the competitive equilibrium. The second border line moves downward as well, and so sequential collusion ( $U_{seq}$  strategy) is selected because it is sustainable whereas a simultaneous collusion is not. In this zone, equilibrium prices decrease in the first phase of collusion and competition policy has a *waterbed effect*.

## 7.2 Impact of increased fine for recidivist firms ( $\theta > 1$ ):

We assume that the value of the fine is increased if the firms have already been fined for the same offense in the past. An increase in  $\theta$  reduces the expected profit of the  $Mc$  and  $U_{seq}$  strategies but does not affect the expected profit of the  $U_{sim}$  and  $Ms$  strategies. So  $\tilde{F}$  is decreased whereas  $F_2$  is increased. The values of  $F_{U_{sim}}$ ,  $F_{Ms}$  and  $F_3$  are the same. As  $F_2$  increases, firms can switch from the  $Mc$  strategy to the  $U_{sim}$  strategy. In this case a stricter antitrust policy leads to higher collusive prices. As  $\tilde{F}$  decreases there is also a region in which the firms switch from the  $Mc$  strategy to the  $Ms$  strategy (if  $F > F_3$ ) or to the  $U_{sim}$  strategy (if  $F_3 > F > F_2$ ).

**Proposition 8:** *An increase in  $\theta$  provides stronger incentives to choose U-form organization.*

## 8 Conclusion

This paper develops a theory concerning the degree of centralization of firms involved in multimarket collusive agreements. Our main assumption is that it is easier for an antitrust authority to find cogent evidence of collusion on one market during an investigation in the other market if the firms' organization is centralized. A divisional structure involves compartmentalization of different agreements and so dissipates evidence. When selecting an organizational structure, firms face a trade-off between coordination among firm's divisions (only feasible in a functional firm) and compartmentalization (only practicable in a divisional

firm). This trade-off depends to a great extent on the substitutability between products. We show that firms choose U-form organization when the goods are close substitutes and the M-form one when they are almost independent. The parameters of competition policy also affect this trade-off. Particularly, an increased value of the probability of cartel detection or a decreased fine for repeat offenders provides for stronger incentives to choose the M-form organization. A variation of the discount factor can non-monotonically alter the organizational structure. If its initial value is low then an increase can yield to a more centralized structure. In this opposite case firms can select M-form organization. If the compartmentalization is not perfect under M-form organization, then firms can prefer to select the U-form one.

The case of complementary goods may be studied, but, intuitively, this would yield to similar results. If the products are weak complements, firms choose the M-form organization because they do not require much coordination. They select U-form organization for more complementary goods and a sequential collusion strategy for very strong complements.

The implications of our framework are broader than the collusion case. Some other firms' offenses can be derived from our model such as tax evasion, corruption in procurement, moonlighting, intellectual property infringement and so on. Illegal activities in several divisions of the same firm favor the choice of M-form organization. Another implication of our results is that they reinforce the traditional argument of managerial overload to explain why a diversification strategy favors a divisional structure. Our model may also contribute to explain the conglomerates' birth and break: if the antitrust authority designs weak stances on collusion issues, then conglomerates are favored but a reinforcement of its investigation capacity may cause their disintegration.

This paper does not address the role of leniency programs primarily due to length constraints. Leniency programs are widely used as part of antitrust policy because they increase successful cartel investigations when they are well designed. The evaluation of the effects of leniency programs in the choice of centralization degree is an interesting topic for future research.

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