



Cartel Organization and Antitrust Enforcement

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Abstract

This paper incorporates the economic theory of organizations into the framework of public law enforcement, and characterizes the dual-coalition structure of cartel organization that allows us to highlight the strategic interactions between cartel participants under different antitrust policies. We show that delegation of authorities over collusive decisions from top executives to subordinates can mitigate the temptation of renege on collusive relationships and thus contributes to facilitating collusion. This result parallels the insights in Baker, Gibbons and Murphy (2002, 2006) which find that the optimal allocation of decision rights is to minimize the maximum temptation to renege on relational contracts. Moreover, the efficiency gains of delegation in facilitating collusion can be mitigated when the corporate leniency program is introduced, in particular whenever it is unlikely to detect cartels absent leniency and the corporate liability is much significant than individual liability.

Key Words: Cartel Organization, Antitrust Enforcement, Leniency Programs

JEL Classifications: D23, K21, L41

1. INTRODUCTION

How are modern cartels organized? How do they operate? Or more precisely, how are collusive agreements reached and enforced among cartel firms and how are duties of running cartels allocated inside a cartel firm? These questions are primary to the theory of cartels and the practice of antitrust, but unfortunately, still remain open.

Empirical studies from the cracked cartels are never sufficient to disclose the sophistication of cartel organization since the most successful cartels are so well-organized that they are unlikely to be detected; moreover, due to confidentiality policy, the details on the organizational form of cracked cartels are rarely disclosed².

¹I am grateful to Cécile Aubert, Stephen Davis, Morten Hviid, Bruno Jullien, Bruce Lyons and Andreas Stephan for their valuable comments, in particular, to my supervisor Patrick Rey for his help to simplify the basic model. I also thank the seminar participants in University of East Anglia and Toulouse University of Social Science. Financial Support from Economic and Social Research Council of UK and grants from National Social Science Foundation of China are greatly acknowledged.

²There are few exceptions of empirical studies on cartel organization based on the revealed reports about cartels' activities before the 1940s, when cartels were legal in most jurisdictions. For instance, Genesove and Mullin (2001) study the cartel organization of sugar institute, which was organized by the trade association from 1927 to 1936. They examine the unpublished memoranda by Louis Place, the former Vice-President of Macahan, a midsize refinery in Philadelphia, which recorded detailed notes on the Board of Directors, Executive Committee, and Enforcement

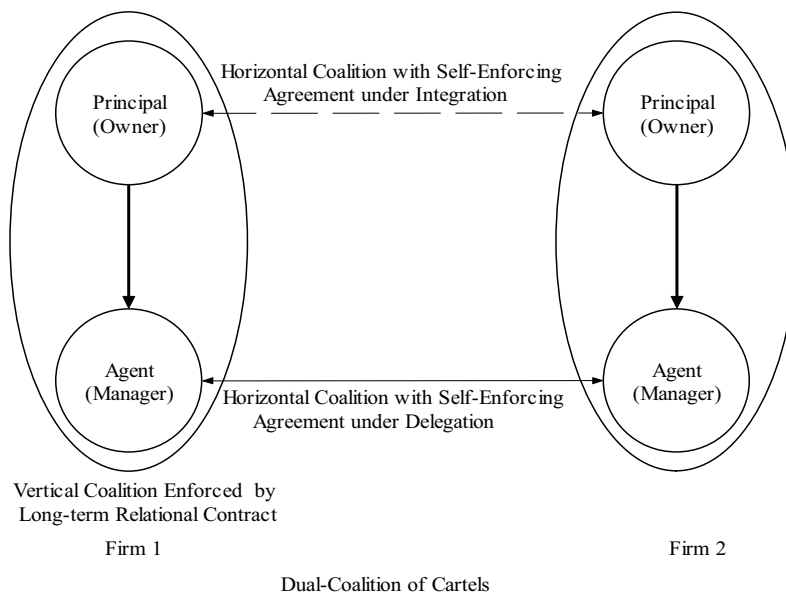


FIG. 1

Theoretical research on cartel organization is therefore quite essential to uncover the internal structure of cartels.

In classical theory of cartels, a collusive firm is regarded as an integrated entity that maximizes net profits from collusion. This short-cut in methodology allows us to characterize horizontal relationships among cartel firms by which collusive agreements are self-enforced, without taking into account complicated hierarchical structures inside the collusive firms; on the other hand, however, this methodology imposes a restriction on the analysis of the vertical relationship inside a collusive firm through which the duties of running cartels are allocated: In spite of the growing literature on the studies of the horizontal relationship, there are few studies concerning the vertical structure of cartel organization³.

This paper makes the first attempt to develop a theory on cartel organization. We establish a simple framework to characterize the dual-coalition structure of cartels as illustrated in Figure 1, and highlight the interactions between cartel organization and antitrust enforcement. In particular, this paper attempts to answer the following primary questions on cartel organization: How are the authorities over collusive decisions allocated in the hierarchy of the firm? And how does it contribute to facilitating collusion?

(Insert Figure 1 here)

Figure 1: Dual Coalition Structure of Cartel Organization

Committee meetings from January 1929 through mid-1930. However, we should bear in mind that the organization of modern cartels have become more sophisticated to deal with the trade-off between efficiency and concealment under antitrust enforcement, and thus these studies are not sufficient to disclose the organization structure of modern cartels.

³The research by two sociologists, Baker and Faulkner (1993), is one exception, who analyze the social organization of three well-known cartels in the heavy electrical equipment industry uncovered in 1960s, by employing the methodology of social network analysis. Their research reveals the basic trade-off between efficiency and concealment in illegal organizations.

To fix ideas, let's consider a typical industry with two identical firms which may either compete in the market or form a horizontal coalition to collude. In each firm, in spite of its sophisticated ownership and governance structure, there always exists some key player who is on the top of the hierarchy and holds the formal authorities, namely, the control rights on stakes allocation and the decision rights on managerial activities⁴; we call the player who holds these authorities "the principal" or "the owner". Although the control rights and decision rights are twinborn from the ownership of the firm, they are often separated and allocated in different layers of hierarchies. The allocation of authorities is the key issue that determines the efficiency of organizations⁵.

The control rights on the allocation of stakes always reside at the top (the principal); while the decision rights on managerial activities can be either kept by the principal, which is the case of "integration" or "centralization", or transferred to an agent recruited from a competitive labour market, which is the case of "delegation" or "decentralization". It is assumed that delegation of decision rights is contractible⁶.

When the firms are involved in collusive activities, the allocation of authority on decisions plays a key role in facilitating collusion. Moreover, it determines the allocation of liabilities for antitrust infringement. Under integration, the principal is the decision-maker and thus the key player liable for antitrust infringement; in addition, as the owner of the firm, the principal must also bear the corporate liability for infringement. While under delegation, the agent becomes the key player of the collusion game and is liable (individually) for the violation of antitrust law. The agent makes decisions whether to collude or compete with the rival firm and whether to respect the collusive agreement or deviate, based on the incentive schemes offered by the principal. As such incentive schemes would reveal key evidence on collusion, they are unlikely to be enforceable by the court of law; instead, they are relational contracts self-enforceable through ongoing interactions.

Firms are riddled with relational contracts, as argued by Baker, Gibbons and Murphy (2002): informal agreements and unwritten codes of conduct powerfully affect the behavior of individuals within firms. Collusive agreements between firms and incentive schemes inside a firm to facilitate collusion, as demonstrated in Figure 1, are typical relational contracts. In economic organizations governed by relational contracts, the optimal allocation of decision rights is to minimize the maximum temptation to renege on relational contracts; this insight, as highlighted in Baker, Gibbons and Murphy (2002, 2006), is also explored in this paper which reveals the basic principles of cartel organization.

Under integration, the principal holds both the control rights over stakes allocation and the authority over collusive decisions; and the temptation of deviation from the collusive agreement is the relevant challenge to facilitate collusion. Whenever the principal delegates the decision rights on collusive activities to the agent,

⁴Following the Grossman-Hart-Moore approach, these authorities are originated from the ownership of an asset which include the decision rights on running the asset and the rights on residual claimant of the asset. See also Baker, Gibbons and Murphy (2006) for the discussion of authority in organizations.

⁵Aghion and Tirole (1997) develops a theory of the allocation of the formal authority (the right to decide) and the real authority (the effective control over decisions) within organizations. While Baker, Gibbons and Murphy (1999) study the allocation of authorities when decision rights are not contractible.

⁶Imagine that delegation of the authority is accomplished through some institutional arrangement which is irretrievable.

the separation of the decision rights from control rights can mitigate the temptation of cheating.

The agent's temptation of deviation can be suppressed under delegation, as his cheating will result to a failure to collude in which case the principal will surely pay nothing to him. On the other hand, the principal's temptation of cheating can also be overcome under the separation of authorities. Since the principal has no decision rights under the delegation regime, she can acquire the stakes of cheating only through incentive contracts that would induce the agent to deviate from the collusive agreement. But there is no self-enforcing relational contract that can induce the agent to cheat: the agent would expect that the principal will "kick-down-the-ladder" following the realization of profits from cheating as there is no future cooperation, in which case he can get nothing but has to bear the liability of antitrust infringement.

Of course, as the principal holds the control rights on the allocation of collusive stakes, the temptation of renege on the payments after the collusive profit is realized becomes a relevant concern to facilitating collusion. But the benefit from renege on the payment which is no more than the firm's stake from collusion is obviously less than the gain from cheating in the production market which may be as large as the total monopolistic profits of the whole industry; therefore the temptation of renege on collusion is reduced under delegation which makes collusion more robust.

Our analysis therefore enriches the economic theory of organizations, in particular the understanding of the interactions between formal and informal contracts. As Klein (2000) argues, "the fundamental economic motivation for the use of court-enforceable contract terms is to supplement self-enforcement", and "contract terms cannot be understood without recognizing that their role often is to control (the temptation of renege) so that it remains below (the surplus from cooperation)" (P.73). These insights are further developed by Baker, Gibbons and Murphy (2002, 2006) who study the organizational forms between and inside firms that are governed by informal agreements. They find that the allocation of alienable (and thus contractible) decision rights across parties influences the facilitation of relational contract, and the optimal allocation of decision rights is determined by precisely the consideration that Klein described, that is, to minimize the temptation of renege. Whilst this research investigates only legal organizations, our analysis shows that the analogue concern prevails in illegal organizations like cartels and organized crime.

Transferring the decision rights from the principal to the agent can mitigate the temptation of renege and contribute to facilitating collusion; this result predicts that the cartel firms would prefer the decentralized vertical structure in collusion, and as a result, the number of top executives (directors, CEOs) who are explicitly engaged in collusive activities and successfully prosecuted would be less than that of engaged managers. Observations of case studies are consistent with this prediction in spite that there is no complete data on engaged individuals of cracked cartels. For instance, Harrington (2006) checked the hierarchical structure of cartel participants who attended cartel meetings, and concluded in Table 4.2 that, among nine cracked cartels, only the Carbonless paper and Graphite electrodes cartels have their top executives engaged in cartel activities. While Baker and Faulkner (1993) analyze three cartels in the heavy electrical equipment industries which were cracked in 1960s, and their studies also indicate that top executives are less involved and less

likely to be prosecuted in decentralized organizations.⁷

The efficiency gain of collusion under delegation can be mitigated when a leniency program is introduced. The adoption of the Corporate Leniency Program (hereafter CLP) that allows cartels to approach the antitrust authority for amnesty is one of the most important developments in antitrust enforcement which has contributed to cracking dozens of cartels since its revision in 1993 in the U.S.⁸. Granting leniency to cartel members who are engaged in cartel activities but report and bring evidence can help the antitrust authority to gather evidence for cartel prosecution which is unlikely to be successful in the absence of a leniency program, and thus contribute to destabilizing collusion. In the presence of a leniency program, the firm which deviates in the production market would further denounce the cartel to benefit from the corporate leniency program that can reduce both the corporate and individual fines. If the whistle-blower can get even positive reward from a leniency program, the agent then has incentives to cheat without fear of the principal "kicking-down-the-ladder" by the principal, as he can still get rewards from the antitrust authority when approaching the leniency program. This makes the temptation of deviation from a collusive agreement a real threat to sustaining collusion even under the delegation regime, and thus contributes to destabilizing collusion under delegation.

On the other hand, however, granting generous leniency to the whistle-blower would make cartels more profitable and thus more robust. In particular, the policy of rewarding the whistle-blower which can encourage the agent to denounce the cartel would also benefit the principal, since the agent can get amnesty only if the principal approaches to corporate leniency⁹. These two opposite effects on facilitating collusion brings a trade-off in the optimal design of leniency programs and thus determines the optimal leniency rate which is related to the effectiveness of antitrust enforcement¹⁰.

This paper incorporates the mechanism design approach into the theory of public law enforcement a la Becker (1968), by taking into account the strategic interactions among cartel participants. The basic framework is closely related to Chen and Rey (2007) which characterizes the basic trade-off on the design of corporate leniency programs and shows that the optimal leniency policy should be related to the effectiveness of antitrust enforcement. The paper is also related to the recent literature on leniency programs and antitrust enforcement¹¹: Motta and Polo (2003) analyze the impact of leniency on collusion in a framework where the antitrust agency can also launch random investigations that sometimes lead to successful prosecution, and study the most effective way to allocate antitrust resources between preliminary investigation and prosecution; Aubert, Rey and Kovacic (2005) compare the impact of reduced fines and positive rewards and argue that rewarding individuals can deter collusion in a more effective way. Moreover, they discuss possible adverse

⁷There is one alternative explanation for this observation which argues that the top executives are more risk-averse than mid-level managers, in particular when they face the risk of imprisonment. This is, however, too trivial. Of course, we do not intend to provide policy implications based on our theoretic research, as there is no sufficient empirical studies to support these results until now.

⁸See the report by Scott Hammond, "Cornerstones of an effective leniency program" (2004).

⁹The Corporate Leniency Program allows only the principal as the legal representative of the engaged firm to approach corporate leniency, which automatically exempts the individual liability of antitrust infringement for all engaged individuals of the firm.

¹⁰See Chen and Rey (2007) for detailed analysis on the optimal design of leniency programs.

¹¹See Spagnolo (2006) for an excellent survey on leniency programs.

effects of whistleblowing programs on firms' behavior and incentives to innovate and cooperate. While Harrington (2005) characterizes the leniency program in a framework that allows the probability of discovery and successful prosecution to change over time, and points out that offering leniency can trigger a "Race-to-the-courtthouse" when detection becomes likely, which in turn increases the expected penalties from engaging in cartel activity.

Our analysis of cartel organization is also supplementary to the recent research on the interactions between corporate governance and collusive behavior¹². In particular, Spagnolo (2000) analyzes the impact of stock-related compensation on product-market collusion, and points out that a perfect foresight stock market can anticipate the losses from punishment phases and discount them on stock prices, which reduces managers' short-term gains from any deviation and thus facilitates collusion. In addition, Spagnolo (2005) characterizes the effects of managerial incentives on firms' collusive behavior: when managers have a preference for smooth time-path of profits, manager-led firms can sustain collusion at lower discount factors; moreover, capped bonus plans and incumbency rents with termination threats make collusion supportable at any discount factor.

The rest of the paper is organized as follows: we present the basic model in section 2, where the basic structure of horizontal and vertical relationships are characterized. In section 3, we analyze antitrust enforcement in the absence of any leniency programs as a benchmark, and demonstrate that cartels become less vulnerable to deviation under delegation. We then turn to antitrust enforcement under the Corporate Leniency Program in section 4, characterizing the optimal leniency policies and the thresholds of deterrence. Finally, we conclude in Section 5.

2. THE MODEL OF COLLUSION

The Horizontal Structure

We consider a simple market structure: in each industry, two identical firms play an infinitely repeated game where, in each period, they can choose to form a hard-core cartel before interacting on the production market. All firms have the same discount rate $\delta \in (0, 1)$ and maximize the expected discounted sum of their profits. In each period, each firm chooses whether to "collude" or "compete"; the expected gross profit of a firm is:

- 0 if both firms compete;
- B if both firms collude;
- $2B$ for a firm that deviates unilaterally from the collusive market agreement, in which case, the other firm gets 0.

Firms can try to sustain on-going collusion by returning to Bertrand competition (which is both the static Nash equilibrium and the minimax) in case a firm deviates from the collusive outcome. In the absence of any antitrust policy, collusion is therefore sustainable if:

$$B(1 + \delta + \delta^2 + \dots) = \frac{B}{1 - \delta} \geq 2B + \delta \times 0(1 + \delta + \dots) = 2B,$$

¹²Buccirosi and Spagnolo (2007) provide an excellent survey on this literature, and address many important open questions for further research.

that is, if

$$\delta > \frac{1}{2}.$$

We will assume throughout the paper that this condition holds, so that collusion is indeed a concern.

The Vertical Structure

In each firm, there is a principal who owns the control rights on stakes allocation and decision rights over collusive activities. The principal can make decisions whether to collude or compete with the rival firms and whether to respect or not the collusive agreement under collusion, which is the case of integration or centralization. Alternatively, the principal can delegate this authority to an agent recruited from a competitive labour market, who makes decisions based on the incentive scheme offered by the principal. It is assumed that delegation of decision rights is accomplished through some institutional arrangement in corporate governance, and is therefore contractible. It is also assumed that both principal and agent are risk-neutral.

The agent's actions are unobservable by the principal, but the realized profit levels which are common knowledge between the principal and agent can reveal the true information on the agent's actions *ex post*. The incentive contracts can thus be contingent on the realized profit levels to induce the "right" behavior of the agent. However, such kinds of contracts may involve key evidence on illegal activities, therefore they are unlikely to be enforceable by the court of law; they can instead be self-enforced through on-going relationships.

3. ANTITRUST ENFORCEMENT ABSENT LENIENCY PROGRAM

3.1. Law Enforcement Against Cartels: A Review of Methodology

The economic theory of public enforcement of law has been developed following Becker (1968), to study the optimal allocation of social resources to apprehend and sanction violators of legal rules.

We follow the basic framework of this literature to study the effectiveness of antitrust enforcement against cartels. It is useful to introduce some heterogeneity among industries following this literature. We assume that the stake of collusion B varies across industries: the bigger B is, the more profitable is collusion, as well as the short-term gains from a deviation. For the sake of simplicity we will assume that δ remains constant across industries.

To fix ideas, we assume that collusive behavior results in a deadweight loss of social welfare and that the antitrust authority aims to deter as much as possible cartels. The effectiveness of antitrust enforcement can be measured by a threshold of deterrence where cartel formation can be deterred given that firms' stakes from collusion are less than this threshold: the antitrust policy is more effective if it yields higher threshold of deterrence.

We assume that collusion leaves some evidence that the antitrust authority can find out if it investigates the industry; however, due to budget and resource limitations, this happens only with some probability $\rho < 1$; in addition, each firm can also bring this evidence to the antitrust authority¹³. When a cartel is detected, either

¹³Usually, cartels will not leave any documents and records about their collusive agreements and it is very difficult to find hard evidence such as paperwork. However, introducing leniency programs might encourage cartel members to create and keep some digital evidence of communication and

through an investigation or because a cartel member provided the incriminating evidence, each firm must pay a fine F and each engaged individual must pay a fine f . For simplicity, we restrict our attention only to stationary antitrust policies which generate a stationary threshold of deterrence over time.

Running a cartel is a kind of sophisticated organized crime which is accomplished by a hierarchy of multi-players. The success of a cartel is therefore determined by its organizational structure that is formed and evolved to deal with different kinds of challenges: coordinating the behavior of all cartel participants on mutually consistent collusive strategies; monitoring the behavior of cartel participants to detect and deter defections from these collusive strategies; and organizing cartel activities to avoid antitrust enforcement. The evolution of antitrust policy will cause the change of the cartel organization as a response, and the effectiveness of the antitrust enforcement is determined by the strategic interactions between the antitrust agency and the cartel, as well as the strategic behavior among cartel participants. It is therefore essential to incorporate the mechanism design approach into the literature of law enforcement, to study the optimal design of antitrust policy against cartels, in particular, the design of a self-reporting mechanism which helps the antitrust authority to disclose the asymmetric information and collect collusive evidence.

3.2. Collusion under Integration: A Benchmark

We set out to analyze the cartel organization in a simple setting of antitrust enforcement without any leniency programs. The antitrust authority designs the enforcement mechanisms to deter cartel formation as much as possible, and these mechanisms are assumed to be fixed and stationary over time¹⁴. After the antitrust policy is announced, the principals in all industries decide whether or not to delegate the authority over decisions to the agents simultaneously. Delegation of authorities is common knowledge and contractible.

Consider the case of integration first where the principals of both firms agree on keeping the decision rights. The repeated game begins followed by this decision; in each period $t = 1, 2, \dots$, the timing of the game is illustrated as follows:

- Stage 1. Each firm chooses whether or not to enter into a collusive agreement. If at least one firm chooses not to collude, then competition takes place and the game ends for that period; otherwise:
- Stage 2. Each firm decides whether to respect the agreement and "collude", or deviate and "compete" on the market. These decisions are not observed by rivals until stage 3; then:
- Stage 3. The profit is realized. Each firm then decides whether to report or not. If no firm reports, the cartel is detected with probability ρ , in which case all firms pay the full fine F and engaged individuals pay fine f .

Absent leniency, firms engaged in collusion never have incentives to denounce cartels. Under integration, in each period, collusion generates the profit B for the coordination, which are now widely accepted as hard evidence, as reported by ICN "Anti-Cartel Enforcement Manual", Chapter 3.

¹⁴The assumption on stationary mechanism enables us to derive a simple recursive structure for repeated games. This assumption reflects the key feature of antitrust policy in the real world which is open and steady over time.

firm, nets the expected fine $\rho(F + f)$, and it is desirable only if the benefit from collusion is positive:

$$B \geq B^0 \equiv \rho(F + f), \quad (1)$$

where B^0 represents the level of collusive stake above which collusion is desirable. We call B^0 the Beckerian Threshold of Deterrence a la Becker (1968). According to (1), given the likelihood of detection ρ due to resource constraints, it is optimal to raise the fines F and f as large as possible to deter as many cartels as possible, which implies that the optimal fine is the maximal fine¹⁵. Let F and f also denote the maximal fine for engaged corporations and individuals, with a slight abuse of notation; the antitrust policy parameters ρ , f and F are exogenously fixed and constant over time.

The Beckerian threshold represents the minimal level of deterrence given antitrust policy parameters ρ , F and f ; it is related to the environment of perfect collusion where collusive agreements can be enforced without any transaction costs.

When collusive agreements are self-enforced through on-going relationships, the temptation of cheating becomes the preeminent challenge that cartels face, as highlighted by Stigler (1964). Assuming that the cartel firm can grab the whole stakes of collusion by deviating unilaterally in the production market, and assuming also that the severest punishment strategies will be employed when cheating occurs, then collusion can be sustained through repeated interactions only if it can bring sufficiently high discounted value that overweighs the gain from one-shot deviation:

$$V = \frac{B - \rho(F + f)}{1 - \delta} \geq 2B - \rho(F + f),$$

where the right-hand-side of the inequality is the net benefit from deviation¹⁶. We assume that both firms will turn to Bertrand competition forever after any unilateral deviation from collusive agreement, and this Nash punishment yields zero profits for both parties.

Rewriting this incentive compatibility constraint of facilitating collusion yields

$$B \geq \underline{B}^I \equiv \frac{\delta\rho(F + f)}{2\delta - 1} > B^0, \quad (2)$$

where \underline{B}^I stands for the Stiglerian threshold of deterrence a la Stigler (1964); it represents the threshold of deterrence in the environment where each firm behaves as an integrated entity under collusion, and faces antitrust enforcement without any leniency programs.

3.3. Delegation and Relational Contracts

Under integration, the temptation of deviation from collusive agreements becomes a relevant threat to the success of cartels; overcoming this temptation is costly to the cartels and raises the threshold of collusive stakes above which collusion is sustainable: The Stiglerian threshold \underline{B}^I is strictly higher than the Beckerian threshold B^0 . This implies that for the firms with collusive stakes between B^0 and \underline{B}^I , collusion is desirable but not sustainable.

¹⁵This is one of the basic results in the theory of public law enforcement a la Becker (1968), see also Polinsky and Shavell (2000) for detailed analysis.

¹⁶We assume that the cartels will still be prosecuted even if they are not successful due to some firm's defection, as the hard evidence will still disclose their collusive behavior.

To improve the efficiency of cartels, the gain of deviation, which is $2B$ under integration, must be reduced. This can be achieved by resorting to enforcement mechanisms through which cartel members can coordinate pricing decisions, monitor sales and reallocate market shares, such that the the gain from cheating can be minimized¹⁷, which is widely discussed in Harrington (2006) as well as Levenstein and Suslow (2006).

In addition to these enforcement mechanisms at the horizontal level, the cartels would also resort to organizational reform at the vertical level which helps to improve the efficiency of collusion. Under integration, the principal holds the control rights on stakes allocation and decision rights on collusive actions, the gains of cheating can be achieved without any transaction costs, and therefore the temptation of deviation is maximal in this case. If instead the principal delegates the decision rights to the agent but still holds the control rights, the separation of authorities can mitigate the temptation of renege on collusive agreements and make the cartels more robust.

To fix ideas, suppose that both firms choose to delegate the authorities to the agents¹⁸, who then become the real authority and make decisions on behalf of the firms. Under delegation, in each period $t = 1, 2, \dots$, the timing of the game is given by:

- Stage 0. The principals of both firms propose incentive schemes to the agents, and the agents decide to accept or not simultaneously. If at least one agent rejects the payment scheme, then competition takes place and the game ends for that period; otherwise:
- Stage 1. Each firm chooses whether to enter into a collusive agreement. If at least one firm chooses not to collude, then competition takes place and the game ends for that period; otherwise:
- Stage 2. Each firm decides whether to respect the agreement and "collude", or deviate and "compete" on the market. These decisions are not observed by the rival until stage 3; then:
- Stage 3. The profits are realized and payments are transferred. Each firm then decides whether to report or not. If no firm reports, the cartel is detected with probability ρ , in which case all firms pay the full fine F and engaged individuals pay fine f .

Under delegation, the cooperation between the principal and agent is sustained by a relational contract that describes the behavior over time in the repeated game, both on the equilibrium path and following a deviation. As the principal and agent play a repeated game with complete information, without loss of generality, we only need to consider an optimal stationary contract which is self-enforcing¹⁹.

¹⁷See Genesove and Mullin (2001) for detailed discussion about the enforcement mechanisms of sugar cartels.

¹⁸We assume that, at the beginning of the game, the principals in the same industry can coordinate when they choose to delegate or not, as delegation of authority is common knowledge to all participants. In this game, asymmetric strategies are never optimal for collusion, as they will bring more incentive compatibility constraints in sustaining collusion than the symmetric case; therefore unilateral deviation from delegation to integration is not beneficial.

¹⁹The same logic in the proof of Theorem 2 in Levine (2003) can be applied to relational contracts with complete information.

Consider the following stationary relational contract $T = \{w^t, t = 0, 1, \dots, \infty\}$, proposed by the principal to induce collusion with the rival firm, where the payments to the agent is contingent on the realized profit

$$w^t = \left\{ \begin{array}{l} w, \text{ if and only if } \pi = B, \\ 0, \text{ otherwise} \end{array} \right\}, \text{ for any } t. \quad (3)$$

Moreover, the contract also specifies what happens if the principal refuses to make a conditional payment after the collusive profit is realized: the agent will turn to competition in the market forever which yields both the principal and agent zero payoffs, and this minimax punishment forms a Nash equilibrium (the worst equilibrium) on the path off the equilibrium.

This relational contract assigns a wage w to the agent only when he succeeds in colluding with the rival firm, and generates the expected discounted value U for the agent:

$$U = \frac{w - \rho f}{1 - \delta},$$

and value V for the principal²⁰:

$$V^D = \frac{B - w - \rho F}{1 - \delta}.$$

The agent will accept this contract and collude with the other firm only when the wage is higher enough to overweigh his expected fines:

$$w \geq \rho f.$$

Since the principal holds the control rights of stakes allocation and the agent is recruited from the competitive labor market, the agent cannot get any rents; which implies that the optimal wage is determined when this constraint is binding

$$w^* = \rho f.$$

Note that, the agent has no incentive to break down the collusive agreement as he will get nothing from deviation, and therefore no additional incentive cost would be given to induce the agent to collude. This implies that the relational contract yields the principal the discounted value V^D under delegation which is exactly the same as under integration:

$$V^D = \frac{B - w^* - \rho F}{1 - \delta} = \frac{B - \rho(F + f)}{1 - \delta}. \quad (4)$$

The relational contract is self-enforcing only when it can bring the principal sufficiently high discounted value from on-going collusion to resist the temptation of renege on the payments, that is,

$$V = \frac{B - \rho(F + f)}{1 - \delta} \geq B - \rho F,$$

or equivalently, the principal's stake from collusion must be high enough:

$$B \geq \underline{B}^D \equiv \frac{\rho f + \delta \rho F}{\delta} > B^0. \quad (5)$$

²⁰ As the principal is not engaged in collusive activities, he is able to shield the individual liability but still has to take corporate liability.

Under delegation, the agent's temptation of deviation from the collusive agreement is suppressed, whereas the principal's temptation to cheat in the production market is still a concern, in spite that the agent is the decision-maker on collusive activities. The principal would induce the agent to sign a collusive agreement with the rival firm and then deviate in the production market. However, since the principal is unable to commit the payment following the deviation, no self-enforcing relational contract can induce the agent to "collude and cheat", as concluded by:

PROPOSITION 1. : *In the absence of leniency programs, there exists no self-enforcing relational contract that can induce the agent to cheat under delegation.*

Proof. Suppose the principal proposes a relational contract $\hat{T} = \{\hat{w}, 0, \dots\}$ to induce "collude and cheat", which offers conditional payment \hat{w} to the agent such that $\hat{w} \geq \rho f$. However, this relational contract is not self-enforcing: the principal will pay 0 rather than \hat{w} to the agent given that the profit from cheating is realized, as there is no future cooperation following a deviation. This contract then yields a negative payoff $-\rho f$ to the agent and, of course, cannot be accepted. ■

This result should not be striking when we take into account the interactions between the vertical and horizontal relationship of the cartel. Under delegation, collusion is enforceable only if both the vertical and horizontal relational contracts are sustainable, and these two relational contracts are entangled. On one hand, the horizontal relationship is robust only when the vertical relationship is sustainable: the principal's renege on payments will result in a retaliation from the agent which breaks down collusion; on the other hand, the vertical relationship will be terminated when the agent is induced to deviate from horizontal agreement, in which case, the principal will "kick-down-the-ladder" after the stakes of cheating are realized and the agent then can get nothing but has to take the liability of antitrust infringement. This concern prevents the agent from taking any actions that will lead to a failure of collusion²¹.

Under delegation, the principal's limited commitment power on payments causes the temptations of renege on the vertical relational contract which is a negative effect to facilitating collusion; whereas on the other hand, it also mitigates the temptation of renege on the horizontal relational contract which is a positive effect to sustaining collusion. Since the benefit from renege on the vertical relationship B is less than the gain from breaking the horizontal relationship $2B$, the negative effect is always dominated by the positive effect, implying that collusion becomes more robust under delegation. As a result, the threshold of deterrence under delegation is strictly lower than under integration: $\underline{B}^D < \underline{B}^I$ as it is easy to check, which is concluded as follows:

PROPOSITION 2. *In the absence of leniency programs, delegation of authority over decisions always dominates integration in facilitating collusion, therefore delegation prevails in collusive equilibrium.*

Proof. See Appendix A. ■

This proposition parallels the results in Baker, Gibbons and Murphy (2002, 2006), which investigate the economic organizations governed by relational contracts and find that the optimal allocation of decision rights is to minimize the maximum temptation to renege on relational contracts.

²¹There is a famous Chinese proverb saying "kill the donkey at the moment it leaves the millstone", which expresses the same meaning.

There is a variety of considerations for the delegation of decision rights in organizations as widely discussed in the economic theory of organizations. Our analysis shows that delegation of authority can enhance the robustness of cartels, which predicts that delegation would prevail in cartel organizations. This prediction is consistent with the observations from case studies as mentioned in the introduction.

However, due to confidentiality policy, the details on the organizational forms of cracked cartels are rarely disclosed, which makes it very difficult to build a database of cartel organizations for empirical research. Theoretical research that incorporates the economic theory of organizations into the study of cartels is therefore quite essential to understand the sophistication of cartel structures and reveal the basic principles of cartel organization.

The efficiency gain of collusion under delegation can be mitigated when a leniency program is introduced. In the presence of a leniency program, the firm which deviates in the production market would further denounce the cartel to benefit from the corporate leniency program that can reduce both the corporate and individual fines. If the whistle-blower can get even positive reward from the leniency program, the agent then has incentives to "collude and cheat" without fear of "kick-down-the-ladder" by the principal, as he can still get positive reward from the antitrust authority when appealing for leniency with the principal. Deviation from the collusive agreement now becomes a relevant threat to the success of the cartel, and collusion becomes less robust under delegation.

4. OPTIMAL DESIGN OF CORPORATE LENIENCY PROGRAMS

Gathering evidence is the key challenge for antitrust agencies, which is unlikely to be successful absent any tip. Thus, inducing those who are engaged in cartel activities to report it and bring adequate evidence would enhance the effectiveness of antitrust enforcement; this is the main purpose of introducing the leniency programs for fighting cartels.

The introduction of corporate leniency programs is one of the most important developments in antitrust policy. First adopted in 1978 in the U.S., this program allows corporations or individuals involved in illegal cartel activity to receive amnesty if they come forward and denounce the cartel. In 1993, the US amnesty program was revised to give firms more opportunities and higher incentives to cooperate with the Antitrust Division: the "first informant" rule now guarantees amnesty to the first reporting firm (and only to the first one), while the "post-investigation amnesty" rule allows the first informant to remain eligible even after an investigation is underway. This revised leniency program has been the most effective antitrust enforcement tool which contributes to cracking dozens of international cartels, convicting U.S. and foreign executives, and enforcing record-breaking corporate fines. This success has encouraged many other countries or jurisdictions to set up their own leniency programs²².

Granting amnesty to cartel members encourages them to report their collusive activities and can thus contribute to destabilizing collusion; however, reducing the expected fine that firms have to pay in case of exposition may also make cartels more profitable and thus more robust. This trade-off determines endogenously the

²²A leniency program has for example been adopted by the EU Commission in 1996, and revised in 2002; many European countries have also adopted leniency programs. South Korea recently adopted a leniency program that can furthermore grant monetary rewards to individual informants.

optimal level of leniency, as characterized by Chen and Rey (2007). The methodology in that paper is applied here to analyze the optimal design of leniency programs in the framework of cartel organization with dual-coalition structure.

4.1. Leniency Programs under Integration

We first consider the optimal design of corporate leniency programs under integration where both principals choose to keep the authority over decisions. The repeated game begins following these decisions; in each period, the timing of the stage game can be illustrated as follows:

- Stage 1. Each firm chooses whether to enter into a collusive agreement. If at least one firm chooses not to collude, then competition takes place and the game ends for that period; otherwise:
- Stage 2. Each firm chooses whether to respect the agreement and "collude", or deviate and "cheat" on the market. These decisions are not observed by rivals until stage 3; then:
- Stage 3. Each firm decides whether to report the evidence to the antitrust agency. The cartel is detected with probability 1 if at least one firm reports, in which case the first informant gets a reduced corporate fine $(1 - q)F$ for the firm and/or $(1 - q)f$ for the engaged individual, while the others pay the full fines; if no one reports then:
- Stage 4. The profit is realized. Each firm then decides whether to report or not. If no firm reports, the cartel is detected with probability ρ , in which case all firms pay the full fine F and the engaged individuals pay full fine f respectively.

Remark 1. Firms can report before the collusive result is disclosed; this allows the firm who deviates in the production market to denounce further the cartel before its defection is uncovered, which increases the gain of deviation. In addition, the collusive firms can also denounce the cartel after the collusive result is revealed, this allows the firms to retaliate upon a deviation by resorting to report. This assumption is consistent with the real situation where the collusive firms are allowed to apply for leniency as soon as they find it profitable.

The corporate leniency program allows the *first informant* (and only the first one) to benefit from the exemption of fines with leniency rate q , and it would be optimal to reward the informant, i.e. $q > 1$ when the antitrust enforcement is not very effective. Moreover, the corporate leniency program allows only the principal as the legal representative of a collusive firm to approach, and any other individuals engaged in collusion are not eligible to apply for leniency unless they come forward with the principal. The individual fines of engaged employers and employees of the firm that qualifies for amnesty will also be reduced automatically with the same amnesty rate.

Introducing a leniency program makes "normal" collusion, that is, "collude and never report" more difficult, but also broadens the scope of collusive strategies. We first analyze the two issues, and then characterize the optimal degree of leniency²³.

Collude and Never Report

²³The analysis in this subsection is cited from section 3.1 in Chen and Rey (2007).

Firms (principals) can still try to collude in every period and never report any evidence to the antitrust agency. The principals then get as before V if they stick to such collusion and get benefit $2B$ if they cheat. But a principal that deviates can now moreover denounce the cartel at stage 3 in order to benefit from leniency, and she will indeed have an incentive to do so since otherwise the other firm will approach the antitrust authority at stage 4 as a retaliation to defection which reduces the benefit from deviation to $2B - F$. Normal collusion is sustainable only when the temptation of "deviate and report" can be resisted:

$$V_N^I = \frac{B - \rho(F + f)}{1 - \delta} \geq 2B - (1 - q)(f + F),$$

that is:

$$B \geq B_N^I(q) \equiv \frac{\rho - (1 - \delta)(1 - q)}{(2\delta - 1)}(f + F), \quad (6)$$

where the subscript N stands for the "collude and never report" strategy and the superscript I represents the "Integration" regime. The threshold $B_N^I(q)$ increases with the amnesty rate and is indeed higher than \underline{B}^I when $q > \underline{q} \equiv 1 - \rho$.

Collude and Report

Firms may however try to take advantage of the leniency program and use it to reduce the expected fines they face. They could for example take turns in denouncing the cartel. This may sound far-fetched, since the cartel would then be systematically denounced and yet go on forever, but in practice, one would expect the antitrust agency to keep such an industry under close scrutiny, making it difficult to collude again for at least some time. Yet the firms could start colluding later on and again apply for leniency at some point; more realistically, they may apply for amnesty when they feel that an investigation becomes likely or that the cartel will collapse. For the sake of exposition, we will stick here to the assumption that the antitrust policy is stationary and treats all industries alike.

Remark 2. The above analysis supposes that firms could in principal report a cartel, benefit from leniency, and yet keep colluding in the future. This is inconsistent with the casual observation that the same firms and same industries are regular "customers" of the antitrust office. However, one would expect that in practice, once a cartel has been exposed, the industry will be kept under closer scrutiny for at least some time, which contributes to reducing the appeal of "collude and report" strategies. Assuming that the cartels will be under intensified monitoring for T periods after being cracked, we show in Chen and Rey (2007) that the basic trade-off in the design of leniency programs absent any restrictions for ongoing collusion as well as the basic results on the optimal leniency policies are kept unchanged. Therefore, it is helpful to restrict our attention to the case without any restrictions for future collusion in theoretical analysis, which makes the basic model quite simple.

Remark 3. In many jurisdictions like the USA and the EU, amnesty is never offered to a repeated offender. This prevents cartels from adopting "collude and report" strategies, but may also lead to other forms of collusion such as "report once and never after that". This form of collusion may actually be more robust than "collude and report" in the absence of any specific rule for repeated offenders: by reporting once, cartel members can make sure that no one has an incentive to report afterwards, which thus stabilizes normal collusion in the future. In other words, ruling out leniency for repeated offenders renders the leniency program completely ineffective as shown by Chen and Rey (2007).

Given our stationary assumptions, a relevant alternative strategy is to collude and systematically report the cartel. It is helpful to distinguish this "on-schedule" self-report from the "off-schedule" report which occurs after a unilateral deviation: in an on-schedule report, both firms can coordinate in reporting which ensures that they have the same chance of winning the amnesty (i.e. $\frac{1}{2}$); whereas an off-schedule report happens following a unilateral deviation from the "collude and never report" strategy, as discussed above, and before this deviation being disclosed, which ensures the deviated firm wins the amnesty definitely. When organizing the "collude and report" strategy, the cartel members will coordinate to report at stage 3, that is, before the collusive profit realized, rather than at stage 4. This prevents any firm from taking advantages of the "off-schedule" report and therefore reduces the gains from deviation.

As both principals are equally likely to be the first informant, the value of such collusion is given by

$$V_R^I \equiv \frac{B - \left(1 - \frac{q}{2}\right)(f + F)}{1 - \delta},$$

where the subscript R stands for "collude and Report". It is clear that reporting is self-sustainable: if an agent anticipates that the other will report the cartel, it is better to report and apply for leniency as well. This alternative form of collusion is therefore sustainable as long as the principals have no incentive to deviate and report²⁴:

$$V_R^I \geq 2B - (1 - q/2)(f + F),$$

that is, whenever

$$B \geq B_R^I(q) \equiv \frac{\delta \left(1 - \frac{q}{2}\right)}{(2\delta - 1)}(f + F). \quad (7)$$

The threshold $B_R^I(q)$ *decreases* as the amnesty rate increases: offering additional leniency makes this form of collusion more attractive (V_R increases) and, by the same token, more robust to deviation. In particular, excessive leniency would benefit the firms by reducing the expected fine and would then facilitate collusion; this occurs when

$$1 - \frac{q}{2} < \rho,$$

or

$$q > \bar{q} \equiv 2(1 - \rho),$$

in which case this collusive strategy is more robust than normal collusion absent leniency: $B_R^I(q) < \underline{B}^I$ for any $q > \bar{q}$.

Optimal leniency rate.

To sum up, "collude and never report" is sustainable when $B \geq B_N^I(q)$, while "collude and report" is sustainable when $B \geq B_R^I(q)$. Conversely, it can be checked that no other form of collusion is sustainable if these are not²⁵. We now seek to characterize the optimal rate of leniency. The antitrust authority aims to deter

²⁴A deviated firm cannot take any advantages of applying leniency under the "on-schedule" reporting: the likelihood of winning does not change following its deviation.

²⁵As usual, the two firms should behave symmetrically in order to maximize the scope for collusion, and colluding in every period maximizes the value of future collusion, which contributes to making it more robust to deviations. In addition, randomizing between reporting or not (even using a public lottery to preserve symmetry) is not sustainable when neither "never reporting" nor "always reporting" can be sustained.

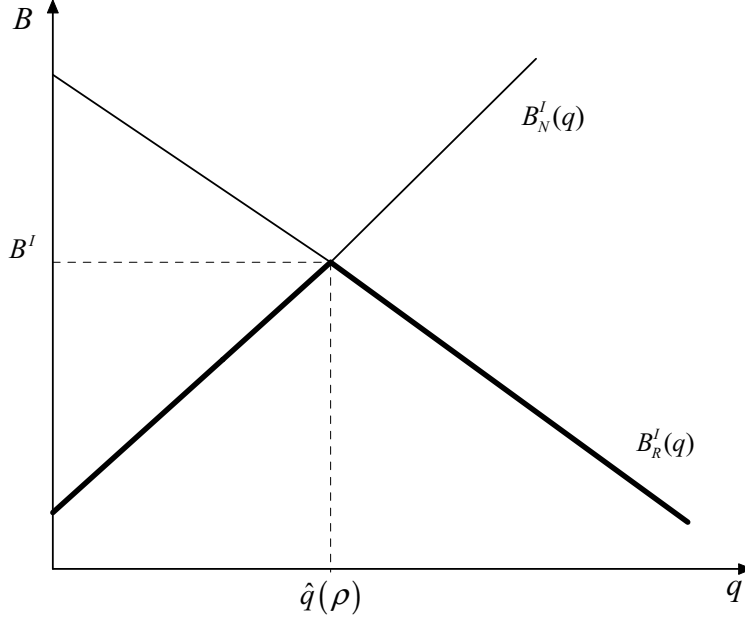


FIG. 2

as many cartels as possible; the amnesty rate q should therefore maximize the deterrence threshold

$$B^I(q) \equiv \min \{B_N^I(q), B_R^I(q)\}, \quad (8)$$

which appears in bold in Figure 2.

(Insert Figure 2 here).

Figure 2: The optimal leniency rate and equilibrium deterrence threshold under Integration

As noted above, introducing leniency makes normal collusion more fragile as soon as $q > \underline{q}$, and does not excessively foster alternative forms of collusion as long as $q < \bar{q}$; since $\bar{q} = 2\underline{q} > \underline{q}$, it is optimal to offer an amnesty rate $q \in (\underline{q}, \bar{q})$, so as to deter any collusion in industries where, absent leniency, normal collusion could prevail. And since increasing q increases B_N^I (i.e., destabilizes normal collusion) but decreases B_R^I (i.e., facilitate "collude and report" strategies), the optimal amnesty rate is such that the two thresholds coincide:

$$B_N^I(q) = \frac{\rho - (1 - \delta)(1 - q)}{2\delta - 1}(f + F) = B_R^I(q) = \frac{\delta \left(1 - \frac{q}{2}\right)}{2\delta - 1}(f + F),$$

which is achieved for

$$q = \hat{q}(\rho) \equiv \frac{1 - \rho}{1 - \frac{\delta}{2}}. \quad (9)$$

From the above analysis, the optimal leniency rate \hat{q} is strictly between $\underline{q} > 0$ and \bar{q} ; it increases as ρ decreases, and it may be desirable to reward informants ($\hat{q} > 1$) when random investigations are not very effective ($\rho < \delta/2$).

The threshold of deterrence $B^I = B_N^I(\hat{q}) = B_R^I(\hat{q})$, which characterizes the effectiveness of the leniency program, is equal to

$$B^I \equiv \frac{\delta(1-\delta+\rho)}{(2\delta-1)(2-\delta)}(f+F), \quad (10)$$

and is indeed higher than \underline{B}^I . We then conclude:

PROPOSITION 3. *Introducing Corporate Leniency Programs contributes to deterring more cartels under the integration mechanism. The optimal leniency rate, as determined by (9), increases when the antitrust enforcement becomes ineffective; whilst the threshold of deterrence, as determined by (10), decreases as the antitrust policy becomes ineffective. Moreover, it would be optimal to grant positive rewards to the first informant whenever it is unlikely to uncover cartels absent self-reporting.*

Let \overline{B} denote the maximum threshold of deterrence that can be achieved by the optimally designed antitrust policy in the presence of a leniency program, as the cartels can always choose a delegation or integration regime to facilitate collusion after the antitrust policy is announced; it appears that the optimal threshold of deterrence is bounded by the deterrence threshold under integration B^I , therefore $\overline{B} = B^I$. Moreover, as shown in the previous section, the cartels can benefit from delegation of authority which makes collusion more robust. The question is, can \overline{B} be achieved by the optimal design of leniency programs even when the cartels can take advantage of delegating the authority to the agent?

4.2. Leniency Programs under Delegation

The principal can also choose to delegate the decision rights to the agent who becomes the real authority over collusive decisions. The timing of the game is similar to integration except that the incentive scheme will be proposed by the principal at the beginning of each period, and the conditional payments will be transferred after the collusive profits are realized. Under delegation, the basic trade-off on the design of leniency programs still prevails, and both "normal collusion" as well as "collude and report" strategies should be taken into account by the same logic.

Collude and Never Report

The principal can induce the agent to "collude and never report" through a relational contract T_N as described in the previous section²⁶, which specifies a wage w_N to the agent if and only if the collusive profit B is realized; and this contract will be accepted by the agent only if the collusive stakes outweigh the expected punishment, that is,

$$w_N \geq \rho f.$$

Moreover, for this relational contract to be self-enforcing, the share of collusive stakes to the agent must be sufficiently large to resist his temptation to "deviate and report", which now becomes a relevant concern whenever the leniency program can grant positive rewards to the qualified firm ($q \geq 1$) that yields the agent positive payoffs $(q-1)f$ even absent the payment from the principal. One may argue that since, under Corporate Leniency Program, the agent is not eligible to approach corporate leniency, it seems then implausible for the agent to deviate and report.

²⁶We assume that the principals can coordinate to adopt the collusive strategies at the beginning of the game.

Whereas, if the agent has reneged on the collusive agreement, he would turn to the principal and ask to report the illegal activity to the antitrust authority; while the principal, however, would choose to report before the deviation is disclosed, since otherwise the rival firm will come forward to the authority as a revenge for defection. Therefore, "deviate and report" is a credible strategy when the agent intends to break down the collusive agreement, and the agent must be given some rents to resist this temptation:

$$U_N = \frac{w_N - \rho f}{1 - \delta} \geq (q - 1)f,$$

that is,

$$w_N \geq \rho f + (q - 1)(1 - \delta)f.$$

The agent would furthermore have incentives to report after the collusive profit is realized and his conditional payment is transferred, which gives him more gains from defection: $w_N + (q - 1)f$. This strategy is however implausible since the principal would prevent him from breaking the ongoing collusion, given that the agent is not eligible to apply for corporate leniency without the participation of the principal.

The optimal wage is then determined when the agent's incentive compatibility constraint is binding, which is given by

$$w_N^* = \rho f + \max\{(q - 1)(1 - \delta)f, 0\}, \quad (11)$$

and the relational contract yields the following discounted value to the principal:

$$V_N^D = \frac{B - w_N^* - \rho F}{1 - \delta} = \frac{B - \rho(F + f) - \max\{(q - 1)(1 - \delta)f, 0\}}{1 - \delta},$$

which is lower than the discounted value under integration V_N^I .

The principal would also have incentives to renege on her payment after the collusive profit is realized, and would moreover approach leniency program as she expects that the agent will turn to the competition strategy forever as a punishment for her renege. This temptation must be resisted for facilitating the relational contract, which requires

$$V_N^D \geq B - (1 - q)F,$$

that is, the stakes from collusion should be large enough such that

$$B \geq B_N^V(q) \equiv \frac{1}{\delta} ([\rho F + (1 - \delta)(q - 1)F] + [\rho f + \max\{(q - 1)(1 - \delta)f, 0\}]), \quad (12)$$

where superscript V stands for the renege on a vertical relationship.

Granting positive reward to the first informant who approaches to leniency program helps to destabilize collusion, by inducing the agent to "deviate and report" and the principal to "renege and report". It would furthermore contribute to fighting collusion by evoking the principal's temptation of "collude and cheat" which would have been suppressed under delegation absent a leniency program: the agent can now be induced to cheat without fear of "kick-down-the-ladder" by the principal, through a Null relational contract T^0 which offers static Nash equilibrium payoff 0 to the agent in each period.

The principal would obtain $2B + (q - 1)F$ from "collude and cheat" followed by denouncing the cartel whenever $q \geq 1$, which is higher than the gains from renegeing

on the vertical relation. The temptation of renege on the horizontal relationship is enlarged, and the threshold for sustaining collusion is increased as a result:

$$B \geq B_N^H(q) \equiv \frac{(\rho + (1 - \delta)(q - 1))}{2\delta - 1}(F + f) > B_N^V, \quad (13)$$

where superscript H stands for the deviation from the Horizontal relational contract.

Indeed, whenever the antitrust authority can grant positive reward to the first informant, the cartels can never benefit from delegation of authority if the "collude and never report" strategy is adopted, since the principal's temptation of "cheat and report" becomes the real threat to the success of collusion under delegation as well as under integration, which implies that the same thresholds of facilitating collusion will be generated under delegation and integration: $B_N^H(q) = B_N^I(q)$.

Collude and Report

Yet, rewarding the whistle-blower would allow the cartel to benefit from generous leniency, which reduces the expected fines when they turn to the "collude and report" strategy; this makes collusion more robust.

The principal can induce the agent to "collude and report" by proposing a stationary relational contract T_R that promises the agent w_R if and only if the collusive profit is realized, which brings the discounted value U_R to the agent as given by:

$$U_R = \frac{w_R - (1 - q/2)f}{1 - \delta}; \quad (14)$$

and the agent will accept this contract only if

$$w_R \geq (1 - q/2)f. \quad (15)$$

Under the "collude and report" strategy, the likelihood of winning the amnesty for each agent is fixed to $1/2$ in the "on-schedule" report, and no one can take advantage of an "off-schedule" report following a deviation. This restrains the agent's temptation of "collude and cheat" as he would get $-(1 - q/2)f$ following a deviation, which is always less than U_R .

The relational contract then gives the optimal profit share $w_R^* = (1 - q/2)f$ to the agent, which brings the principal exactly the same value as under integration when $q \leq 2$:

$$V_R^D = \frac{B - \left(1 - \frac{q}{2}\right)F - \left(1 - \frac{q}{2}\right)f}{1 - \delta}.$$

For the relational contract to be self-enforcing, this value must be higher enough to resist the temptation of renege:

$$V_R^D \geq B - (1 - q)F,$$

as the principal can always renege on payments as soon as she wins the leniency in systematical "collude and report", which is more profitable; and the threshold of sustaining a vertical relationship is then given by:

$$B_R^V(q) \equiv \frac{1}{\delta} \left[(\delta F + f) - \left(\delta - \frac{1}{2}\right)qF - \frac{q}{2}f \right]. \quad (16)$$

Whenever $q \leq 2$, the agent cannot be induced to deviate from the collusive agreement. Whenever $q \geq 2$, however, both the principal and agent can benefit

from the generous amnesty under the "collude and report" strategy; this yields the principal a discounted value V_R^D that is higher enough to outweigh the gain from cheating²⁷:

$$V_R^D = \frac{B + \left(\frac{q}{2} - 1\right) F}{1 - \delta} > 2B + \left(\frac{q}{2} - 1\right) F,$$

and mitigates the principal's temptation of renege as a result. Therefore, it would never be optimal to set $q \geq 2$, and the temptation of renege on the horizontal relational contract is resisted under the "collude and report" strategy.

To sum up, collusion is sustainable under delegation only if $B \geq \min\{B_N^H(q), B_R^V(q)\}$.

4.3. Optimal Leniency Policy and Delegation vs. Integration

As the cartels can always choose to delegate or not the decision rights following the announcement of antitrust policy, the optimal design of leniency policy must take into account all feasible collusive strategies under both delegation and integration. As before, the antitrust authority aims to deter as many cartels as possible; the amnesty rate q should therefore maximize the following deterrence threshold subject to $q \geq 1$:

$$\min\{B^D, B^I\} = \min\{\min\{B_N^H(q), B_R^V(q)\}, \min\{B_N^I(q), B_R^I(q)\}\}.$$

As we have shown that the cartel cannot benefit from delegation when "normal collusion" is adopted, since it yields the same threshold of deterrence under both delegation and integration, that is $B_N^H(q) = B_N^I(q)$; it appears that the maximum threshold of deterrence \bar{B} can be achieved only if $B_R^V(q) \geq B_R^I(q)$, that is, the cartel cannot take advantage of delegation when "collude and report" is employed, which occurs only if

$$q \geq q_0 \equiv \frac{2(1 - \delta)f + 2\delta F}{(1 - \delta)f + (3\delta - 1)F} > 1. \quad (17)$$

Adopting a "collude and report" strategy brings the principal the same discounted value under both delegation and integration mechanism:

$$V_R^D = \frac{B - \left(1 - \frac{q}{2}\right)(F + f)}{1 - \delta} = V_R^I,$$

as the agent has no incentive to renege under delegation.

Yet, the temptations of renege that the principal faces are quite different under delegation and integration regimes. Under integration, the principal would have incentive to deviate from a collusive agreement which brings a gain $2B$, but she cannot take further advantages of winning the amnesty in the "on-schedule" report following the deviation; the net benefit from deviation is $2B - \left(1 - \frac{q}{2}\right)(F + f)$. Whilst under delegation, the principal's temptation of breaking the horizontal relationship is resisted, but the temptation of renege on the vertical relational contract becomes a relevant threat: the principal would renege on payments as soon as she wins the amnesty which ensures a net benefit $B - (1 - q)F$ from renege. This temptation becomes more attractive if $\frac{q}{2}(F - f) + f \geq B$, that is, the reduced corporate and individual fines outweighs the additional gains from cheating; and this happens when the corporate fine is relatively larger. In this case, less cartels can

²⁷Note that $w_R^* = 0$ when $q \geq 2$, and $\delta > \frac{1}{2}$ by assumption.

be sustained under delegation than under integration and, as a result, the cartels prefer to keep the authority over decisions; therefore integration would prevail in the collusive equilibrium.

As the maximum threshold of deterrence \bar{B} is achieved under integration given the optimal leniency rate \hat{q} , it can be achieved under delegation only if $\hat{q} \geq q_0$, that is, the optimal leniency program involves positive rewards to the first informant. This occurs only if the corporate fine is much larger than the individual fine

$$\eta \equiv \frac{F}{f} \geq \eta_1 \equiv \frac{(1-\delta)(1-\delta+\rho)}{(\delta^2+\delta-1)-(3\delta-1)\rho}, \quad (18)$$

where η is the ratio of liability between the corporation and individual; and the lower bound η_1 is bounded from above only when the likelihood of detecting cartels absent a leniency program is small:

$$\rho < \rho_0 \equiv \frac{(\delta^2+\delta-1)}{(3\delta-1)}. \quad (19)$$

To sum up:

PROPOSITION 4. *Whenever it is unlikely to detect cartels absent self-reporting, it is optimal to grant positive rewards to the first informant in the corporate leniency program; moreover, cartels cannot take advantage of delegation whenever the corporate fine is much higher than the individual fine ($\eta \geq \eta_1$), in which case, the maximum deterrence threshold can be achieved.*

Proof. See Appendix B. ■

Assuming $\rho < \rho_0$, that is, the likelihood of detecting cartels absent self-reporting is quite low, it is then optimal to offer a positive reward to the first informant under integration mechanism. When the cartels turn to the delegation mechanism and stick to normal collusion, positive rewards to the first informant can bring the agent incentives to cheat without fear of the principal's renege on payments; therefore deviation from the collusive agreement becomes a relevant threat to the success of collusion, and the cartels cannot take advantage of delegation in this case.

If instead the "collude and report" strategy is adopted, then the principal's temptation of renege after winning the amnesty becomes the relevant concern, which yields more stakes than renege on the collusive agreement under integration whenever the corporate fine becomes more significant and thus a reduction of the fine is more valuable than the additional gains from cheating. The "collude and report" strategy is less robust under delegation, and cartels would instead turn to the integration mechanism; therefore the maximum deterrence threshold can be achieved, as illustrated in Figure 3.

(Insert Figure 3 here)

Figure 3: Optimal leniency under delegation: $\rho < \rho_0$ and $\eta \geq \eta_1$.

However, this will not happen when the ratio of liability decreases such that $\eta < \eta_1$, in which case the additional gain of cheating under integration B outweighs the reduction of the fine under delegation $\frac{q}{2}(F-f)+f$, and the temptation of renege in "collude and report" is less significant under delegation. Therefore, collusion is more robust under delegation and the maximum threshold of deterrence cannot be achieved.

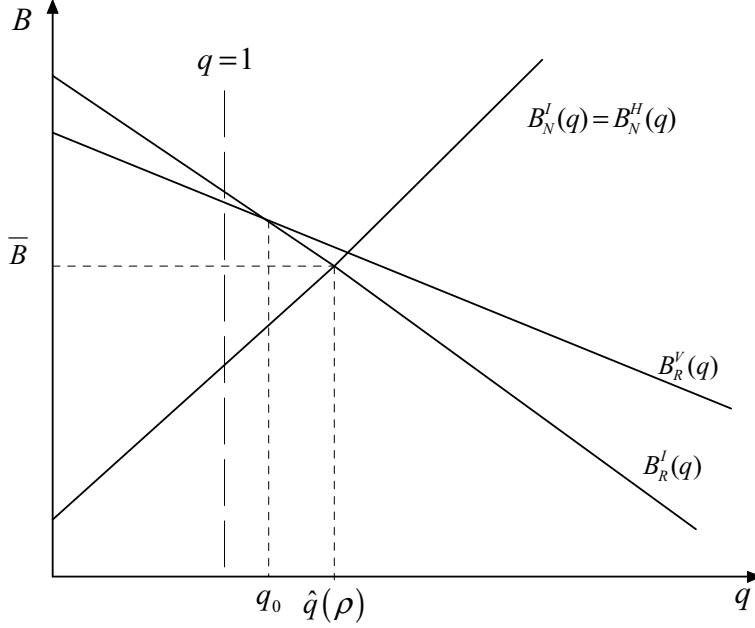


FIG. 3

In this case, the optimal leniency rate \tilde{q} ($\tilde{q} > 1$) is determined when the thresholds of deterring "collude and never report" and "collude and report" coincide, that is, $B_N^H(\tilde{q}) = B_R^V(\tilde{q})$, as given by

$$\tilde{q} \equiv \frac{(\delta(1-\rho) - (1-\delta)^2)\epsilon + \delta(\delta-\rho)}{\left(\frac{1}{2} - (1-\delta)^2\right)\epsilon + \left(\delta(1-\delta) + \frac{1}{2}(2\delta-1)^2\right)} < \hat{q}, \quad (20)$$

and the equilibrium threshold of deterrence under delegation is given by $B_1^D = B_N^H(\tilde{q}) = B_R^V(\tilde{q})$:

$$B_1^D = \frac{(2\delta-1)[(1-\delta+\rho)f + (1-\delta+(2\delta-1)\rho)F]}{(1-2(1-\delta)^2)f + (2\delta(1-\delta) + (2\delta-1)^2)F} (F+f). \quad (21)$$

This threshold is lower than the maximum level \bar{B} , as illustrated in Figure 4.

(Insert Figure 4 here.)

Figure 4: Optimal leniency under delegation: $\rho < \rho_0$ and $\eta < \eta_1$.

When antitrust enforcement becomes so effective that the cartels can be uncovered with high probability even absent leniency program (that is, $\rho > \rho_0$), it would never be optimal to grant positive rewards to the whistle-blower whenever the cartels stick to the integration mechanism; in particular, the optimal leniency rate is $\hat{q}(\rho) < 1$ whenever $\rho > 1/2 > \rho_0$. When this happens, rewarding the first informant (i.e. $q \geq 1$) can help to destabilize normal collusion under delegation, but would make "collude and report" more attractive and thus facilitate more car-

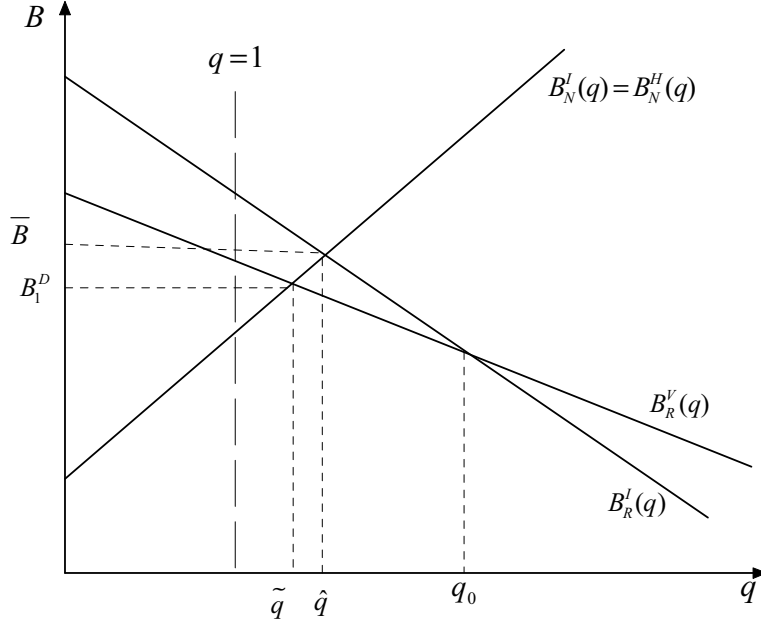


FIG. 4

tel formation under integration: $B_R^I(q) < B_R^I(\hat{q}) = \bar{B}$ as $q > \hat{q}$; it is therefore not optimal.

In this case, the optimal leniency rate is determined when the threshold of facilitating normal collusion (which is now $B_N^V(q)$ as "cheat" is not a relevant threat to collusion given $q < 1$) meets the threshold of facilitating "collude and report" $B_R^V(q)$, as given by

$$q' = 2(1 - \rho); \quad (22)$$

and the equilibrium threshold of deterrence is given by $B_2^D = B_N^V(q') = B_R^V(q')$:

$$B_2^D = \frac{\rho f + (1 - \delta + (2\delta - 1)\rho) F}{\delta}. \quad (23)$$

This threshold is also lower than the maximum level \bar{B} , as demonstrated in Figure 5.

(Insert Figure 5 here.)

Figure 5: Optimal leniency under delegation: $\rho > 1/2 > \rho_0$.

In both cases, although the maximum threshold cannot be attained, adopting leniency program still contributes to fight collusion, as both thresholds B_1^D and B_2^D are strictly higher than \underline{B}^D , the threshold of deterrence in the absence of leniency program, as summarized:

PROPOSITION 5. *When the ratio of liability decreases such that $\eta < \eta_1$, collusion becomes more robust under delegation; in which case the optimal leniency rate \tilde{q} and the optimal threshold of deterrence B_1^D are determined by (20) and (21) respectively. Whenever antitrust enforcement becomes effective absent leniency programs such that $\rho > \frac{1}{2}$, it would never be optimal to grant positive rewards in leniency*

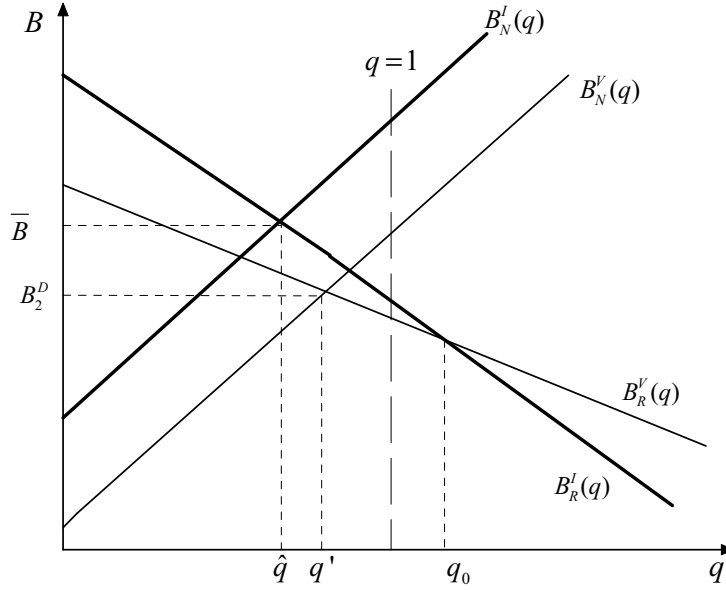


FIG. 5

programs, and collusion is more robust under delegation; in which case the optimal leniency rate q' and optimal threshold of deterrence B_2^D are given by (22) and (23) respectively. In both cases, the maximal threshold of deterrence is not achievable, but introducing leniency programs contributes unambiguously to fighting collusion.

Proof. See Appendix C. ■

When the Corporate Leniency Program is adopted, delegating the decision rights to the agent may not be beneficial to facilitating collusion. In particular, when it is optimal to grant positive rewards in leniency programs, the agent can be induced to cheat without fear of "kick-down-the-ladder" by the principal under normal collusion as he can still get a positive reward when approaching leniency program; and the temptation of renege on the horizontal collusive agreement becomes a relevant threat to collusion. If instead the "collude and report" strategy is adopted, when the corporate fine is much higher than individual fine, the principal's temptation of renege on vertical relational contract under delegation that brings significant reduction of fines becomes more significant than the temptation of renege on horizontal relationship under integration which brings additional gains from cheating in the production market. Cartels would then prefer the integration mechanism in which case the maximum deterrence threshold can be achieved, as concluded in Proposition 4.

However, the cartels can still benefit from delegation in facilitating collusion when the individual liability is relatively significant or antitrust enforcement becomes more effective, in which cases the temptation of renege under delegation is less significant than under integration, as summarized in Proposition 5. Our analysis thus shows that the evolution of antitrust policy will change the organizational form of the cartels, in particular, the allocation of authorities over decision rights

in the hierarchy.

5. CONCLUDING REMARKS

This paper incorporates the economic theory of organizations into the framework of public law enforcement, and characterizes the dual-coalition structure of cartel organizations that allows us to highlight the strategic interactions between cartel participants under different antitrust policies. We show that delegation of authorities over collusive decisions from top executives to subordinates can mitigate the temptation of renege on collusive relationships and thus contributes to facilitating collusion. This result parallels the insights in Baker, Gibbons and Murphy (2002, 2006) which find that the optimal allocation of decision rights is to minimize the maximum temptation to renege on relational contracts. Moreover, the efficiency gains of delegation in facilitating collusion can be mitigated when the corporate leniency program is introduced, in particular whenever it is unlikely to detect cartels absent leniency and the corporate liability is much significant than individual liability.

It is common sense that antitrust enforcement is unlikely to be effective if the antitrust authority has little knowledge about how cartels are organized and operated. This paper makes the first attempt to establish theory of cartel organization, and we believe that further studies to disclose the sophisticated organizational structure of cartels are of great importance both to the theory and practice. In particular, how the authorities are optimally allocated in the hierarchy of cartels when there exists asymmetric information between the principal and agent is still open; and how the optimal design of antitrust policies including both the corporate and individual leniency programs can contribute to fighting collusion is not discussed in this paper. We leave these questions for future research.

Appendices

Appendix A: Proof of Proposition 2

The first part of the claim is obvious from the fact that collusion is more robust under delegation than under integration (i.e. $\underline{B}^D < \underline{B}^I$); in particular, for those industries with small stake from collusion B such that $\underline{B}^D < B < \underline{B}^I$, collusion can be sustained under delegation but not under integration.

Moreover, when both firms choose the delegation mechanism, no firm can benefit from a unilateral deviation to the integration mechanism. To show this, assume that firm A sticks to delegating authority whilst firm B deviates to integration. As this is commonly observed at the beginning of the game, when both firms collude, firm A has no incentive to break down the collusive agreement only if $B \geq \underline{B}^D$, that is, the principal has no incentive to renege on the vertical relation; whilst firm B will respect the collusive agreement only if $B \geq \underline{B}^I$. Therefore, collusion is sustainable only if $B \geq \max\{\underline{B}^I, \underline{B}^D\} > \underline{B}^D$. Then, for the industries with benefit of collusion B satisfies $\underline{B}^D < B < \underline{B}^I$, collusion is not sustainable as firm B always has incentives to deviate.

Therefore, whenever $\underline{B}^D < B < \underline{B}^I$, only delegation prevails in the collusive equilibrium; when $B > \underline{B}^I$, delegation and integration are indifferent in sustaining collusion.

Appendix B: Proof of Proposition 4

Let B^* denote the optimal threshold of deterrence, that is

$$B^* = \max_{\{q \geq 1\}} \min\{B^D, B^I\} = \max_{\{q \geq 1\}} \min\{\min\{B_N^H(q), B_R^V(q)\}, \min\{B_N^I(q), B_R^I(q)\}\}.$$

Rewrite these thresholds as follows:

$$\begin{aligned} B_N^H(q) &\equiv \frac{(\rho + (1 - \delta)(q - 1))}{2\delta - 1} (F + f) = B_N^I(q), \\ B_R^V(q) &\equiv \frac{1}{\delta} \left[\left(\delta - \frac{q}{2}(2\delta - 1) \right) F + \left(1 - \frac{q}{2} \right) f \right], \\ B_R^I(q) &\equiv \frac{\delta \left(1 - \frac{q}{2} \right)}{2\delta - 1} (F + f); \end{aligned}$$

then we have $B_R^V(q) \geq B_R^I(q)$ if and only if

$$q \geq q_0 \equiv \frac{2(1 - \delta)\epsilon + 2\delta}{(1 - \delta)\epsilon + (3\delta - 1)},$$

where $q_0 > 1$.

We are interested in the case that the maximum deterrence threshold can be achieved, that is,

$$\min_{q \geq 1} \{B_N^H(\hat{q}), B_R^V(\hat{q})\} \geq \bar{B} = B_N^I(\hat{q}) = B_R^I(\hat{q}),$$

or equivalently

$$B_R^V(\hat{q}) \geq B_R^I(\hat{q});$$

and this happens when

$$\hat{q} \geq q_0,$$

which is equivalent to

$$\eta \geq \eta_1 \equiv \frac{(1 - \delta)(1 - \delta + \rho)}{(\delta^2 + \delta - 1) - (3\delta - 1)\rho}.$$

Note that η_1 is bounded only when

$$\rho < \rho_0 \equiv \frac{(\delta^2 + \delta - 1)}{(3\delta - 1)}.$$

Appendix C: Proof of Proposition 5

Whenever $\eta < \eta_1$, $\hat{q} < q_0$, then the maximum threshold of deterrence cannot be achieved. In this case, the optimal leniency rate is determined when $B_N^H(q) = B_R^V(q)$, as given by

$$\tilde{q} \equiv \frac{(\delta(1 - \rho) - (1 - \delta)^2)\epsilon + \delta(\delta - \rho)}{\left(\frac{1}{2} - (1 - \delta)^2\right)\epsilon + \left(\delta(1 - \delta) + \frac{1}{2}(2\delta - 1)^2\right)} < \hat{q},$$

and the optimal threshold under delegation is given by

$$B_1^D = B_R^V(\tilde{q}) = \frac{(2\delta - 1)[(1 - \delta + \rho)f + (1 - \delta + (2\delta - 1)\rho)F]}{(1 - 2(1 - \delta)^2)f + (2\delta(1 - \delta) + (2\delta - 1)^2F)} (F + f).$$

When antitrust enforcement becomes effective such that $\rho > 1/2$, it would never be optimal to grant positive rewards in leniency programs if the cartels stick to integration mechanism, in particular, the optimal leniency rate is $\hat{q}(\rho) < 1$ whenever $\rho > \delta/2 > \rho_0$. As the temptation of renege on the horizontal relationship is resisted when $q < 1$, the relevant threshold of facilitating normal collusion is given by $B_N^V(q)$; in this case, the optimal leniency rate is determined when

$$B_N^V(q) = B_R^V(q),$$

which yields

$$q' = 2(1 - \rho),$$

and the equilibrium deterrence threshold

$$B_2^D = B_N^V(q') = B_R^V(q') = \frac{\rho f + (1 - \delta + (2\delta - 1)\rho)F}{\delta}.$$

To sum up, the optimal threshold of deterrence B^* is given by

$$\left\{ \begin{array}{l} B^* = \bar{B}, \quad \text{if } \rho < \rho_0 \text{ and } \eta \geq \eta_1; \\ B^* = B_1^D, \text{ if } \rho < \rho_0 \text{ and } \eta < \eta_1; \\ B^* = B_2^D, \text{ if } \rho > 1/2; \end{array} \right\}$$

It is easy to check that $B_2^D > \underline{B}^D$. When $\rho < \rho_0$, $q' > \tilde{q}$ implies $B_2^D = B_R^V(q') < B_R^V(\tilde{q}) = B_1^D$, therefore $B_1^D > \underline{B}^D$.

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