

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

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## Abstract

We characterize a new determinant of the choice of organizational design by multimarket collusive firms. Firms face a trade-off between the coordination advantage (under the U-form organization) and the possibility to hide hard evidence from the antitrust authority (under the M-form one). We also investigate the impact of leniency programs on this trade-off.

*JEL classification:* L22; L41; K42

*Keywords:* collusion; antitrust policy; organizational design; leniency program

## 1 Introduction

Since the works of Chandler (1962, 1975), many papers have studied the choice of firms' organizational structure and its implications for firm performance. It is widely recognized that: "*One of the key determinant of firms' success is an organization which fits with strategy*" (Roberts, 2004). In our paper, we highlight a new determinant which influences the degree of centralization of firms: the possibility to hide

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information from outside investigations. Firms can adopt a functional form (U-form) in which a manager chooses the prices of all the products maximizing the global profit of the firm, or a divisional structure (M-form) in which several divisional managers, maximizing the profit of their own divisions, determine each one the price of one product. We show that when a firm infringes antitrust laws on several markets, it may choose a decentralized organization, so as to reduce the possibility for the antitrust authority to find evidences of several infractions when it investigates on only one offense.

Several papers have already examined the determinants of organizational structure. The optimal organizational design depends on the complementarities among tasks (Harris and Raviv, 2002). Different organizational structures provide also various agent's incentives. Indeed, the M-form structure often allows a more precise performance measure,<sup>1</sup> and so yields the implementation of higher effort than in the U-form organization (Maskin, Qian and Xu, 2000; Besanko, Régibeau and Rockett, 2005; Berkovitch, Israel and Spiegel, 2010). But, the U-form organization may be better from this point of view when the tasks concern different products localized in different regions (Maskin et alii, 2000). Moreover, this structure allows more flexibility in the design of incentives when the tasks are significantly asymmetric (Besanko et alii, 2005).

It can sometimes be optimal to choose a structure which implements *ex-post* inefficiently projects in order *ex-ante* to incite the CEO to produce higher effort in searching projects with low investment cost. So a U-form structure can be a commitment to reject high cost projects (Berkovitch et alii, 2010). An M-form structure can also be selected to experiment on a small-scale uncertain projects before to implement them in all divisions (Qian, Roland and Xu, 2006). The organizational structure depends also on the firm's size. In particular, firms switch from the U-form organization to the M-form one when they grow and diversify (Chandler, 1962; Aghion and Tirole, 1995; Spiegel, 2009).

Strategic considerations can also be influential. In the U-form organization, the production department is dissociated from the marketing department. This separa-

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<sup>1</sup>the profit of a division is easier to compute than the contribution of a department at a project's success (Aghion and Tirole, 1995; Besanko, Régibeau and Rockett, 2005)

tion produces a double marginalization problem committing the firms to choose higher prices (Zhou, 2005). In the same way, Baye, Crocker and Ju (1996) show that Cournot competing firms can constitute competing independent divisions to obligingly increase their total production. Tan and Yuan (2003) show that firms can divide their product in several perfect complement components sold by independent divisions to commit themselves to higher prices when firms compete in price with differentiated products.

But, to the best of our knowledge, neither paper highlights the necessity to protect internal informations from investigations by outside agents.

The closer paper in this spirit is Aubert, Kovavic and Rey (2006). They study the impact of leniency program and reward program for informants. They show that if the antitrust authority gives reward to self-reporting employees, then colluding firms have to propose higher compensations to their employees. They should also reduce turn-over and restructuration in order to avoid compensation concerning new employees. In this way, the antitrust policy may increase the inertia of firms' internal organization.

Our main argument is that the M-form organization compartmentalizes collusive agreements in different divisions and then reduces the probability that antitrust authority finds hard evidences of several infractions when it investigates in only one market. In contrast, in a U-form structure, the collusive agreements are centralized under the supervision of only one manager and once the antitrust authority has successfully prosecuted one cartel, the probability to discover others is high. Connor (1997) presents details about market characteristics in the lysine market and states that ADM was highly centralized. The breaking up of this cartel was fastly followed by the dissolution of the others in which ADM was involved.

To study the interactions between collusion, firms' organization structure and competition policy, we consider a framework with two firms, two goods and an antitrust authority. We assume that the two goods are substitutes. Firms can choose between two organizational forms: a U-form and an M-form. In the U-form structure, one manager chooses the price of the two goods maximizing the firm's profit. In the M-form organization, the prices are decided by two managers. Each manager chooses the price of one good to maximize the profit of his own division. So a trade-off exists between the coordination among the two prices (only feasible in the U-form organi-

zation) and the compartmentalization of collusion's evidences (only in the M-form structure).

Our paper is related to the literature on collusion and multi-market contacts. Two papers are more related to ours: Thomas and Willig (2006) and Choi and Gerlach (2009a).

Conventional wisdom holds that multi-market contacts help collusion when the markets are asymmetric (Bernheim and Whinston, 1990). This also occurs when firms' objective functions are concave (Spagnolo, 1999), or when the demand is random (Matsushima, 2001). So, firms generally enhance the possibilities of collusion by linking the different markets in one collusive agreement. On the contrary, Thomas and Willig (2006) show that the compartmentalization of collusive agreements can also yield to higher firms' payoffs 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). When the two collusive agreements are linked, the probability of price war is not reduced but its negative impact on profits is increased because the war extends to the other market. In their paper, the two collusive agreements may be insulated to prevent from the risk of contagion of prices wars. In ours, they may be separated (by selecting an M-form structure), to contain the risk of contagion of antitrust authority's investigations.

Choi and Gerlach (2009a) focus on different questions but their model is closed to ours. They study the impact of antitrust policy on the collusion structure when two firms interact on two markets with demand linkages (the two goods can be substitutes or complements). If the two goods are closed substitutes, collusion can be sustained only if the firms simultaneously collude in the two markets and they revert to competitive equilibrium once at least one cartel has been successfully prosecuted, because collusion is not sustainable in only one market. In this case, antitrust policy has a *knock-on effect*. If the two goods are strong complements, the firms can almost obtain the monopoly profit 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*. The authors study as well the possibility for the antitrust authority to increase its investigation capacities and so the detec-

tion of one cartel implies the detection of the second.<sup>2</sup> This case is equivalent to our U-form case. Our framework has a similar backbone, but some hypothesis are different (we detail this in a footnote after the presentation of our model). Moreover, our problematic departs from theirs by focusing on the organizational design of firms.

Our main results are the following. When firms act under the U-form organization, they simultaneously collude in the two markets if the antitrust fine is not too high. They adopt sequential collusion if fine is higher and if the two goods are weak substitutes. When we endogenize the choice of organizational structure, the results change. Under perfect compartmentalization in the M-form organization (the antitrust authority can not discover another cartel when it investigates a cartel), we obtain four different zones. When the antitrust fine is not too high and the two goods are sufficiently substitutable, both firms choose the U-form organization and simultaneously collude in the two markets. When goods are very weak substitutes, firms choose the M-form organization, simultaneously collude in the two markets and continue to collude in one market once the other cartel has been detected. When fine is higher and the goods are weak substitutes, firms choose the M-form organization, simultaneously collude in the two markets and stop collusion on the two markets if one cartel is detected. In the other cases, firms do not collude and the organization structure is irrelevant. The main intuition is that firms face a trade-off between coordination and compartmentalization. If the two products are closed substitutes, competition between the two divisions of an M-firm results in low collusive prices and so firms choose the U-form structure despite the increased risk of fine. If products are weak substitutes, firms need less coordination and the compartmentalization favors the M-form structure. We also show that an increased value of the probability of cartel detection or an increase of the discount factor favors the adoption of the M-form structure whereas an increase in the fine for repeat offenders favors the adoption of the U-form structure. If the compartmentalization is not perfect, a fifth zone appears. When the antitrust fine is high and product substitutability is very low, the firms choose the sequential collusion strategy. Indeed the protection against investigations is not sufficient. The impact of leniency programs depends on their

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<sup>2</sup>In Choi and Gerlach (2009b), they assume that the two markets are localised in two countries and they study the interaction between the two national antitrust authorities. In Choi and Gerlach (2010) they study the leniency program design in the same international context.

design. Simple leniency program effects depend on parameters' values (fine's level and substitutability degree). Amnesty plus favors the U-form organization when the fine reduction is low and the M-form one in the opposite case.

The paper is organized as follows. In section 2, we set up our basic framework. Section 3 characterizes the collusive strategies under the U-form organization. Section 4 does likewise under the M-form structure. Section 5 analyzes endogenous choice of organization structures. In section 6, we introduce leniency programs and the conclusion follows in section 7.

## 2 The Model

We consider a simple framework consisting of an antitrust authority and two identical firms 1 and 2 producing each two differentiated products A and B. Each firm produces the two goods at the same constant marginal cost  $c$ . Without loss of generality, we assume that  $c = 0$ .

Firms play a two-stage game in which they firstly choose cooperatively an organizational structure and then play an infinitely repeated game of price competition. Firms can decide to reach a collusive agreement. The collusion strategy is modelled as a grim trigger strategy: once a firm deviates from the collusive agreement, all firms play non-cooperatively forever. Both firms have the same discount rate  $\delta \in (0, 1)$ . Collusion requires communication between firms and generates hard evidences, which can be found by the antitrust authority with an exogenous probability.

The demand function for product  $i$  is given by:<sup>3</sup>

$$Q^i(p^i, p^j) = a - bp^i + d(p^j - p^i), \forall i \neq j, \{i, j\} \in \{A, B\}$$

The parameter  $d$  is a measure of the substitutability between products: they are independent when  $d = 0$  and perfect substitutes when  $d \rightarrow \infty$ .

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<sup>3</sup>Belleflamme, Picard and Thisse (2000) indicate how this demand function can be derived from a quadratic utility function.

## 2.1 Organization design

In the first stage, firms choose between two organizational forms. First, they can adopt a centralized or unitary organizational structure (U-form) in which a manager chooses the prices of the two products maximizing the global profit of the firm. Second, they can adopt a decentralized or multidivisional structure (M-form) in which two divisional managers, maximizing the profit of their own divisions, determine each one the price of one product.

Once firms have selected the organizational structure, they can reach a collusive agreement. If they have adopted the same organizational form, then they select a symmetric collusive agreement. In the opposite case, one manager wants to maximize the global profit of his firm whereas in the other firm two managers seek to maximize only their own division's profit. So equilibrium prices should reflect these two different objectives. In the next paragraph, we simplify the analysis by choosing assumptions which guarantee that the U-form organization is the best reply to itself. Consequently, the two firms will always select the same organizational structure in a pure strategy Nash equilibrium.<sup>4</sup>

## 2.2 Antitrust policy

The antitrust authority is supposed to deter collusion. At the end of each collusive period, the antitrust authority can suspect collusion in a market with probability  $\rho$ . Then the antitrust authority opens an investigation which leads to a successful prosecution with probability  $\mu_1$ . In this case, the antitrust authority imposes a fine  $F$  on each cartel's member. We suppose that convinced cartels revert to non-cooperative behavior forever.

During an investigation of one market, the antitrust authority may find hard evidences of a collusive agreement in the other market (in the case firms collude on both markets). The probability of this event depends on the firms' organizational

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<sup>4</sup>If firms chose the organizational structure non cooperatively, the firms could face a coordination problem due to multiplicity of equilibria for some parameters' values. We have no new insights on coordination game and so we remove this problem by assuming that the organization choice is cooperative.

structures: it is equal to  $\mu_2$  if the two firms are centralized,  $\mu_3$  if they are decentralized and  $\mu_4$  if we consider asymmetric organizational structure. In the case of successful prosecution, firms must pay a second fine  $F$ .

We intuitively assume that:  $\mu_1 \geq \mu_2 \geq \mu_4 \geq \mu_3$ . It is easier for an antitrust authority to find hard evidences of collusion in one market during an investigation in the other market if firms act in a centralized way.

To simplify the exposition and to highlight the main effects, we assume that:<sup>5</sup>

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

The hypothesis  $\mu_2 = \mu_4$  implies that the asymmetric case is always dominated by the U-form symmetric case. So we disregard the asymmetric case in this paper.

If a firm deviates from a collusive agreement by cutting its price(s), the antitrust authority can still detect collusion during this deviation period, but past offense can not be detected any more once firms have reverted to competitive prices.

We introduce the possibility of higher fine for repeat offenders. Formally, the first time the firms are successfully prosecuted, the imposed fine is  $F$  whereas this amount is increased if the firms are prosecuted twice. We assume that the second fine is  $\theta F$ , with  $\theta \geq 1$ .

We introduce the leniency programs in section 6. We successively study simple leniency program and amnesty plus program.

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, cartel could adopt complex price paths (Harrington, 2004b and 2005; Harrington and Chen, 2006). If  $F$  was dependent on the offense's level, firms could choose lower prices than the monopoly price to decrease the expected fine (Besanko and Spulber, 1989; Souam, 2001) and may choose higher post-cartel prices if these prices were used to estimate the damage (Harrington, 2004a). In this paper, we choose to disregard these effects so as to simplify the model and focus on other interesting effects of the antitrust policy.

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<sup>5</sup>Choi and Gerlach (2009a) 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,  $\mu_2 = 1$ , by investing  $I$ .  $\mu_3$  and  $\mu_4$  are irrelevant in their framework.



### 3 U-form organization

When firms interact under the U-form organization, they have three different cartel options. The first is to simultaneously collude in the two markets ( $U_{sim}$  strategy). The second is to cartelize one market and start collusion in the other market once the first cartel has been detected ( $U_{seq}$  strategy). Finally, the last possibility is to collude in only one market and stop colluding once firms are fined ( $U_{one}$  strategy).

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

Suppose firms simultaneously collude in both markets, then in a U-form organization, the detection of collusion in only one market yields successful prosecution in the other market. In this case, the antitrust authority imposes a fine of  $2F$  and firms engage in repeated price competition forever.

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

	Collusion	Deviation	Punishment
Price	$p_i^X = \frac{a}{2b}$	$p_i^{dX} = \frac{a}{2b} - \varepsilon$	$p_i^{pX} = c = 0$
Quantity	$q_i^X = \frac{a}{4}$	$q_i^{dX} = \frac{a}{2}$	$q_i^{pX} = \frac{a}{2}$
Profit	$\pi_i^{cU} = \frac{a^2}{4b}$	$\pi_i^{dU} = \frac{a^2}{2b}$	$\pi_i^{pU} = 0$

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

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

Deviations are punished with eternal Nash reversion, so the current gain from deviation is:

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

Collusion in both markets is sustainable if and only if one shot defection followed by punishment leaves less profits than staying on the collusive path. Thus it has to hold that:

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

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

In this section, we consider that 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 second market (named market A). We successively determine equilibrium values in the second and in the first cartels (respectively in the markets A and B).

### 3.2.1 Second cartel

In the market B, the cartel has been discovered and 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:  $p^A = \frac{a+dp^B}{2(b+d)}$ . Setting  $p^B = 0$ , we obtain:

$$\tilde{p}_i^A = \frac{a}{2(b+d)} \quad , \quad \tilde{q}_i^A = \frac{a}{4} \quad \text{and} \quad \tilde{\pi}_i^c = \frac{a^2}{8(b+d)}$$

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

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

The present value of the profits from a deviation is defined as:

$$\tilde{\Pi}_i^d = 2\tilde{\pi}_i^c - \rho\theta F$$

Consequently, collusion is sustainable if and only if:

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

### 3.2.2 First cartel

We have considered that firms firstly collude in the market B. In this market, equilibrium prices and quantities are the same than in the previous case and each firm's per-period payoff associated with collusion is equal to:  $\tilde{\pi}_i^c = \frac{a^2}{8(b+d)}$ .

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

$$\begin{aligned}\Pi_i^{U_{seq}} &= \tilde{\pi}_i^c - \rho F + \delta(1-\rho)\Pi_i^{U_{seq}} + \delta\rho\tilde{\Pi}_i \\ &= \frac{(1-\delta+2\delta\rho)\tilde{\pi}_i^c - [1-\delta(1-\rho)+\delta\rho\theta]\rho F}{[1-\delta(1-\rho)]^2}\end{aligned}$$

The current gain from deviation is:

$$\Pi_i^{dU_{seq}} = 2\tilde{\pi}_i^c - \rho F$$

Then collusion is sustainable if and only if:

$$\Pi_i^{U_{seq}} \geq \Pi_i^{dU_{seq}} \Leftrightarrow F_{U_{seq}} \equiv \frac{-1+3\delta-2\delta\rho-2\delta^2(1-\rho)^2}{[1-\rho+\rho\theta-\delta(1-\rho)^2]}\tilde{\pi}_i^c \geq F$$

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 cartel. However, the collusive sustainability in the first cartel is stronger than in the second, because of an expected increased fine (if  $\theta > 1$ ). Moreover, the expected payoff associated with collusion is higher in the first cartel because it takes the expected payoff associated with collusion in the second cartel into account.

### 3.3 Collusion in only one market ( $U_{one}$ strategy)

The last possibility is to collude in only one market. If the cartel is discovered, firms are fined and collusion stops thereafter.

If  $\theta = 1$ , collusion in only one market is dominated by the previous strategy ( $U_{seq}$  strategy). Indeed, if firms benefit from colluding in only one market, then they benefit to collude in the second market once the first cartel has been discovered and fined. The strategy applied in the second cartel and in the first one is the same and generates the same profit.

However, if  $\theta > 1$ , firms can choose to collude in only one market if sequential collusion in both markets is not still viable. The first time the cartel is successfully prosecuted, the imposed fine is  $F$  whereas this amount is significantly increased if the cartel is prosecuted twice.

If firms choose to collude in only one market, then the collusive equilibrium prices are the same as previously, and the individual per-period profit is given by:

$$\tilde{\pi}_i^c = \frac{a^2}{8(b+d)}.$$

The present values of collusion and deviation are respectively defined as:

$$\begin{aligned}\Pi_i^{U_{one}} &= \tilde{\pi}_i^c - \rho F + \delta(1-\rho)\Pi_i^{U_{one}} = \frac{\tilde{\pi}_i^c - \rho F}{1 - \delta(1-\rho)} \\ \Pi_i^{dU_{one}} &= 2\tilde{\pi}_i^c - \rho F\end{aligned}$$

Collusion is sustainable if and only if:

$$\Pi_i^{U_{one}} \geq \Pi_i^{dU_{one}} \Leftrightarrow F_{U_{one}} \equiv \frac{2\delta(1-\rho) - 1}{\delta\rho(1-\rho)}\tilde{\pi}_i^c \geq F$$

This sustainability condition is the same as in the 3.2.1 section imposing  $\theta = 1$ . If  $\theta > 1$ , this previous constraint is easier to satisfy than the condition:  $F \leq \tilde{F}$ .

### 3.4 Comparison of the three cartel options

This section compares the equilibrium profits of the three cartel options under the U-form organization.

#### 3.4.1 Analytical conditions

When both cartels are sustainable, simultaneous cartels in both markets dominate sequential cartels if and only if (with  $\bar{\rho} \equiv 1 - \rho$ ):

$$\Pi_i^{U_{sim}} \geq \Pi_i^{U_{seq}} \Leftrightarrow F_1 \equiv \frac{[1 - \delta\bar{\rho}]^2 \pi_i^{cU} - [1 - \delta\bar{\rho}^2](1 - \delta + 2\delta\rho)\tilde{\pi}_i^c}{\{3 - 2\rho - \delta\rho\theta + (3\rho - 6)\delta\bar{\rho} + (3 - \rho + \rho\theta)\delta^2\bar{\rho}^2\}\rho} \geq F$$

When both cartels are sustainable, simultaneous cartels in both markets dominate one market collusion if and only if:

$$\Pi_i^{U_{sim}} \geq \Pi_i^{U_{one}} \Leftrightarrow \frac{[1 - \delta(1-\rho)]\pi_1^{cU} - [1 - \delta(1-\rho)^2]\tilde{\pi}_i^c}{[3 - 2\rho + (\rho - 3)\delta(1-\rho)]\rho} \geq F$$

Finally, sequential cartels dominate one market collusion if and only if:

$$\Pi_i^{U_{seq}} \geq \Pi_i^{U_{one}} \Leftrightarrow \frac{\tilde{\pi}_i^c}{\rho\theta} \geq F$$

Consequently, firms may collude in only one market only if sequential collusion in both markets is not a sustainable strategy.

### 3.4.2 Graphical representation

We plot the sustainability threshold values and the three previous conditions in a  $F$ - $d$  diagram to identify different regions representing the various organizations of collusion. Two cases are analyzed: one with no increased fine ( $\theta = 1$ ) and one with an increased fine ( $\theta > 1$ ) if firms relapse.

**Basic fine ( $\theta = 1$ ):** We assume that  $\rho = 0.01$ ,  $\theta = 1$ ,  $b = 2$ ,  $a = 10$  and  $\delta = 0.8$ .

Three different regions appear in the graph:  $U_{seq}$ ,  $U_{sim}$  and *No Collusion*. These areas are bounded by the border lines in full line

If products are sufficiently strong substitutes, then the  $U_{seq}$  strategy is harder to sustain and firms prefer to form simultaneous cartels in the two markets. For high values of  $d$ , firms simultaneously collude in both markets if the fine is not too high and switch to a competitive equilibrium for high values of  $F$ . The  $U_{seq}$  strategy is easier to sustain if products are sufficiently weak substitutes and dominates the  $U_{sim}$  strategy as  $F$  increases.

The comparison between  $U_{seq}$  and  $U_{sim}$  provides two effects. Firstly, the  $U_{sim}$  strategy yields higher profits than the  $U_{seq}$  strategy. Secondly, cartels are longer-lasting in the  $U_{seq}$  strategy than in the  $U_{sim}$  strategy and the expected present value of the fine is less in sequential cartelization as the second fine is payed later.

If we consider middle values of  $F$  and low values of  $d$ , firms prefer to form sequential cartels even if the  $U_{sim}$  strategy is sustainable. If  $F$  is higher, sequential collusion is still sustainable while a simultaneous one is not. Finally, if  $F$  is very high or  $d$  is increased, neither of them is sustainable.

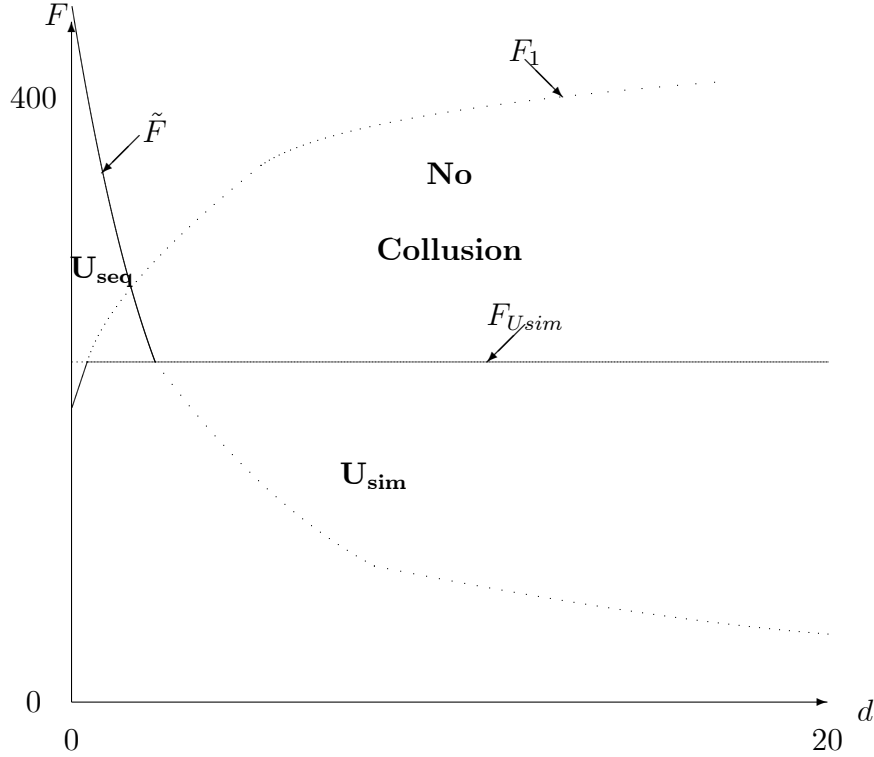


Figure 1: Collusive equilibria in a U-form organization with basic fine

If  $\theta = 1$ , the  $U_{one}$  strategy is always strictly dominated by the two other strategies.

**Increased fine ( $\theta > 1$ ):** We assume that  $\rho = 0.01$ ,  $\theta = 1.5$ ,  $b = 2$ ,  $a = 10$  and  $\delta = 0.8$ . We draw the new border lines in full lines and draw the previous border line between the  $U_{sim}$  and  $U_{seq}$  areas in dotted line (figure 2).

If  $F > F_{U_{sim}}$  ( $U_{sim}$  strategy is not sustainable), then increasing fine if firms relapse leads expected effects. For many values in which firms choose the  $U_{seq}$  strategy with basic fine, firms switch to the  $U_{one}$  strategy with increased fine (zone 1 in the graph). For these values, the increased fine is dissuasive in order not to relapse in the second market. However, it does not impact on the no collusion area. Collusion is shorter but not deterred.

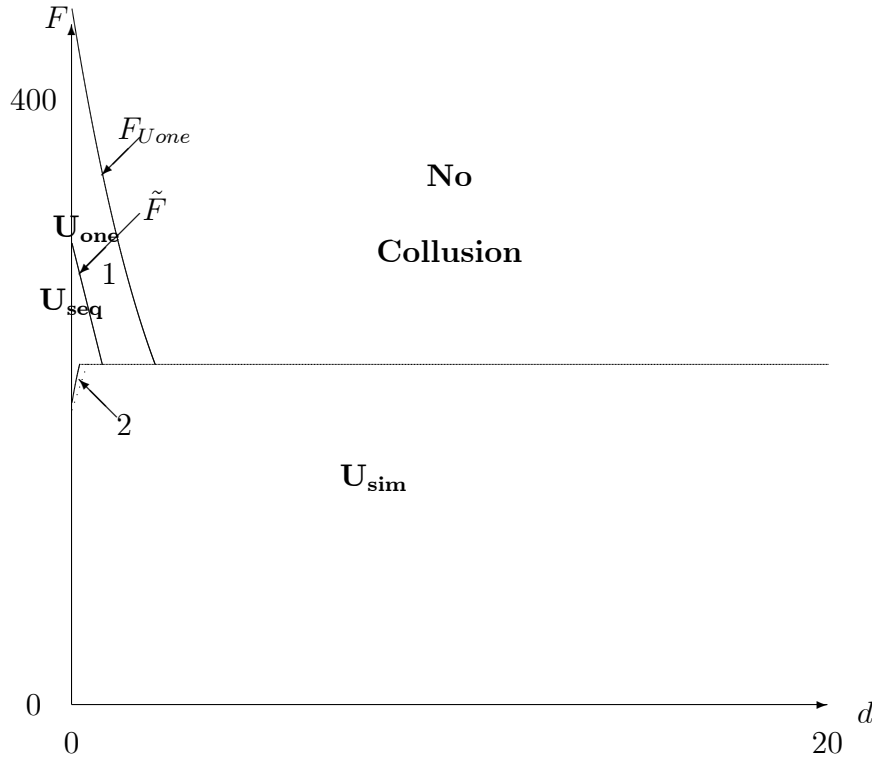


Figure 2: Collusive equilibria in a U-form organization with increased fine

If  $F \leq F_{U_{sim}}$ , increasing fine can result in higher collusive prices. Firms may switch from  $U_{seq}$  strategy to  $U_{sim}$  strategy (zone 2 in the graph). In this zone, firms choose  $U_{seq}$  strategy with the basic fine because this strategy prevents them from the risk of a double fine. So  $U_{seq}$  is chosen with basic fine to decrease the expected fine. With increased fine,  $U_{seq}$  no longer decreases the expected fine. One fine is paid later but its amount is increased.

## 4 M-form organization

It could be best for firms to be in an M-form organization when they simultaneously collude in the two markets. In this case, the M-form organization reduces efficiency of competition authority's investigations and firms may continue to collude on one market once the other cartel has been discovered.

However, if firms cartelize only one market or if firms choose sequential cartelization, the M-form organization has no advantages with regard to the other. The two forms would result in the same prices and profits flow. Consequently, under an M-form organization, only simultaneous cartels are studied.

Two sub-cases must be distinguished. Indeed, when a cartel has been successfully detected in only one market, firms can continue to collude in the other market (designed by *Mc* strategy) or stop (designed by *Ms* strategy).

#### 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 in price. Equilibrium prices are the same than considering two firms competing with differentiated products (one firm producing the product A alone, the other firm the product B).

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

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

Concerning the 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 of the other market, because the collusive price is the best response to the price in the other market.

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

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

The current gain from deviation is:

$$\Pi_i^{dMs} = 2\pi_i^{cM} - \rho F - (1 - \rho) \rho \mu F$$



Consequently, collusion is sustainable if and only if:

$$\Pi_i^{Ms} \geq \Pi_i^{dMs} \Leftrightarrow F_{Ms} \equiv \frac{2\delta(1-\rho)^2 - 1}{\delta(1-\rho)^2 [1 + (1-\rho)\mu] \rho} \pi_i^{cM} \geq F$$

## 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 than with *Ms* strategy. In the second phase (firms collude in only one market), prices, quantities and profits are the same than the results obtained in the section 3.2.1.

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

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

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

$$\Pi_i^{dMc} = 2\pi_i^{cM} - \rho F - (1-\rho)\rho\mu F$$

Collusion is sustainable if and only if the two following conditions hold ( $\bar{\rho} \equiv 1 - \rho$ ):

$$\Pi_i^{Mc} \geq \Pi_i^{dMc} \Leftrightarrow F_{Mc} \equiv \frac{[1 - \delta\bar{\rho}][2\delta\bar{\rho}^2 - 1]\pi_i^{cM} + \delta\bar{\rho}\rho(1-\mu)\tilde{\pi}_i^c}{\{\rho(1-\mu)\theta + [1 - \delta\bar{\rho}]\bar{\rho}[1 + \bar{\rho}\mu]\}\bar{\rho}\delta\rho} \geq F$$

and

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

If  $\mu = 0$ , the first condition is less restrictive than the second one. If  $\mu > 0$ , the most restrictive condition depends on the degree of differentiation between the two products. For low values of  $d$ , the first condition is the most restrictive (and conversely).

## 5 Organization choice

This section describes all of the various equilibrium choices of organizational structures.

## 5.1 Comparison of the two organizational structures

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

$$\Pi_i^{U_{sim}} \geq 2\Pi_i^{Mc} \Leftrightarrow F_2 \equiv \frac{[1 - \delta(1 - \rho)] \left( \frac{\pi_i^{cU}}{2} - \pi_i^{cM} \right) - \delta(1 - \rho)\rho(1 - \mu)\tilde{\pi}_i^c}{[1 - \delta(1 - \rho) - \delta\rho\theta](1 - \mu)(1 - \rho)\rho} \geq F$$

If  $F > \tilde{F}$  and  $F \leq F_{U_{sim}}$ , the comparison is slightly different. If a cartel is successfully prosecuted 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 a U-form organization, the fine is simply  $2F$  whereas in an M-form, firms must pay a basic fine  $F$  and have to pay twice with a probability of  $\mu$ . Firms adopt the  $U_{sim}$  strategy instead of the  $Ms$  strategy if and only if:

$$\Pi_i^{U_{sim}} \geq 2\Pi_i^{Ms} \Leftrightarrow F_3 \equiv \frac{\frac{\pi_i^{cU}}{2} - \pi_i^{cM}}{(1 - \rho)(1 - \mu)\rho} \geq F$$

If  $F \leq \tilde{F}$  holds, the present discounted value of profits if firms choose the  $U_{seq}$  strategy is higher than in an M-form organization if and only if ( $\bar{\rho} \equiv 1 - \rho$ ):

$$\Pi_i^{U_{seq}} \geq 2\Pi_i^{Mc} \Leftrightarrow \frac{\{ [1 - \delta + 2\delta\rho - \delta\bar{\rho}(1 + \rho - 2\rho\mu) + \delta^2\bar{\rho}^2(1 - 2\rho\mu)] \tilde{\pi}_i^c - 2[1 - \delta\bar{\rho}]^2 \pi_i^{cM} \} \frac{1}{\rho}}{\delta\rho\theta - 1 - 2\bar{\rho}\mu + \delta\bar{\rho}[2 + \rho - 2\rho\theta + (4\bar{\rho} + 2\rho\theta)\mu] + \delta^2\bar{\rho}^2[\rho\theta - \rho - 1 - 2(\bar{\rho} + \rho\theta)\mu]} \leq F$$

## 5.2 Perfect compartmentalization

In this section, the comparison between a U-form and an M-form organization is studied. We start by setting  $\mu = 0$  to highlight the main differences between these two organizational forms.

Without any competition policy ( $\rho = 0$ ), firms choose a U-form organization and collude if  $\delta$  is sufficiently high. This is a well-known result in economic theory, and so the interesting case  $\rho > 0$  is studied thereafter.

### 5.2.1 Benchmark case

We assume that  $\rho = 0.01$ ,  $\theta = 1$ ,  $b = 2$ ,  $a = 10$  and  $\delta = 0.8$ .

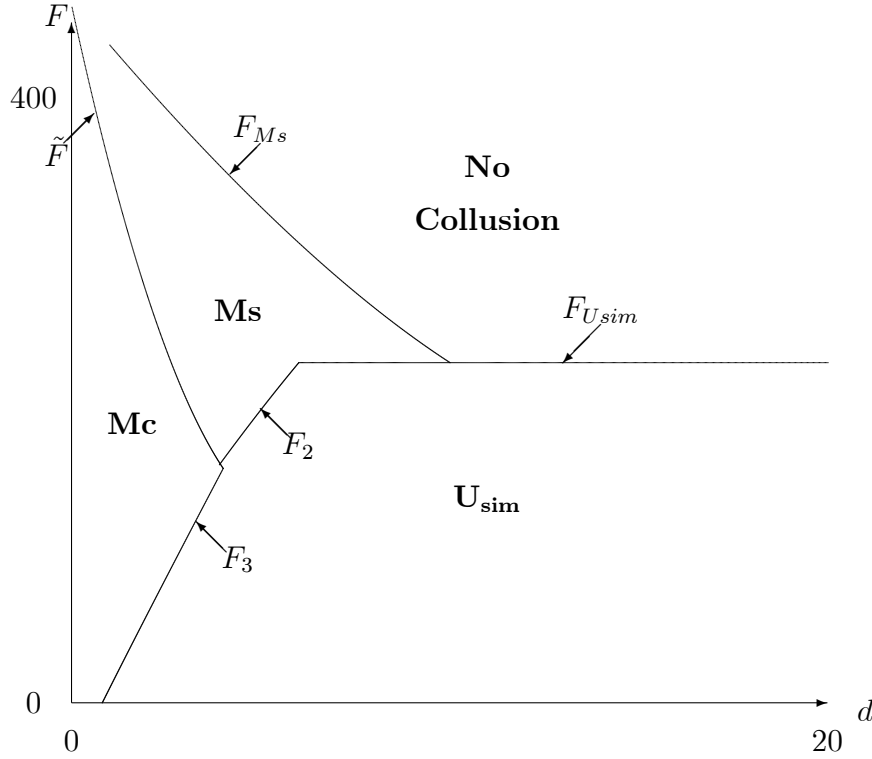


Figure 3: Organizational structures

If goods are independent ( $d = 0$ ), firms adopt the M-form organizational mode even if the fine is null. In this case, equilibrium prices are not impacted by the absence of coordination between divisions. Firms choose this organizational structure because they still collude in one market if a cartel has been discovered in the other market.

If goods are substitutes, 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 the U-form organization. The threshold value of  $d$  for which a firm is indifferent between the U-form and M-form organizations increases as the antitrust fine

increases. An increased fine involves firms to choose the M-form organization because the compartmentalization between divisions prevents from being fined twice.

If the condition  $F > F_{U_{sim}}$  holds, simultaneous collusion with a U-form organization is not sustainable. Consequently, firms choose the M-form organization if collusion is still sustainable under this organizational structure.

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

If the condition  $F > \tilde{F}$  holds, the  $Mc$  strategy is no more sustainable. Thus, firms may adopt the  $Ms$  strategy. They collude in both markets and revert to competitive equilibrium once at less one cartel is successfully prosecuted. 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. In the major part of this area (in which  $F > F_{U_{sim}}$ ), collusion is sustainable only if firms can opt for the M-form organization. The possibility for firms to choose the M-form organization increases the values of parameters under which a collusive agreement appears.

The following proposition summarizes the previous results:

**Proposition 1:**

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

### 5.2.2 Effects of different parameters

We study the movement of the border lines in Figure 3 if the values of  $\rho$ ,  $\delta$  and  $\theta$  are modified.

**Impact of the probability of detection ( $\rho$ ):** We consider that, ceteris paribus, the value of  $\rho$  is increased twofold ( $\rho = 0.02$ ,  $\theta = 1$ ,  $b = 2$ ,  $a = 10$  and  $\delta = 0.8$ ). We draw on the same plot the new border lines in full line and the border lines of the benchmark case values in dotted lines for comparison.

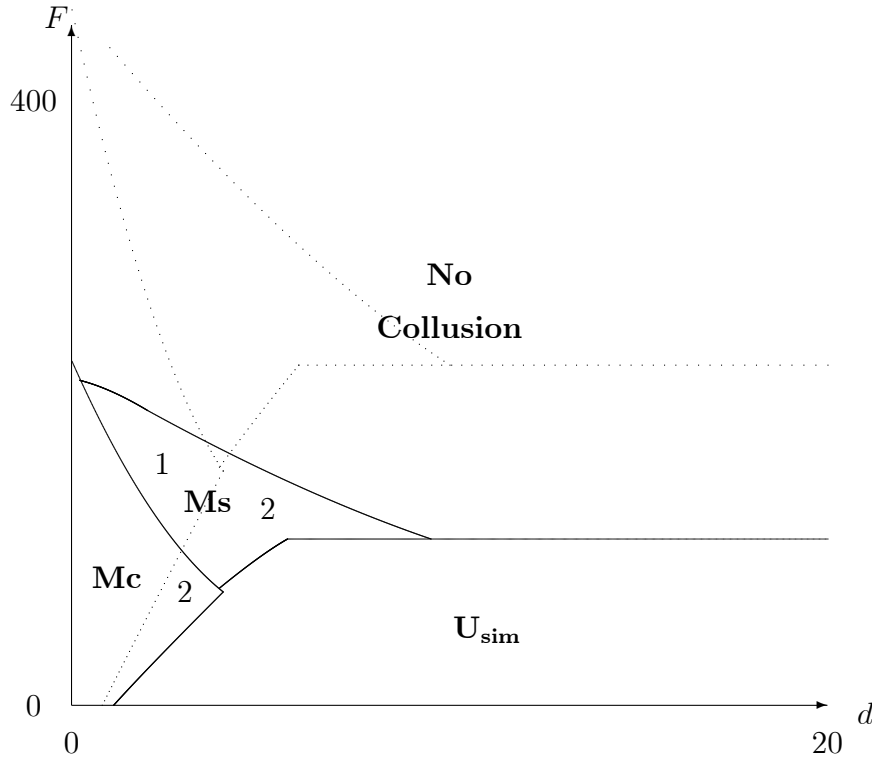


Figure 4: Impact of the probability of detection

An increased probability of detection ( $\rho$ ) hinders collusion and makes it less desirable whatever the type of collusion is (the threshold values of  $F$  beyond which collusion is not yet sustainable decrease everywhere).

Moreover, the border lines between  $M$  and  $U$  areas move to the right. Firms can prefer to compartmentalize their activities in order to maintain collusion in one market once the cartel in the other has been detected. In this way, the expected amount of fine is reduced.

An increased probability of detection leads to three positive competitive effects. Firstly, it decreases the life expectancy of cartels. Secondly, some of the cartels under the M-form organization are induced to stop collusion in both markets if one cartel has been desisted (zone 1 in the graph). Finally, in the regions for which firms prefer  $M_s$  or  $M_c$  strategies to the  $U_{sim}$  strategy (zones 2 in the graph), collusive prices decrease.

**Impact of the discount factor ( $\delta$ ):** Only the value of  $\delta$  is increased ( $\rho = 0.01$ ,  $\theta = 1$ ,  $b = 2$ ,  $a = 10$  and  $\delta = 0.9$ ).

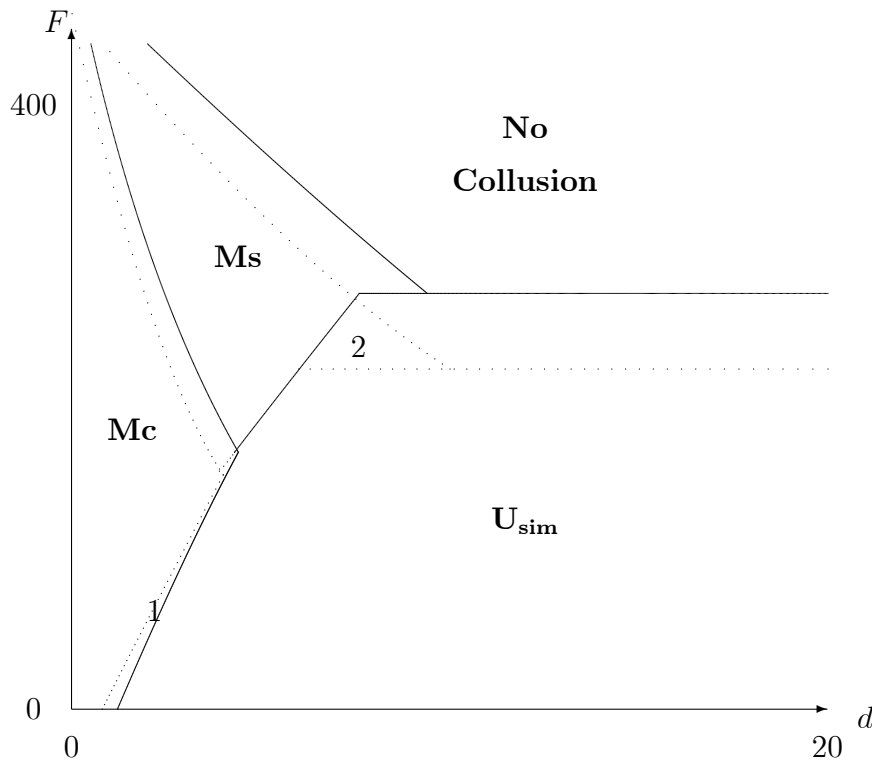


Figure 5: Impact of the discount factor

An increased value of  $\delta$  fosters collusion whatever the type of collusion is. So the sustainability border lines move upward.

The border lines between  $Mc$  and  $U_{sim}$  areas move to the right. When  $\delta$  increases, firms could switch from the  $U_{sim}$  strategy to the  $Mc$  strategy (1 in the graph) because the expected value from continuing collusion in the second market once firms has been successfully prosecuted on one market is increased.

Moreover, there is region (2 in the graph) in which firms switch from the M-form to U-form organization when  $\delta$  increases. In this zone, the  $U_{sim}$  strategy was not sustainable in the benchmark case whilst it is sustainable with an increased value of  $\delta$ .

**Impact of increased fine for recidivist firms ( $\theta$ ):** We consider that the value of  $\theta$  is increased twofold ( $\rho = 0.01$ ,  $\theta = 2$ ,  $b = 2$ ,  $a = 10$  and  $\delta = 0.8$ ).

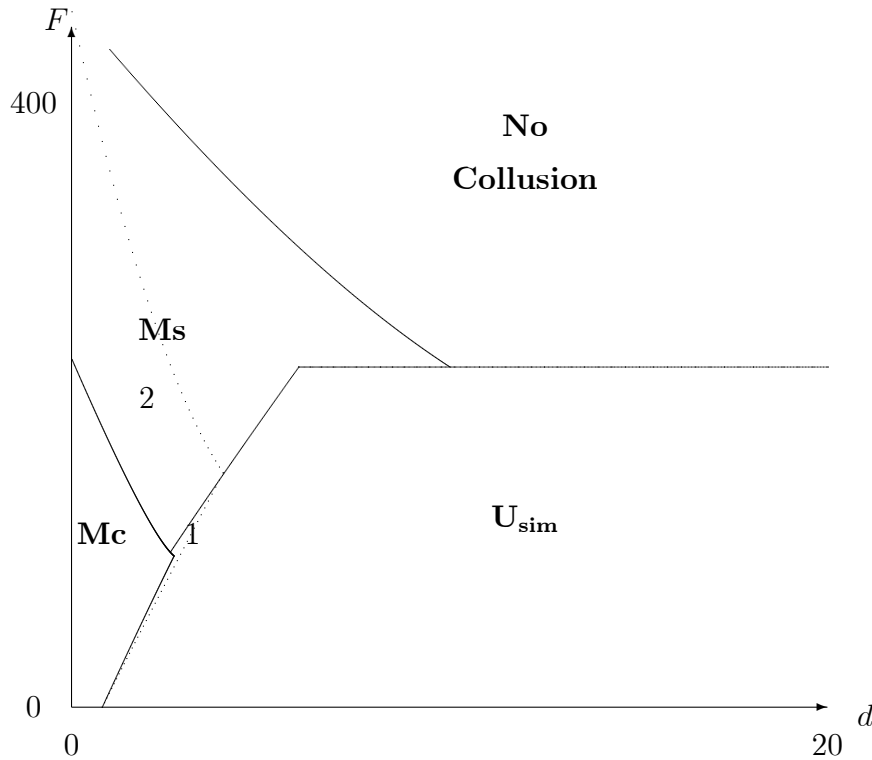


Figure 6: Impact of  $\theta$

An increased value of  $\theta$  globally makes the  $Mc$  strategy less likely to occur in consideration of the  $Ms$  one. But there also exists a little region (2 in the graph) in which firms switch from the  $Mc$  strategy to the  $U$  strategy.

So an increased value of  $\theta$  generally decreases the long-run viability of the cartel (zone 1) except in the little region (zone 2) in which it can yield to a price increase on the collusive path.

The following proposition summarizes the major results:

**Proposition 2:**

- *An increase of  $\rho$  provides stronger incentives to choose the M-form organization.*
- *An increase of  $\delta$  provides stronger incentives to choose the M-form organization if the antitrust fine is low but can provide firms to choose a more centralized structure if  $F$  is high.*
- *An increase of  $\theta$  provides stronger incentives to choose the U-form organization.*

### 5.3 Imperfect compartmentalization

We now turn to the case of imperfect compartmentalization in an M-form organization. If a cartel is successfully prosecuted in one market, the antitrust authority may find evidences of collusion in the other market (if firms collude in both markets) with probability  $\mu > 0$ . We assume that  $\mu = 0.5$  and keep the values of the other parameters unchanged.

The two border lines between  $U_{sim}$  and  $Mc$  areas and  $U_{sim}$  and  $Ms$  areas move to the left. Firms switch to the U-form organization if  $\mu$  is increased. This leads to a price increase in the collusive path (zones 1).

The maximal values of the antitrust fine allowing to sustain the  $Ms$  strategy and the first phase of the  $Mc$  strategy decrease. 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 chosen because it could be sustainable whereas a simultaneous one is not. In this zone, equilibrium prices decrease in the first phase of collusion and competition policy has a *waterbed effect*.

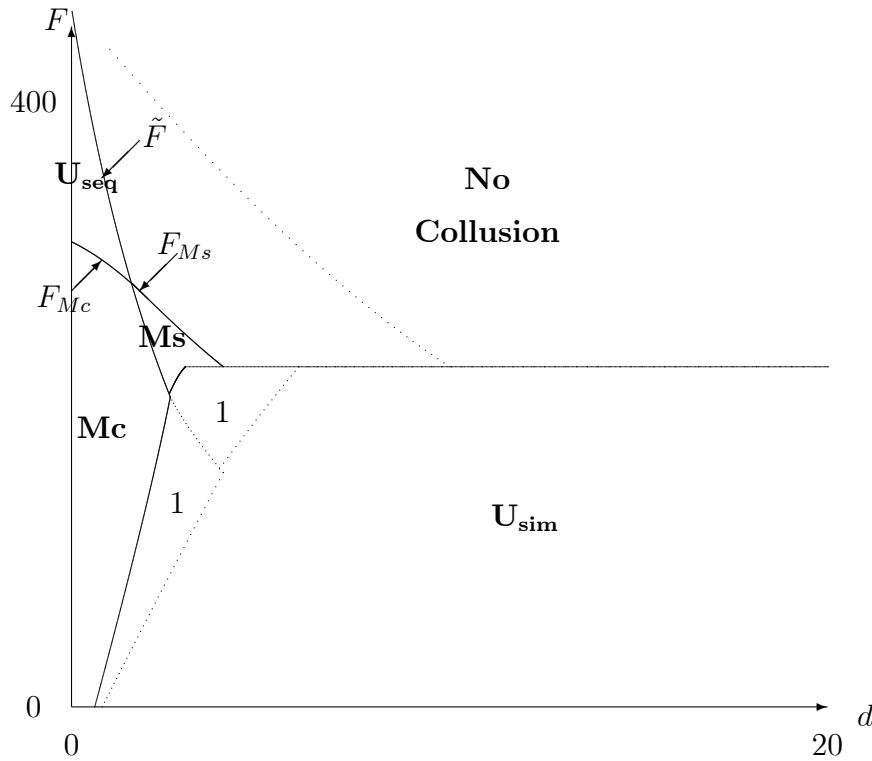


Figure 7: Imperfect compartmentalization

**Proposition 3:** *An increase of  $\mu$  provides stronger incentives to choose the U-form organization.*

## 6 Leniency programs

The impact of leniency programs is studied in this section. Leniency programs are widely used by the antitrust policy<sup>6</sup> because they increase successful cartel investiga-

<sup>6</sup>See Spagnolo (2008) for a survey of literature.

tions when they are well designed.<sup>7</sup> These programs reduce fines for cartel members who report themselves to and assist the antitrust authority. We assume that only the first firm which reports evidence can apply for leniency programs. If two firms simultaneously reveal the cartel to the antitrust authority, each one can obtain the reduced fine with probability  $\frac{1}{2}$ . Moreover, we suppose that the first informant benefits from total immunity from fines.<sup>8</sup>

Firms can apply for leniency program at two given times. First, they can report hard evidences before cartels are detected. Second, but only under the M-form organization, they can report the second cartel after one cartel is detected but before the second cartel is prosecuted.<sup>9</sup> In this second case, we assume that reporting the cartel B [respectively A] after the detection of the cartel A [B] allows total amnesty for cartel B [A] and may allow, if antitrust authority adopts amnesty plus programs,<sup>10</sup> a reduced fine for the cartel A [B]. This fine is then equal to  $\tau F$  with  $\tau < 1$  in this amnesty plus case and  $\tau = 1$  under simple leniency program.

## 6.1 U-form organization

The presence of a leniency program does not impact on the behavior of centralized firms along the collusive path. They still choose the same equilibrium prices and earn the same collusive profit. The profit along the punishment path is the same too. In contrast, the deviation profit increases. If a firm deviates from the collusive agreement by cutting its prices, this firm simultaneously reports evidences of cartel to prevent itself from being fined.<sup>11</sup> So, cartel agreements become more difficult to sustain.

Under the U-form organization, amnesty plus does not change anything. If firms play the  $U_{sim}$  strategy the two cartels are simultaneously discovered and the firms do

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<sup>7</sup>Brenner (2009) and Miller (2009) provide empirical studies on the success of leniency programs.

<sup>8</sup>Total amnesty limited to the first applicant is generally the optimal design for leniency program (Spagnolo, 2005; Harrington, 2008).

<sup>9</sup>i.e. before the firms know if the antitrust authority has enough evidences to successfully prosecute the second cartel.

<sup>10</sup>These programs have been introduced by the US Department Of Justice.

<sup>11</sup>Allowing a deviator firm to simultaneously apply for a leniency program is optimal for the antitrust authority (Spagnolo, 2005).

not have new evidences to report. If firms play the  $U_{seq}$  strategy, then when a cartel is detected, the other market is competitive and firms do not have evidences to report.

**Simultaneous collusion ( $U_{sim}$  strategy):** In this case, collusion is sustainable if and only if:

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

**Sequential collusion ( $U_{seq}$  strategy):** In this case, collusion is sustainable if and only if:

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

As in the case without any leniency program, the second cartel is harder to sustain than the first one.

## 6.2 M-form organization

Under the M-form organization, the leniency programs may modify the collusive strategies. We assume that each divisional manager has not any evidence on collusion in the other division, but the firm's CEO can obtain informations from the divisional managers and the leniency program is applied if the expected profit of the firm is increased.

### 6.2.1 $M_s$ strategy

Once one cartel has been detected and before they know if the antitrust authority has sufficient evidence to successfully prosecute the second one (with probability  $\mu$ ), firms simultaneously choose to report or not the second cartel.

The expected fines depend on the choices of the two firms following this payoff matrix:<sup>12</sup>

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<sup>12</sup>The strategy 'report' means that a firm reports the second cartel.

	Firm 2	
Firm 1	Report	Not Report
Report	$\frac{1}{2}\tau F + \frac{1}{2}2F; \frac{1}{2}\tau F + \frac{1}{2}2F$	$\tau F; 2F$
Not Report	$2F; \tau F$	$F + \mu F; F + \mu F$

**Case 1:** If  $\mu = 0$  and  $\tau = 1$ , the reporting game has two pure-strategy Nash equilibria: when both choose to either report or not. The firms' expected profit are higher in the second one, so we assume that firms play this equilibrium even if they play weakly dominated strategies. In this case, the firms' expected profit when they play the  $Ms$  strategy are the same with or without leniency programs.

As under the U-form organization, the only effect of leniency program is the increased deviation profit by canceling the risk of fine. In this case, the collusion is sustainable if and only if:

$$\Pi_i^{Ms} \geq \Pi_i^{dMs} \Leftrightarrow \frac{2\delta(1-\rho)^2 - 1}{\rho} \pi_i^{cM} \geq F$$

**Case 2:** If  $\mu > 0$  or  $\tau < 1$ , then the previous game has a unique pure-strategy Nash equilibrium when both firms report the second cartel once the first cartel has been detected. The expected profits of a division if firms play the  $Ms$  strategy is:<sup>13</sup>

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

Without any leniency program, the expected fine is equal to:  $[1 + (1-\rho)\mu] \rho F$ . So the leniency program decreases the expected division profit if and only if:

$$\left[ \frac{1}{2}(1-\rho)(2+\tau) + \rho \right] \rho F \geq [1 + (1-\rho)\mu] \rho F \Leftrightarrow \frac{1}{2}\tau \geq \mu$$

<sup>13</sup>The expected fine of a division has three components: (1) collusion has been detected in the division's market but not in the other market. So division can apply for leniency and has a probability of 0.5 to be the first one. In this case, the expected fine is:  $\rho(1-\rho)(\frac{1}{2}F + \frac{1}{2}\tau F)$ . (2) collusion has not been detected in the division's market but has been detected in the other market. The other firm's division applies for leniency and benefits from total amnesty if it is the first informant. In the other case, the division must pay a fine  $F$ . The expected fine is equal to:  $(1-\rho)\rho \times \frac{1}{2}F$ . Last, (3) the antitrust authority simultaneously detects collusion in the two markets and leniency is not possible. The expected fine is:  $\rho^2 F$ .

If  $\mu$  is high and/or  $\tau$  is low the leniency program increases the expected profit of the firms playing the  $Ms$  strategy.

The other effect of leniency program is the increased deviation profit by canceling the risk of fine. In this case, collusion is sustainable if and only if:

$$\Pi_i^{Ms} \geq \Pi_i^{dMs} \Leftrightarrow \frac{2\delta(1-\rho)^2 - 1}{\left[1 + \frac{1}{2}(1-\rho)\tau\right]\rho} \pi_i^{cM} \geq F$$

### 6.2.2 $Mc$ strategy

The expected profit under the  $Mc$  strategy is the same with or without leniency programs. But there is a new sustainability constraint: firms must not be incited to report the second cartel after the detection of the first.

Once the first cartel has been detected, a firm can report and gets a profit of  $-\tau F$ , or can choose not to report and gets a profit of  $-F - \mu F + (1-\mu)\tilde{\Pi}_i$  (considering that the other firm does not report). Firms can commit not to report if and only if:

$$-(1+\mu)F + (1-\mu)\tilde{\Pi}_i \geq -\tau F \Leftrightarrow F_{rep} \equiv \frac{(1-\mu)\tilde{\pi}_i^c}{[1-\delta(1-\rho)](1+\mu-\tau) + (1-\mu)\rho\theta} \geq F$$

The other effect of leniency program is to increase the deviation profit by canceling the risk of fine during the deviation period. So the first and second constraints turn into:

$$\Pi_i^{Mc} \geq \Pi_i^{dMc} \Leftrightarrow \frac{[1-\delta(1-\rho)][2\delta(1-\rho)^2 - 1]\pi_i^{cM} + \delta(1-\rho)\rho(1-\mu)\tilde{\pi}_i^c}{\{\delta(1-\rho)\rho(1-\mu)\theta + [1-\delta(1-\rho)][1+(1-\rho)\mu]\}\rho} \geq F$$

and

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

## 6.3 Organizational choices

The expected profits under the  $U_{sim}$  and the  $Mc$  strategies are the same with or without leniency programs; so the border line between these two regions remains identical. On the contrary, the expected profit under the  $Ms$  strategy is affected by the leniency program (unless  $\mu = 0$  and  $\tau = 1$ ).

Firms adopt the  $U_{sim}$  strategy instead of the  $Ms$  one if and only if:

$$\Pi_i^{U_{sim}} \geq 2\Pi_i^{Ms} \Leftrightarrow \frac{\frac{\pi_i^{cU}}{2} - \pi_i^{cM}}{(1 - \frac{1}{2}\tau)(1 - \rho)\rho} \geq F$$

If  $\frac{1}{2}\tau > \mu$ , leniency program decreases the expected profits under the  $Ms$  strategy and the border line moves to the left. If  $\frac{1}{2}\tau < \mu$ , leniency program increases the expected profits and the border line moves to the right.

## 6.4 Simple leniency programs ( $\tau = 1$ )

This section investigates the effects of simple leniency programs. Two cases must be distinguished:  $\mu = 0$  and  $\mu > 0$ .

### 6.4.1 Perfect compartmentalization

As in our benchmark case, we assume  $\rho = 0.01$ ,  $\theta = 1$ ,  $b = 2$ ,  $a = 10$ ,  $\mu = 0$  and  $\delta = 0.8$ . As previously, the new border lines are drawn in full lines and the benchmark case (without leniency program) border lines are drawn in dotted lines for comparison.

By increasing deviation profits, leniency programs make collusion harder to sustain. The sustainability border lines move downward and some cartels are deterred (zones 1).

An interesting area is the zone named 2 in the graph in which leniency program induces firms to switch from the  $U_{sim}$  to the  $Ms$  strategy. Leniency program does not deter collusion but reduces the cartel's damage for consumers since collusive prices are lower with the  $Ms$  strategy.

A third effect is to induce firms to switch from the  $Mc$  to the  $Ms$  strategy (zone 3). In this area, leniency program shortens the cartel duration.

Last, in the zone 4, leniency program has an ambiguous impact on consumers' surplus. Indeed, the firms switch from the  $Mc$  to the  $U_{sim}$  strategy. The cartel duration is decreased but collusive prices are higher.

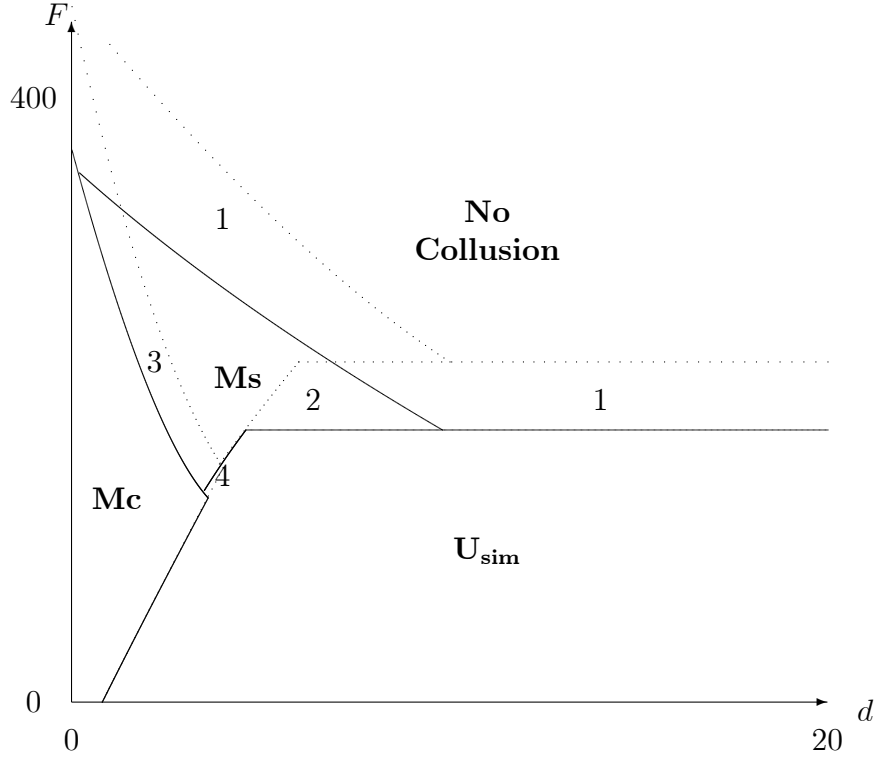


Figure 8: Perfect compartmentalization ( $\tau = 1$ )

#### 6.4.2 Imperfect compartmentalization

As in section 5.3, we assume that:  $\rho = 0.01$ ,  $\theta = 1$ ,  $b = 2$ ,  $a = 10$ ,  $\mu = 0.5$  and  $\delta = 0.8$ . This example is a very specific case because  $\frac{1}{2}\tau = \mu$ . The expected profit under the  $Ms$  strategy is the same with or without leniency program even if firms report the second cartel once the first one has been detected.

Collusion is harder to sustain and the leniency programs deter some cartels (zones 1). They induce firms to switch from the  $U_{sim}$  to the  $Ms$  strategy and to reduce their collusive prices in zone 2. These effects are qualitatively similar to those observed in the perfect compartmentalization case. The third effect is also similar to the case  $\mu = 0$ : firms switch from the  $Mc$  to the  $Ms$  strategy (zone 3), but it is more important. When  $\mu > 0$ , leniency program strongly destabilizes the  $Mc$  strategy. The new sustainability constraint (not report) is difficult to fulfill. There is also a

zone where firms switch from the  $Mc$  strategy to the  $U_{seq}$  one (zone 5). In this zone, as in zone 2, leniency programs decrease the collusive prices. These programs have also a *waterbed effect*. Last, in the zone 4, firms switch from the  $Mc$  strategy to the  $U_{sim}$  one and leniency programs increase the collusive prices. This zone is larger if  $\frac{1}{2}\tau > \mu$  and slighter if  $\frac{1}{2}\tau < \mu$ .

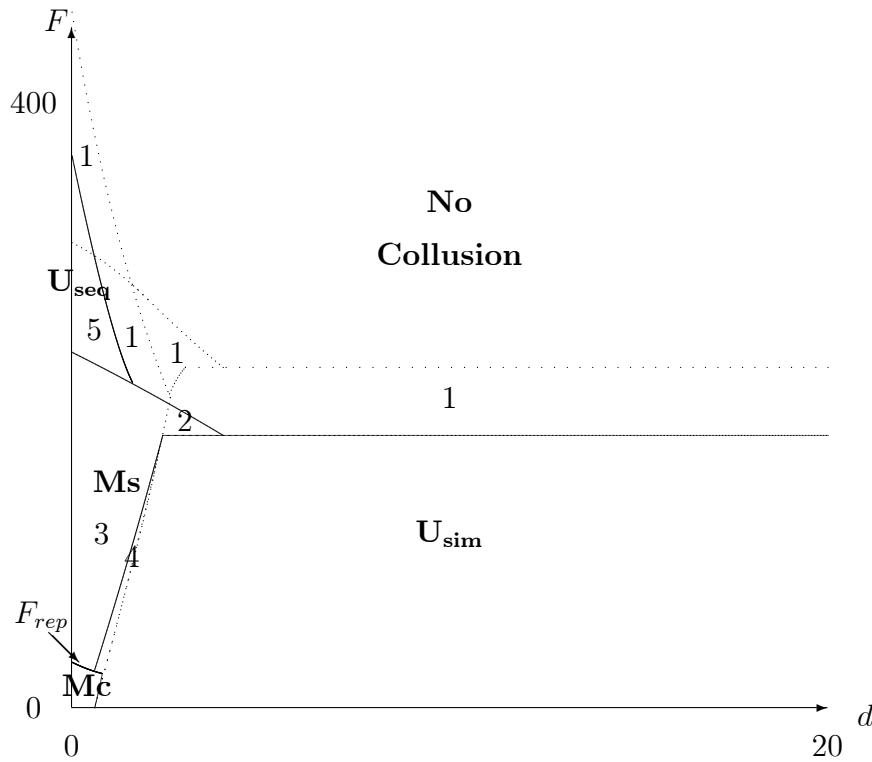


Figure 9: Imperfect compartmentalization ( $\tau = 1$ )

**Proposition 4:** *Simple leniency programs impact on the organizational design depending on the values of  $F$  and  $d$ .*

## 6.5 Amnesty plus ( $\tau < 1$ )

The effects of amnesty plus are studied in this section. We have to consider two cases:  $\frac{1}{2}\tau > \mu$  and  $\frac{1}{2}\tau < \mu$ .



### 6.5.1 Perfect compartmentalization

We assume that:  $\rho = 0.01$ ,  $\theta = 1$ ,  $b = 2$ ,  $a = 10$ ,  $\mu = 0$ ,  $\delta = 0.8$  and  $\tau = 0.5$ . We draw in full lines the border lines with amnesty plus and in dotted lines the cases with and without simple leniency program (previously studied).

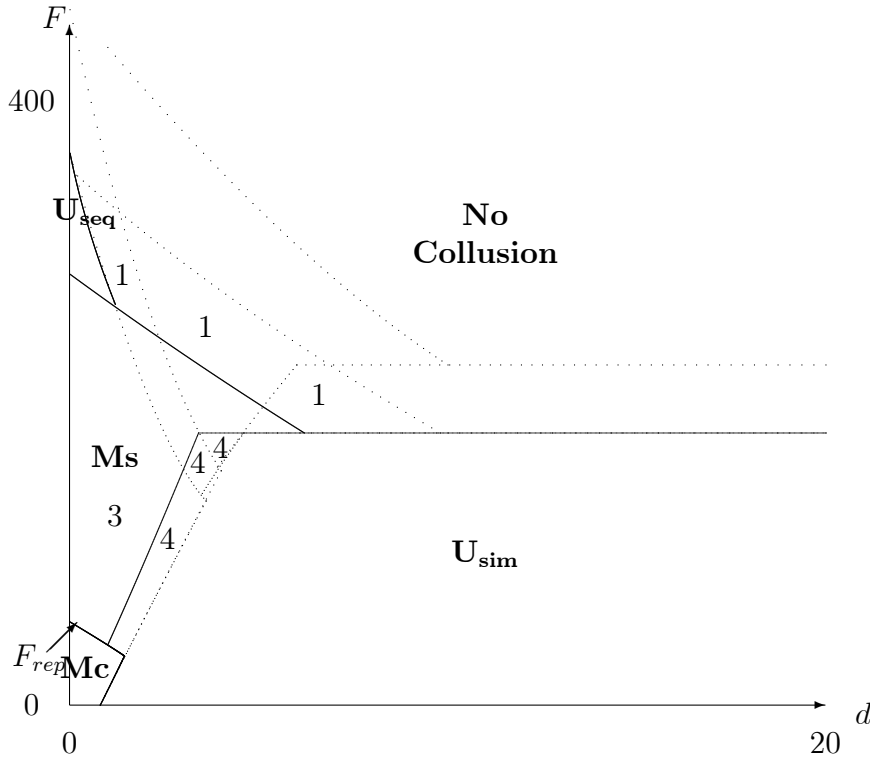


Figure 10: Amnesty plus ( $\frac{1}{2}\tau > \mu$ )

Amnesty plus aims at destabilizing other cartels when one cartel has been successfully prosecuted. This effect exists and is very important (zone 3 in the graph). In this zone, antitrust policy has a *knock-on effect* with amnesty plus whereas the *Mc* strategy is selected with or without simple leniency program.

Under the *Ms* strategy, firms face a prisoner's dilemma when they have the possibility to report the second cartel once a cartel has been detected. The report strategy is dominant for both firms but in this case the expected profits are decreased. This

effect explains why amnesty plus deters some cartels (zones 1) while simple leniency program does not and clarifies also why the border line between  $Ms$  and  $U_{sim}$  shifts toward the left. This shifting hurts the consumers by increasing the collusive prices in zones 4.

For high values of  $F$  and very low values of  $d$ , firms switch from the  $Mc$  strategy to the  $U_{seq}$  one. Amnesty plus has been designed to have a *knock-on effect*; but paradoxically it has a *waterbed effect* in this zone. In spite of the fact that it is not the intended effect, the consumers' surplus is increased by delaying the formation of the second cartel and by decreasing the collusive prices.

### 6.5.2 Imperfect compartmentalization

As in section 5.3, we assume that:  $\rho = 0.01$ ,  $\theta = 1$ ,  $b = 2$ ,  $a = 10$ ,  $\mu = 0.5$  and  $\delta = 0.8$ , and choose a low value for  $\tau$ :  $\tau = 0.1$ .

Amnesty plus is still successful in destabilizing strategy  $Mc$ . In zone 3, firms switch from  $Mc$  to  $Ms$  when amnesty plus is effective but the benefit is weak because in the case  $\mu > 0$ , the simple leniency program strongly destabilizes alone the  $Mc$  strategy.

Under the assumption  $\frac{1}{2}\tau < \mu$  amnesty plus leads to opposite effects to the case  $\frac{1}{2}\tau > \mu$ . With  $\frac{1}{2}\tau < \mu$ , amnesty plus increases the expected profits under the  $Ms$  strategy and induces the border line between  $U_{sim}$  and  $Ms$  to move to the right. So in zone 4, firms switch from the  $U_{sim}$  to the  $Ms$  strategy and the collusive prices are decreased. In this case, amnesty plus does not deter collusion but softens its negative effect. Under the  $Ms$  strategy, the raise of expected profits explains also why the collusive sustainability is increased. Amnesty plus insures firms against antitrust fines and then helps to sustain the collusive agreement. This effect is strong enough to reverse the opposite one under simple leniency program and to allow firms to sustain collusion in a zone (1 in the graph) where collusion was not possible without leniency program.

To sum up, with  $\frac{1}{2}\tau < \mu$ , amnesty plus may soften (but not deter) collusion if  $F \leq F_{U_{sim}}$  (considering the value of  $F_{U_{sim}}$  computed under simple leniency program) and may help to sustain collusion for higher fine. On the contrary, with  $\frac{1}{2}\tau > \mu$ ,

amnesty plus involves always socially positive effects if  $F > F_{U_{sim}}$ . If  $F \leq F_{U_{sim}}$ , the effects depend on the degree of differentiation.

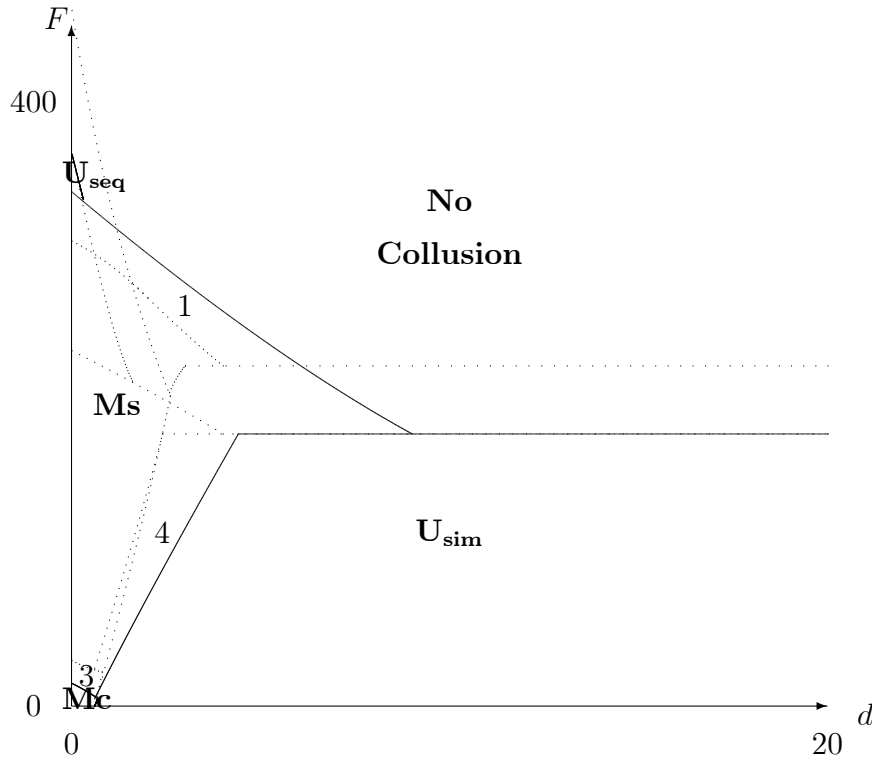


Figure 11: Amnesty plus ( $\frac{1}{2}\tau < \mu$ )

With endogenous organizational design, amnesty plus has not only an impact on firms' reporting strategies (as in Roux and Von Ungern-Sternberg, 2007) and on cartels' formation (as in Lefouilli and Roux, 2009) but also on the collusive prices. This third effect can be positive or negative depending on the parameters' values. So, as Roux and Von Ungern-Sternberg (2007) and Lefouilli and Roux (2009), we find that the effects of amnesty plus may be procompetitive but may also be procollusive.

**Proposition 5:** *Amnesty plus favors the U-form organization if  $\frac{1}{2}\tau > \mu$  and favors the M-form one if  $\frac{1}{2}\tau < \mu$ .*

## 7 Conclusion

This paper highlights a new determinant of the choice of organizational forms by introducing an antitrust authority devoted to fight multimarket collusion. Our main assumption is that it is easier for an antitrust authority to find hard evidences of collusion on one market during an investigation in the other market if the firms' organization is centralized. A divisional structure involves a compartmentalization of the different agreements and so dissipates evidences. When firms have to select an organizational structure, they 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 the U-form organization when the goods are closed 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 stronger incentives to choose an M-form organization. A variation of the discount factor can modify the organizational form according to the amount of the antitrust fine. If the fine is relatively low, then an increased value of the discount factor favors the choice of an M-form organization, and conversely. If the compartmentalization is not perfect under the M-form organization, then firms can prefer to select a U-form one. The impact of a leniency program on the organization design depends on the parameters' values.

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 the U-form organization for more complementary goods and the 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 as tax evasion, corruption in procurement, moonlighting, intellectual protection law infringement and so on. Illegal activities in several divisions of the same firm favor the choice of an M-form organization.

Another implication of our results is that when firms diversify in less related product lines (which requires less coordination), they switch from a U-form organization to an M-form one. So our results reinforce the traditional argument of managerial overload to explain why a diversification strategy favors a divisional structure.

If under the M-form organization, only imperfect compartmentalization occurs, firms may recover perfect compartmentalization with a spin-off process. So 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 break.

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