E C O N O M I C S B U L L E T I N

Coordinating Antitrust Policies Against International Cartels

Hiroo Iwanari
The Fair Trade Commission of Japan

Toshiji Kawagoe
Future University - Hakodate

Taisuke Matsubae
Waseda University

Hirokazu Takizawa
Research Institute of Economy, Trade and Industry

Abstract

Theoretical research on leniency programs has so far focused attention on cartels formed within a country; the purpose of the paper is to analyze the situation where a cartel is formed internationally. We consider a model with two firms operating in two countries. The antitrust authority (AA) in each country chooses either to implement a leniency program or to use traditional investigation to detect/deter cartel activity. Given the combination of antitrust policies, the two firms play market games simultaneously in both countries. Assuming that the information on the existence of a cartel in one country spills over to the other, we analyze a strategic interdependency faced by the AAs. Several policy objectives of the AA are considered. We find that if the objective is to maximize revenues from the penalty imposed on cartels, an asymmetric equilibrium exists in which one country chooses to free-ride the other's choosing a leniency program.

The views expressed here are the personal views of the authors and do not reflect those of the institutions to which they belong. The names of the authors are listed in alphabetical order.

Citation: Iwanari, Hiroo, Toshiji Kawagoe, Taisuke Matsubae, and Hirokazu Takizawa, (2007) "Coordinating Antitrust Policies Against International Cartels." *Economics Bulletin,* Vol. 4, No. 25 pp. 1-11
Submitted: June 14, 2006. **Accepted:** June 25, 2007.
URL: http://economicsbulletin.vanderbilt.edu/2007/volume4/EB-06D40011A.pdf

1 Introduction

A leniency program is an antitrust policy that allows a firm engaging in collusive behavior to receive immunity from the fine imposed on such an illegal activity if it provides evidence to prove the existence of the cartel. It is supposed to raise the probability of detecting cartels and/or to deter cartels. Various kinds of leniency programs have been introduced and proven to be a very effective means to this end in many countries, such as the US, the EU, Canada, Australia, Korea and others. Recently, the Japanese antitrust authority has also started to implement a leniency program based on the amendment of the Japan's Anti-monopoly Act.

There are some theoretical studies on leniency programs using repeated game theory. Motta and Polo (2003) point out a detrimental effect of a leniency program that reducing a fine makes collusive behavior more easy by increasing expected payoff from collusion. They also point out, however, if the antitrust authority (hereafter AA) properly chooses its policy parameter, leniency program can overcome such a detrimental effect. Spagnolo (2004) proved that courageous leniency programs, which give reward to self-reporting firms, may deter collusion completely and costlessly. Aurbert, Kovacic, and Rey (2003) compare courageous leniency programs for a firm (whistle-blowing) with the one for an individual (bounty). Apesteguia, Dufwenberg, and Selten (2003) and Hamaguchi, Kawagoe, and Shibata (2004) are the only papers on the leniency program based on laboratory experiments and report some puzzling results.

The research on leniency programs has so far focused attention on cartels formed within a country; the purpose of the paper, in contrast, is to analyze the situation where a cartel is formed internationally. We consider a model with two oligopolistic firms operating in two countries. The antitrust authority in each country chooses either to implement a leniency program or to use traditional, probabilistic investigation to detect and/or deter cartel activity. Given the combination of antitrust policies in both countries, the two firms play market games simultaneously in both countries. Assuming that the information of a cartel activity detected in one country spills over to the other, we analyze a strategic interdependency faced by the AA's in the two countries. Several possible policy objectives of the antitrust authority are considered. First, under our setting, implementing a leniency program itself does not exclude cartel formation defninitely. It can only induce a colluding firm to report the cartel activity. Second, implementing leniency program is dominant strategy for both governments when the objective of the government is to maximize probability of detecting cartel activities. Third, however, if both governments try to maximize revenue from the penalty levied on cartel activities, then there exists an asymmetric equilibria in which one country chooses to free-ride the other country's choosing to implement a leniency program.

The organization of the paper is as follows. In section 2, we present our analytical framework. In section 3, equilibrium conditions for the sustainability of cartels will be shown according to the possible policy combinations of each country. In section 4, strategic coordination problem between countries will be analyzed. Conclusions is given in the last section.

2 Model

Suppose that two oligopolistic firms, indexed by $i = 1, 2$, simultaneously and repeatedly play market games in two countries, A and B. Table I shows the payoff matrices of the stage games played in both countries. These market games are essentially the prisoners' dilemma, but it should be noted that interpretation of each strategy is slightly different.[1] By C, we denote an action where a firm lures the other into collusion via communication leaving a hard evidence, while D denotes a competitive action. Thus, (C, C) means formation of a cartel with a hard evidence of mutual agreement. In (C, D) or (D, C), both firms do not reach a collusive agreement.

We assume $0 < a \leqslant 1$. This assumption guarantees that the market game in country B belongs to a class of prisoners' dilemma games, and that there is less incentive to deviate from collusive agreement in country B than in country A. If $a = 1$, markets in both countries are same. The common discount factor for the firms is denoted by $\delta \in [0, 1)$.

However, these payoff structures of the original market games are changed in the presence of antitrust policy. In this paper, we consider two possible forms of antitrust policies, the "traditional" antitrust policies and a leniency program. The explanation of how those policies work within a country is in order now.

The first is the "traditional" antitrust policy (hereafter denoted by T) where the AA, by itself or through a third-party informant, obtains tips of cartel activities. Here, we assume that the AA will succeed in cartel detection with probability $p \in (0, 1)$ when the firms are in collusion. When an AA find a cartel activity, it will levy a fine $F > 0$ on both firms, although it cannot force them to change their behavior to the competitive one. We assume that $pF < 1$ throughout the paper to ensure that collusion is still a profitable enterprise in the presence of antitrust policies. We also assume that the AA's detection of cartels is error-free. The payoff matrix of the game with the AA's implementing T is shown in Table II.[2] When both firms choose (C, C), they earn one from collusion, but they may have to pay a fine F with probability p. Thus their expected payoff in (C, C) is $1 - pF$.

Another antitrust policy available to each government is to implement a leniency program on top of the traditional antitrust policy (hereafter denoted by L). In this case, both firms decide not only whether to collude or not, but also, in case of collusion, whether to report a hard evidence to the AA or not. Denote the strategy to "collude and not report" as CNR, and the strategy to "collude and report" as CR. We assume that if at least one colluding firm reports the cartel, then the AA can prove the existence of the cartel activity with probability one. Then the reporting firm will pay a reduced fine bF where $b < 1$, and the other firm will incur a full fine F. We assume that only the first reporting firm can enjoy a reduced fine, and that if both firms report simultaneously in our games, they can have a fine reduced with equal probability. So, their payoff in that case is $1 - \frac{b+1}{2}F$. A leniency program is said to be of reduced fine type if $b > 0$; it is said to be of rewarding type if $b < 0$. The payoff structure of the stage game for both firms under a leniency program is shown in Table III. In the case of (CNR, CNR), cartel

[1] The prisoners' dilemma game is often used as a discretized simplification of the strategic situation arising in Cournot competition or Bertrand competition.

[2] Table II shows the payoff matrix in country B. The payoff matrix in country A is obtained by substituting one for a in this table. The same applies to Table III.

activities can be found by traditional investigation by the AA, so the payoff in this case is $1 - pF$.

In this paper, we focus on the situation where the AA's in both countries adopt either the traditional antitrust policy or a leniency program. This situation can cause some complication because the AA's in both countries may exchange information regarding cartel detection. We assume that if a cartel activity is found by a AA in one country, then the information of this investigation will allow the AA in the other country to succeed in detection in the same period with probability $\alpha \in [0, 1]$. Thus, for example, when firms collude in both countries and the AA's in both countries adopt the traditional antitrust policy, this caltel activity is detected with probability $p(1 + \alpha(1 - p))$ in each country. Note that, even in the case of international cartel activities, the antitrust laws in each country only allow the AA to investigate domestic cartel activities.

3 Equilibria in an International Oligopoly Market

We now turn to equilibrium analysis under various combinations of antitrust policies. The AA in each country chooses T or L. Then both firms play an infinitely repeated game with discounting.

Throughout most of the analysis below, we assume that the values of parameters p, b and F are common to both countries.[3] Furthermore, we only focus on symmetric pure-strategy equilibria in which the action taken is the same across firms as well as over periods on the equilibrium path. We focus on "grim trigger" type strategies where both firms take the same designated action on the equilibrium path and once either firm deviates from the designated path, they are supposed to switch to (D, D) forever.[4]

We address the well-known multiplicity problem in repeated games by assuming that, as a result of coordination, both firms choose to play a Pareto optimum equilibrium among all symmetric pure strategy equilibria that are possible under each discount factor. As we focus on symmetric pure strategy equilibria, the equilibrium payoff to each firm is the same, and we can identify the Pareto optimum condition with the highest payoff. Also we think that firms collude whenever it is more profitable to collude than to compete. By this assumption, to each δ is associated an essentially unique equilibrium.[5]

As a benchmark case, first consider the situation where there are no AA's. A strategy for each firm in the stage game is a combination of actions in the two countries. Denote a strategy that specifies action C in country A by C^A, D by D^A, and likewise for country B. Then we denote a stage-game strategy where a firm plays C in both countries as (C^A, C^B) and likewise for the other strategy profiles. We also denote a strategy profile where both firm play C in both countries as $\big((C^A, C^B), (C^A, C^B)\big)$ and likewise for the other strategy profiles. We consider an infinitely repeated play of such a stage game. We denote by

[3] In reality, the reduction rate of fine for the first firm to report collusion is the same in most countries adopting leniency program: $b = 0$.

[4] In all the four cases of policy combination, (D, D) is a Nash equilibrium of market games in both countries. Hence, the strategy profile in which both firms play D every period regardless of the past history constitutes a subgame-perfect equilibrium, and this brings the worst payoffs to both players. This means it is the optimal penal code for both firms (Abreu, 1988). Therefore the strategies we consider are simple strategies, to which we may limit attention for exploring subgame-perfect equilibrium payoffs.

[5] The size of the discount rate can be regarded as reflecting the speed ofinnovation that varies across industries.

$\delta^{(C^A,C^B)}$ the threshold value of the discount factor above which the simple strategy profile with both firms playing (C^A, C^B) on the path is supported as an equilibrium, and likewise for the other symmetric pure strategy equilibria. Thus $\big((C^A, C^B), (C^A, C^B)\big)$ is sustained as a perfect equilibrium if $\delta \geqslant \delta^{(C^A,C^B)} = 1 - 2/(a+3)$. Observe that $\delta^{(C^A,C^B)} < 1/2$ if $a < 1$. This means that there exists a value of discount factor, under which collusion is impossible when we think of country A alone but the simultaneous collusion in both countries is sustainable. This is the effect of the so-called multimarket contact (Bernheim and Whinston, 1990).

3.1 Equilibria under Antitrust Policies

We now turn to equilibrium analysis when the AA's in both countries implement some antitrust policy. As noted, there are four possible combinations of both countries' choice as summarized in Table IV.

Case A: Both AA's choose T. Under T, the AA in each country succeeds in detecting a cartel activity with probability p. For simplicity, we assume that the probability distributions in the two countries are independent and identically distributed.

As cartel information can spill over to the other country's AA, cartel detection rate is increased from p to $p(1+\alpha(1-p))$, when the firms collude in both markets. This reduces the average payoff from the international cartel activity, making collusion more difficult. On the other hand, however, the average payoff from deviation per country when both firms are engaged in collusion in both countries, $(3+a)/2$, is less than the payoff from deviation when both firms collude only in country A, making deviation less profitable. So which equilibrium is more likely to be achieved depends on these two countervailing effects. When the stage game in both countries are the same ($a = 1$), the following proposition holds.

Proposition 3.1. *Consider the situation in which both AA's choose T. As the spilover rate increases and/or the markets become more similar, it becomes harder to form an international cartel, i.e. $\delta^{(C^A,C^B)}$ is increasing in α and a. In particular if $a = 1$, $\delta^{(D^A,C^B)} = \delta^{(C^A,D^B)} < \delta^{(C^A,C^B)}$.*

Case B: In this case, country A chooses T and country B chooses L. Under L, a leniency program is enforced as well as the traditional investigation (i.e. besides leniency programs, cartels will be detected by a traditional method with probability p). Here both firms choose from $\{C, D\}$ in country A, and from $\{CR, CNR, D\}$ in country B, which makes six possible strategies.

First, let us think about the incentives for country B to adopt L, when both countries are adopting T. The AA in country B wants to make collusion harder. However, adoption of L does not make collusion more difficult, since $\delta^{(C^A,CNR^B)}$ in case B is equal to $\delta^{(C^A,C^B)}$ in case A. Thus,

Proposition 3.2. *Suppose that both AA's choose T. The change of country B's policy from T to L does not influence equilibrium condition of collusion in both countries.*

On the other hand, our basic intuition is that a leniency program is effective when its introduction makes CNR (collude and not report) harder to sustain, and CR (collude and report) is realized. Let's see when this happens in detail.

In industries where $\delta \geqslant \delta^{(C^A,C^B)} = \delta^{(C^A,CNR^B)}$, the AA's in both countries can not deter collusion. So we will focus on $\delta < \delta^{(C^A,C^B)} = \delta^{(C^A,CNR^B)}$. As we compare the situation before and after the introduction of a leniency program, we will assume that policy choice in country B does not affect competition in country A.

Before the adoption of a leniency program in country B, country A might be in the state of C^A (collusion) or D^A (no collusion). Let's consider first the case where C^A is realized in country A. If it holds that

$$\delta^{(C^A,D^B)} < \delta < \delta^{(C^A,CNR^B)},$$

where country B adopts L, then the industries with $\delta \in [\delta^{(C^A,CR^B)}, \delta^{(C^A,CNR^B)})$ turn to collude (and report cartel activities to the AA). That is, a leniency program might induce (temporary) collusion.

Next, let us consider the case where the firms are not colluding before the introduction of the leniency program in country B. With the discount factor in the range above, we can think of the situation where the firms play D in country A and C in country B. Here $\delta^{(D^A,C^B)}$ is equal to $\delta^{(D^A,CNR^B)}$. Now suppose that country B adopts a leniency program, and that there exists $\delta' \in (\delta^{(D^A,CR^B)}, \delta^{(D^A,CNR^B)})$, it is easier for firms to report a hard evidence of cartel activities than not to report.

Here, we consider conditions such that a leniency program effectively deter collusion or firms report their cartel activities to the AA. We will call them B conditions for "effective leniency program". These conditions can be analyzed in two cases: $(C^A, \cdot\,)$ and $(D^A, \cdot\,)$.

In the case of C^A, for the leniency program in B to be effective, the following must hold:

$$\delta^{(C^A,D^B)} < \delta^{(C^A,CR^B)} < \delta^{(C^A,CNR^B)}.$$

The first inequality implies that it is easier for the firms not to collude than to collude and report. The second inequality implies that it is easier for the firms to collude and report than to collude and not to report. Proposition 3.3 below gives the condition where these inequalities hold.

On the other hand, in the case of D^A, a leniency program is "effective" when the following holds:

$$\delta^{(D^A,CR^B)} < \delta^{(D^A,CNR^B)}.$$

Proposition 3.3 again gives the condition which supports this. Note that if δ is small enough, then firms behave competitively in both countries.

Proposition 3.3. *Suppose that the AA of country A chooses T and the AA of country B chooses L, and $a = 1$.*

1. *Consider the situation where both firms collude in country A. Assume that $4p - 3 < b < 2[p + \alpha(1-p)(2p-1)] - 1$. Then effective leniency programs($\delta^{(C^A,D^B)} < \delta^{(C^A,CR^B)} < \delta^{(C^A,CNR^B)}$) in country B are supported.*

2. *Consider the case in which both firms behave competitively. Note that in this case, $\delta^{(D^A,CNR^B)} = \delta^{(D^A,C^B)}$. Assume that $b < 2p - 1$. Then effective leniency programs ($\delta^{(D^A,CR^B)} < \delta^{(D^A,CNR^B)} = \delta^{(D^A,C^B)}$) in country B are supported.*

This implies that if p is small enough, then only "leniency program with reward giving" is effective. Thus,

Corrollary 3.4. *Suppose that country A chooses T and country B chooses L, and that $a = 1$. When $p < 1/2$, $\delta^{(C^A, CNR^B)} > \delta^{(C^A, CR^B)}$ holds only if $b < 0$. That is, "leniency program with reduced fine" is not effective in country B.*

Case C: The AA in country A chooses L, while the AA in country B chooses T. The analysis in this case is identical to case B.

Case D: Consider the situation in which both AA's implement a leniency programs. Then,

Proposition 3.5. *Suppose that both AA's implement a leniency programs. If the condition $b < 2[p + \alpha(1-p)(2p-1) - 1]$ holds, then it is more likely for both colluding firms to report under the leniency programs ($\delta^{(CNR^A, CNR^B)} > \delta^{(CR^A, CR^B)}$).*

4 Policy Choice by the Governments

So far we have analyzed equilibrium conditions of the games regarding international cartels with various policy mixtures of governments. In this section, we focus on each government's strategic choice of antitrust policymaking. The assumption on the government's objective function is a crucial factor in this analysis. So we subdivide this section into three parts, based on the possible objectives of antitrust policies.

4.1 Deterring Cartel Activities

It may be naturally thought that one of the purposes of antitrust policy is to prevent collusion, that is the AA's objective is to force firm to choose strategy D. However, condition under which strategy CR (collude and report) is realized. For example, in Case B of Section 3.2., we analyzed incentives for country B to change from T to L in the situation where country A adopts a traditional antitrust policy. There we saw that introduction of L may not be useful for deterrence of cartel activities as such.

In collusive industries with a high discount rate, deterring collusions definitely requires increases of p and F.[6] Moreover, we can see that reinforcement of the traditional antitrust policy such as an increase in p will improve viability of leniency program with reduced fine.

4.2 Maximizing probability of detection

Suppose next that the government maximizes probability of detecting cartel activities. The payoff structure based on detecting probability is shown in Table VII. From this, one can easily derive the following proposition. In this game, it is a dominant strategy for both governments to implement a leniency program, so the outcome (L, L) is an equilibrium.

[6] In antitrust enforcement, it might be likely that p increases in industries where CR is played repeatedly (as a result of stricter monitoring by the AA's), and also that F might be larger in those industries (due to their maliciousness).

4.3 Maximizing the amount of revenue

Next, whether realistic or not, consider the situation in which the government in each country intends to maximize revenue from their fines imposed on cartels. Whether implementing leniency program is beneficial for the governments depends on each firm's strategic choice. Suppose that cartels in both countries raise revenue from fines and leniency programs are effective in that the governments induce CR for both firms. Thus, let us assume both firms' choices according to the policy choices of both governments as those in Table V. Then the payoff structure for governments is shown in Table VI.

Proposition 4.1. *If $b > 4p - 2p^2 - 1$, then Nash equilibrium choices for both governments are (L, T) and (T, L). If $b < 4p - 2p^2 - 1$, then (T, T) is a Nash equilibrium.*

Therefore, both countries do not adopt a leniency program in any Nash equilibrium when their objective is to maximize the amount of revenue. Values of the parameters will decide whether one of both countries adopts a leniency program, or neither country adopts it.

5 Conclusions

In this paper, we analyzed a coordination problem in implementing a leniency program between two governments in a setting that two international firms try to form an international cartel. The results depends much on the policy objectives of both governments.

Our findings are as follows. First, under our setting, implementing a leniency program itself does not exclude cartel formation defninitely. It can only induce a colluding firm to report the cartel activity. Second, implementing leniency program is dominant strategy for both governments when the objective of the government is to maximize probability of detecting cartel activities. Third, however, if both governments try to maximize revenue from the penalty levied on cartel activities, then there exists an asymmetric equilibria in which one country chooses to free-ride the other country's choosing to implement a leniency program.

References

ABREU, D. (1988): "On the theory of infinitely repeated games with discounting," *Econometrica*, 56(2), 383–396.

APESTEGUIA, J., M. DUFWENBERG, AND R. SELTEN (2003): "Blowing the Whistle," mimeo.

AURBERT, C., W. KOVACIC, AND P. REY (2003): "The Impact of Leniency Programs on Cartels," International Industrial Organization Conference, Conference Paper.

BERNHEIM, D., AND M. WHINSTON (1990): "Multimarket Contact and Collusive Behavior," *Rand Journal of Economics*, 21(1), 1–26.

HAMAGUCHI, Y., T. KAWAGOE, AND A. SHIBATA (2004): "An Experimental Study of Leniency Programs," RIETI Discussion Paper Series 05-E-003.

MOTTA, M., AND M. POLO (2003): "Leniency Programs and Cartel Prosecution," *International Journal of Industrial Organization*, 21(3), 347–379.

SPAGNOLO, G. (2004): "Optimal Leniency Policies for Cartel Deterrence," *mimeo.*

Appendix A

Table I: Market Games in Countries A and B

Country A

		Firm 2	
		C	D
Firm 1	C	$1, 1$	$-1, 2$
	D	$2, -1$	$0, 0$

Country B

		Firm 2	
		C	D
Firm 1	C	$1, 1$	$-1, 1 + a$
	D	$1 + a, -1$	$0, 0$

Table II: The Market Game under the Traditional Antitrust Policy

		Firm 2	
		C	D
Firm 1	C	$1 - pF$,$1 - pF$	$-1, 1 + a$
	D	$1 + a, -1$	$0, 0$

Table III: The Market Game under a Leniency Programs

		Firm 2		
		CNR	CR	D
Firm 1	CNR	$1 - pF, 1 - pF$	$1 - F, 1 - bF$	$-1, 1 + a$
	CR	$1 - bF, 1 - F$	$1 - \frac{1+b}{2}F, 1 - \frac{1+b}{2}F$	$-1, 1 + a$
	D	$1 + a, -1$	$1 + a, -1$	$0, 0$

Table IV: Four possible combinations of two countries' choices

		Government B	
		T	L
Government A	T	Case A	Case B
	L	Case C	Case D

Table V: Both firms' choices

		Government B	
		T	L
Government A	T	(C^A, C^B)	(C^A, CR^B)
	L	(CR^A, C^B)	(CR^A, CR^B)

Table VI: The payoff structure for both governments

		Government B	
		T	L
Government A	T	$2p(2-p)F, 2p(2-p)F$	$2F, (b+1)F$
	L	$(b+1)F, 2F$	$(b+1)F, (b+1)F$

Table VII: The payoff structure for the governments based on detecting probability

		Government B	
		T	L
Government A	T	$p(1+\alpha(1-p)), p(1+\alpha(1-p))$	$\alpha, 1$
	L	$1, \alpha$	$1, 1$

Appendix B

Proof of Proposition 3.1. Of sixteen strategy profles, symmetric strategy profiles except for (D^A, D^B) are as follows, $(C^A, C^B), (C^A, D^B), (D^A, C^B)$. The equilibrium condition for both firms to play (C^A, C^B) is

$$\delta \geqslant \delta^{(C^A, C^B)} = 1 - \frac{2 - 2p(1 + \alpha(1-p))F}{3+a},$$

which is obviously increasing in α and a.

The equilibrium condition for both firms to play (C^A, D^B) is

$$\delta \geqslant \delta^{(C^A, D^B)} = 1 - \frac{1 - pF}{2}.$$

The equilibrium condition for both firms to play (D^A, C^B) is

$$\delta \geqslant \delta^{(D^A, C^B)} = 1 - \frac{1 - pF}{1+a}.$$

If $a = 1$, then it holds that $\delta^{(D^A, C^B)} = \delta^{(C^A, D^B)} < \delta^{(C^A, C^B)}$.

□

Proof of Proposition 3.2. Suppose the AA in country A adopts T and the AA in country B changes the antitrust policy from T to L. Because both firms' taken payoff on the equilibrium path and in case of deviation from the equilibrium path are same in both cases; (T, T) and (T, L), each delta becomes as follows.

$$\delta^{(C^A, C^B)} = 1 - \frac{2 - 2p(2-p)F}{3+a} = \delta^{(C^A, CNR^B)} = 1 - \frac{2 - 2p(2-p)F}{3+a}.$$

□

Proof of Proposition 3.3. Symmetric strategy profiles except for (D^A, D^B) are as follows.

$$(C^A, CR^B), (C^A, CNR^B), (C^A, D^B), (D^A, CR^B), (D^A, CNR^B).$$

In each case, the delta is evaluated as follows.

$$\delta \geqslant \delta^{(C^A, CNR^B)} = 1 - \frac{2 - 2p(2-p)F}{3+a}, \ \delta \geqslant \delta^{(C^A, CR^B)} = 1 - \frac{2 - \frac{b+3}{2}F}{3+a}.$$
$$\delta \geqslant \delta^{(C^A, D^B)} = 1 - \frac{1 - pF}{2}, \ \delta \geqslant \delta^{(D^A, CNR^B)} = 1 - \frac{1 - pF}{1+a},$$
$$\delta \geqslant \delta^{(D^A, CR^B)} = 1 - \frac{1 - \frac{b+1}{2}F}{1+a}.$$

If $a = 1$ and b is $4p - 3 < b < 2[p + \alpha(1-p)(2p-1)] - 1$, then $\delta^{(C^A, D^B)} < \delta^{(C^A, CR^B)} < \delta^{(C^A, CNR^B)}$.

Also if $a = 1$ and b is $b < 2p - 1$, then $\delta^{(D^A, CR^B)} < \delta^{(D^A, CNR^B)} = \delta^{(D^A, C^B)}$.

□

Proof of Proposition 3.5. Of eighty-one possible combination of both firm's strategies, symmetric strategy profiles except for (D^A, D^B) are as follows.

$$(CNR^A, CNR^B), (CNR^A, CR^B), (CNR^A, D^B), (CR^A, CNR^B), (CR^A, CR^B),$$

$$(CR^A, D^B), (D^A, D^B), (D^A, CNR^B), (D^A, CR^B).$$

In each case, the delta is evaluated as follows.

$$\delta \geqslant \delta^{(CNR^A, CNR^B)} = 1 - \frac{2 - 2p(2-p)F}{3+a}, \ \delta \geqslant \delta^{(CNR^A, CR^B)} = 1 - \frac{2 - \frac{b+3}{2}F}{3+a},$$
$$\delta \geqslant \delta^{(CNR^A, D^B)} = 1 - \frac{1 - pF}{2}, \ \delta \geqslant \delta^{(CR^A, CNR^B)} = 1 - \frac{2 - \frac{b+3}{2}F}{3+a},$$
$$\delta \geqslant \delta^{(CR^A, CR^B)} = 1 - \frac{2 - (b+1)F}{3+a}, \ \delta \geqslant \delta^{(CR^A, D^B)} = 1 - \frac{1 - \frac{b+1}{2}F}{2},$$
$$\delta \geqslant \delta^{(D^A, CNR^B)} = 1 - \frac{1 - pF}{1+a}, \ \delta \geqslant \delta^{(D^A, CR^B)} = 1 - \frac{1 - \frac{b+1}{2}F}{1+a}.$$

Therefore, if b is $b < 2[p + \alpha(1-p)(2p-1) - 1]$, then $\delta^{(CNR^A, CNR^B)} > \delta^{(CR^A, CR^B)}$. □