A Multimarket Supergame between Two Heterogeneous Conglomerates

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This paper studies a price-setting supergame between two two-market firms with different costs. The two firms may be able to sustain collusion when independent specialists could not do in either market. When independent specialists can sustain collusion in both markets, the two firms can sustain collusion better unless the ratios of their margins are the same in the two markets. Unless the ratios are the same, some market will be monopolized by the firm whose margin is *relatively* higher in the market in collusion optimal to the firms. In contrast to optimal collusion between two independent specialists, prices can be lower than the monopoly-profit-maximizing prices of the lower-cost firms in optimal collusion between the two firms.

I. Introduction

The pricing and market sharing actions of multiproduct and/or multimarket firms may differ from those of dispersed independent specialists. This paper, using a supergame model (Friedman 1971; Abreu 1988), examines the hypothesis that when conglomerate firms face other conglomerates in a number of markets, they will compete less sharply than would specialists by respecting each firm's interest in markets important to it. Edwards (1955) first advanced this hypothesis. His words, as quoted in Scherer (1980, p. 340), may be the best way to understand the hypothesis:

> When one large conglomerate enterprise competes with another, the two are likely to encounter each other in a considerable number of markets. The multiplicity of their contacts may blunt the edge of their competition. A prospect of advantage from vigorous competition in one market may be weighed against the danger of retaliatory forays by the

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> competitor in other markets. Each conglomerate competitor may adopt a live-and-let-live policy designed to stabilize the whole structure of the competitive relationship. Each may informally recognize the other's primacy of interest in markets important to the other, in the expectation that its own important interests will be similarly respected. Like national states, the great conglomerates may come to have recognized spheres of influence and may hesitate to fight local wars vigorously because the prospect(s) of local gain are not worth the risk of general warfare.

Bae (1987a), Bernheim and Whinston (1987) and Harrington (1987) studied strategic aspects of multimarket contacts in models of repeated games. Harrington considered two industries with a finite time horizon. Due to the multiplicity of static equilibria, firms can sustain collusion in one market. He showed that power to punish the deviator in one market can be shared in the other market which lacks punishment power due to the uniqueness of the static equilibrium. Bae, in a quantity-setting supergame model, showed that pooling punishment power in two markets can enhance sustainability and profitability of collusion. Bernheim and Whinston obtained similar result in price-setting supergames.

This paper develops independently a price-setting supergame between two heterogeneous two-market firms. The paper shows that by reciprocally increasing the market share of each firm in the market in which it has a relatively higher margin, the firms can increase both the sustainability and the profitability of collusion unless the ratios of the two firms' margins are the same in the two markets. Therefore, the two firms may be able to sustain collusion when independent specialists could not do in either market. Furthermore, when independent specialists can sustain collusion in both markets, the two firms can sustain collusion better unless the ratios of their margins are the same in the two markets. Bernheim and Whinston derived similar results in various special cases.

This paper also shows that, unless the ratios of the two firms' margins are the same in the two markets, monopolizing some market in collusion is optimal for the two firms. Monopolists in optimal collusion are the firms whose margins are *relatively* higher in the markets, and hence they are not necessarily the most efficient firms in the markets. Furthermore, in contrast to optimal collusion between two independent specialists, prices can be lower than the monopoly-profit-maximizing prices of the lower-cost firms in optimal collusion between the two firms.

The paper is organized as follows. Section II introduces a model of a price-setting supergame between two firms that serve one market with different costs. Section III analyzes how the set of sustainable collusion changes when the two firms encounter each other in two markets. Section IV concludes the paper.

II. Single-market Supergame

The model presented below is adapted from Bae (1987b). Suppose two firms produce homogeneous goods with different constant unit costs. Let c_i be the unit cost of firm i, $D(p)$ the market demand, and δ the time discount factor, where $0 < \delta < 1$. Assume that there exists $\bar{p}$ such that $\bar{p} > \max(c_1, c_2)$ and $D(p) > 0$ if and only if $p < \bar{p}$. The profit of firm i, when it monopolizes the market with price equal to p, is $\pi_i(p) \equiv (p - c_i) D(p)$. Assume that $\pi_i(p)$ is strictly quasiconcave for $p \in (c_i, \bar{p})$ and let p_i^m denote its maximum. Then, p_i^m is the monopoly-profit-maximizing price of firm i. Hereafter, it is referred to simply as the optimal price of firm i.

A Nash equilibrium in a supergame is a (subgame) perpect equilibrium (Selten 1965, 1975) if the prescribed strategies form a Nash equilibrium in every subgame. This requirement of perfect equilibrium rules out empty threats. Abreu (1988) showed that under very general conditions one can obtain all perfect equilibrium outcomes by considering strategies that have simple structures. These strategies use optimal punishment for each player, which is the worst possible perfect equilibrium for him. Any perfect equilibrium outcome can be sustained if all the players punish a player by going to his optimal punishment in the next period when he deviates from his prescribed action in any period.

Punishments can be restricted to a certain subset of perfect equilibria. Bae (1987b) and Harrington (1988) used the following form of punishment: when $c_i < c_j$, they used the repetition of the limit-pricing equilibrium of the static game, in which the two firms set prices equal to $\min(p_i^m, c_j)$ and firm i serves the whole market. The limit-pricing equilibrium is the unique perfect equilibrium of the static game if $c_1 \neq c_2$.[1] When $c_1 = c_2$, they used the repetition of the Bertrand equilibrium in which the two firms set prices equal

[1] When $c_1 \neq c_2$, the static game has a continuum of Nash equilibria in which both firms name the same price $p \in [\min(c_1, c_2), \max(c_1, c_2)]$ and the lower-cost firm makes all sales. But the limit-pricing equilibrium is the unique perfect equilibrium because the higher--cost firm uses weakly dominated strategies in other Nash equilibria.

to c_1 and share the market. The Bertrand equilibrium is the only perfect equilibrium of the static game if $c_1 = c_2$.

The results of this paper do not rely on the use of optimal punishments. Hence, we simply assume that the two firms use, for firm i, the punishment which yields firm i payoff of V_i. Furthermore we assume that $V_1 \geq 0$ and $V_2 \geq 0$ because each firm has the option to shut down and hence its payoff cannot be nagative in its punishment.

Collusion is defined by the pair (p, α), where p is the collusive price and α is the market share of firm 1. Hence, (p, α) results in a profit pair $(\alpha\pi_1(p), (1-\alpha)\pi_2(p))$. Since collusion is required to yield positive profits to the firms, (p, α) should satisfy that $\max(c_1, c_2) < p < \bar{p}$ and $0 < \alpha < 1$. Collusion is defined to be sustainable if and only if it can be an outcome realized by a perfect equilibrium with the assumed punishments of value V_1 and V_2 for firm 1 and firm 2, respectively.

The supremum of firm i's profit when it deviates from (p, α) is $\pi_i(\min(p, p_i^m))$ since the best way for firm i to deviate from collusion is to undercut the collusive price and serve the whole market. Now, the application of Proposition 1 in Abreu (1988) gives the following proposition.

Proposition 1

(p, α) is sustainable if and only if

$$I_1(p, \alpha) \equiv \pi_1(\min(p, p_1^m)) + \delta V_1 - (1/(1-\delta))\,\alpha\pi_1(p) \leq 0 \tag{1}$$

and
$$I_2(p, \alpha) \equiv \pi_2(\min(p, p_2^m)) + \delta V_2 - (1/(1-\delta))\,(1-\alpha)\pi_2(p) \leq 0. \tag{2}$$

If firm 1 adheres to collusion, its payoff is $(1/(1-\delta))\,\alpha\pi_1(p)$ while if it deviates from collusion, the supremum of its payoff is $\pi_1(\min(p, p_1^m)) + \delta V_1$. Therefore, the supremum of firm 1's net gain from chiselling (p, α) is $I_1(p, \alpha)$ and hence firm 1 does not have incentive to deviate from collusion if and only if $I_1(p, \alpha) \leq 0$. Similarly, firm 2 does not have incentive to deviate from collusion if and only if $I_2(p, \alpha) \leq 0$. Proposition 2 presents conditions on α for firms not to deviate from collusion.

Proposition 2

For $p \in (\max(c_1, c_2), \bar{p})$, there exist $\underline{\alpha}(p)$ and $\bar{\alpha}(p)$ such that $\underline{\alpha}(p)$

> 0, $\bar{\alpha}(p) < 1$, $I_1(p, \alpha) \leq 0$ if and only if $\alpha \geq \underline{\alpha}(p)$, and $I_2(p, \alpha) \leq 0$ if and only if $\alpha \leq \bar{\alpha}(p)$.

Proof: From (1), $I_1(p, \alpha) \leq 0$ if and only if $\alpha \geq \underline{\alpha}(p) \equiv (1-\delta)(\pi_1(\min(p, p_1^m)) + \delta V_1)/\pi_1(p)$ and, from (2), $I_2(p, \alpha) \leq 0$ if only and if $\alpha \leq \bar{\alpha}(p) \equiv 1-(1-\delta)(\pi_2(\min(p, p_2^m)) + \delta V_2)/\pi_2(p)$.

Proposition 2 maintains that firm 1 and firm 2 have minimum required market shares $\underline{\alpha}(p)$ and $1-\bar{\alpha}(p)$, respectively, in order not to chisel collusion. The following proposition reveals some properties of collusion that are Pareto optimal to the firms among sustainable collusion. Hereafter, such collusion is simply referred to as optimal collusion.

Proposition 3

Let (p, α) be optimal collusion.
Then, i) $0 < \underline{\alpha}(p) \leq \alpha \leq \bar{\alpha}(p) < 1$, and
ii) $\min(p_1^m, p_2^m) \leq p \leq \max(p_1^m, p_2^m)$.

Proof: i) follows from Proposition 2. Suppose that $p \in (\max(c_1, c_2), \min(p_1^m, p_2^m))$. For all $i = 1, 2$: $\pi_i(p) < \pi_i(\min(p_1^m, p_2^m))$ since $\pi_i(p)$ is strictly quasiconcave for $(c_i, \bar{p})$. Hence, $(\min(p_1^m, p_2^m), \alpha)$ Pareto dominates (p, α) for all $\alpha \in (0, 1)$. Furthermore, $(\min(p_1^m, p_2^m), \alpha)$ is sustainable if (p, α) is sustainable since for all $i = 1, 2$ and for all $\alpha \in [0, 1]$: $I_i(\min(p_1^m, p_2^m), \alpha) \leq I_i(p, \alpha)$ if $I_i(p, \alpha) \leq 0$. Therefore, (p, α) cannot be optimal and hence the first inequality of ii) holds.

Now, suppose that $p \in (\max(p_1^m, p_2^m), \bar{p})$. For all $i = 1, 2$: $\pi_i(p) < \pi_i(\max(p_1^m, p_2^m))$ since $\pi_i(p)$ is strictly quasiconcave for $(c_i, \bar{p})$. Hence, $(\max(p_1^m, p_2^m), \alpha)$ Pareto dominates (p, α) for all $\alpha \in (0, 1)$. Furthermore, $(\max(p_1^m, p_2^m), \alpha)$ is sustainable if (p, α) is sustainable since $I_i(\max(p_1^m, p_2^m), \alpha) \leq I_i(p, \alpha)$ for all $i = 1, 2$ and for all $\alpha \in [0, 1]$. Therefore, (p, α) cannot be optimal and hence the second inequality of ii) holds.

Proposition 3 says that the price must lie between the two firms' optimal prices in optimal collusion. An increase in the collusive price from the optimal price of the higher-cost firm decreases profits of both firms in collusion without changing their maximum profits from chiselling collusion. A decrease in the collusive price from the optimal price of the lower-cost firm decreases the two firms' maximum profits from chiselling collusion and profits in collusion proportionately. Therefore, whenever there exists sustainable collusion with a price out of the interval of the two firms' optimal prices, Pareto-dominating, sustainable collusion exists with a price in that interval.

III. Two-market Supergame

Suppose two firms face each other in two markets as duopolists. Some symbols used in Section II are subscripted by A and B, which denote market A and B.

The two firms may separate strategies in two markets. In this case, their behavior is not different from that of independent specialists. Therefore, we consider the case in which the two firms link strategies in the two markets. Suppose that if a firm deviates from collusion or its prescribed action in punishments in *any* market, the two firms go to to its punishments in *both* markets. We assume that when the two firms link strategies in the two markets, their punishments in each market do not change.

Collusion between the two firms is defined by the quadruple $(p_A, \alpha_A, p_B, \alpha_B)$, where p_k is the collusive price in market k, and α_k is the market share of firm 1 in market k. Collusion is assumed to satisfy that $p_k \in (\max(c_{1k}, c_{2k}), \bar{p}_k)$ for all $k = A, B$.

The supremum of firm i's payoff when it deviates from collusion is $\pi_{iA}(\min(p_A, p_{iA}^m)) + \pi_{iB}(\min(p_B, p_{iB}^m)) + \delta V_{iA} + \delta V_{iB}$. Now, the following proposition gives necessary and sufficient conditions for sustainable collusion.

Proposition 4

$(p_A, \alpha_A, p_B, \alpha_B)$ is sustainable if and only if $I_i(p_A, \alpha_A, p_B, \alpha_B) \equiv I_{iA}(p_A, \alpha_A) + I_{iB}(p_B, \alpha_B) \leq 0$, for all $i = 1, 2$.

Proposition 4 implies that the two firms may be able to sustain collusion by linking the strategies in the two markets when the independent specialists could not. A better understanding of this case is presented in the following proposition, which is the most significant finding of this paper.

Proposition 5

Suppose that $\max(c_{1k}, c_{2k}) < p_k < \bar{p}_k$ for all $k = A, B$, and that

$$(p_A - c_{1A})/(p_A - c_{2A}) > (p_B - c_{1B})/(p_B - c_{2B}). \tag{3}$$

If $\alpha_A < 1$ and $\alpha_B > 0$, then there exist α_A' and α_B' such that

i) $\alpha_A < \alpha'_A \leq 1$ and $0 \leq \alpha'_B < \alpha_B$,

ii) $\alpha'_A \pi_{1A}(p_A) + \alpha'_B \pi_{1B}(p_B) > \alpha_A \pi_{1A}(p_A) + \alpha_B \pi_{1B}(p_B)$

and $(1 - \alpha'_A) \pi_{2A}(p_A) + (1 - \alpha'_B) \pi_{2B}(p_B) > (1 - \alpha_A) \pi_{2A}(p_A) + (1 - \alpha_B) \pi_{2B}(p_B)$, and

iii) $I_i(p_A, \alpha'_A, p_B, \alpha'_B) < I_i(p_A, \alpha_A, p_B, \alpha_B)$ for all $i = 1, 2$.

Proof: Since $(p_A - c_{1A})/(p_A - c_{2A}) > (p_B - c_{1B})/(p_B - c_{2B})$, $\pi_{1A}(p_A)/\pi_{1B}(p_B) > \pi_{2A}(p_A)/\pi_{2B}(p_B)$. Let r be a number such that $\pi_{1A}(p_A)/\pi_{1B}(p_B) > r > \pi_{2A}(p_A)/\pi_{2B}(p_B)$ and m be a number such that $0 < m \leq \min(1 - \alpha_A, \alpha_B/r)$. Lastly, let $\alpha'_A = \alpha_A + m$ and $\alpha'_B = \alpha_B - rm$. Then i) holds. In addition, ii) holds because

$$\alpha'_A \pi_{1A}(p_A) + \alpha'_B \pi_{1B}(p_B) = \alpha_A \pi_{1A}(p_A) + \alpha_B \pi_{1B}(p_B) + m(\pi_{1A}(p_A) + r\pi_{1B}(p_B))$$

and $$(1 - \alpha'_A) \pi_{2A}(p_A) + (1 - \alpha'_B) \pi_{2B}(p_B) = (1 - \alpha_A)\pi_{2A}(p_A) + (1 - \alpha_B)\pi_{2B}(p_B) - m(\pi_{2A}(p_A) - r\pi_{2B}(p_B)).$$

Finally, iii) follows from ii) because

$$I_1(p_A, \alpha_A, p_B, \alpha_B) = \sum_{k=A,B}(\pi_{1k}(\min(p_k, p^m_{1k})) + \delta V_{1k}) - (1/(1-\delta))(\alpha_A\pi_{1A}(p_A) + \alpha_B\pi_{1B}(p_B))$$

and $$I_2(p_A, \alpha_A, p_B, \alpha_B) = \sum_{k=A,B}(\pi_{2k}(\min(p_k, p^m_{2k})) + \delta V_{2k}) - (1/(1-\delta))((1 - \alpha_A)\pi_{2A}(p_A) + (1 - \alpha_B)\pi_{2B}(p_B)).$$

When two firms serve two regional markets and their cost differences stem from the significance of transportation costs and differing plant locations, it is likely that $c_{1A} <(>) c_{1B}$ and $c_{2A} \geq(\leq) c_{2B}$. In this case, (3) holds for any pair of collusive prices. Also, when $c_{1A} <(>) c_{2A}$ and $c_{1B} \geq(<) c_{2B}$, (3) holds for any pair of collusive prices.

Proposition 5 has important implications. When the two firms link strategies in the two markets, they do not have minimum required market shares in a single market unlike the independent specialists. Therefore, unless the ratios of the two firms' margins are the same in the two markets, the two firms can increase both the sustainability and the profitability of collusion by riciprocally increasing the market share of each firm in the market in which its margin is relatively higher. Such trade of market shares can increase profits of both firms in collusion because the two markets become more specialized by relatively more profitable firms. The two firms' maximum profits from chiselling collusion and the payoffs in their punishments do not depend on their market shares in collusion. Hence, an increase in the profitability due to trade of market shares results in increase in the sustainability of collusion.

Now, two results stem from Proposition 5. The two firms may be able to sustain collusion when independent specialists would not be able to in either market. When independent specialists can sustain collusion in both markets, the two firms can sustain collusion better unless the ratios of their margins are the same in the two markets. If the ratios are the same, trading market shares cannot increase profits of both firms.

Suppose that the ratios of the two firms' margins are different in the two markets. If neither market is monopolized by the firm whose margin is relatively higher, trading market shares can increase both the profitability and sustainability of collusion. Hence, in optimal collusion, some market is monopolized. Monopolists in optimal collusion are the firms whose margins are *relatively* higher in the markets, and hence they are not necessarily the most efficient firms in the markets. Proposition 6 gives some properties of optimal collusion.

Proposition 6

Let $(p_A, \alpha_A, p_B, \alpha_B)$ be optimal collusion. Then

i) $(1-\alpha_k)\,\alpha_l = 0$ if $(p_k - c_{1k})/(p_k - c_{2k}) > (p_l - c_{1l})/(p_l - c_{2l})$, and

ii) $p_k \leq \max(p^m_{1k}, p^m_{2k})$ for all $k = A, B$.

Proof: i) follows from Proposition 5. Suppose that $p_k > \max(p^m_{1k}, p^m_{2k})$ for some $k = A, B$.

Let $p'_k = \min(p_k, \max(p^m_{1k}, p^m_{2k}))$. Then, for all $i = 1, 2$: $\pi_{iA}(p'_A) + \pi_{iB}(p'_B) > \pi_{iA}(p_A) + \pi_{iB}(p_B)$ since $\pi_{1k}(p)$ is strictly quasiconcave for $p \in (c_{ik}, \bar{p}_k)$ for all $k = A, B$. Hence, $(p'_A, \alpha_A, p'_B, \alpha_B)$ (weakly) Pareto dominates $(p_A, \alpha_A, p_B, \alpha_B)$ for all $\alpha_A \in [0, 1]$ and for all $\alpha_B \in [0, 1]$. Furthermore, $(p'_A, \alpha_A, p'_B, \alpha_B)$ is sustainable if $(p_A, \alpha_A, p_B, \alpha_B)$ is sustainable since for all $i = 1, 2$: $I_i(p'_A, \alpha_A, p'_B, \alpha_B) \leq I_i(p_A, \alpha_A, p_B, \alpha_B)$ for all $\alpha_A \in [0, 1]$ and all $\alpha_B \in [0, 1]$. Therefore, $(p_A, \alpha_A, p_B, \alpha_B)$ cannot be optimal and hence ii) holds.

Prices should not be higher than the optimal prices of the higher-cost firms in the two markets for the same reasons as in the two specialists' case. However, prices in optimal collusion between two-market firms can be lower than the optimal prices of the lower-cost firms. This happens because a simultaneous decrease in prices in the two markets from the optimal prices of the lower-cost firms can decrease each firm's maximum profit from chiselling collusion more than proportionately with its profit in collusion. The following proposition gives a numerical example for such a case.

Proposition 7

Suppose the $D_A(p) = D_B(p) = 10 - p$, $c_{1A} = c_{2B} = 0$, and $c_{1B} = c_{2A} = 2$.
Also suppose that

$$V_{1B} = V_{2A} = 0 \text{ and}$$
$$V_{1A} = V_{2B} = (1/(1-\delta))\,\pi, \text{ where } 0 \le \pi \le 16. \tag{14}$$

Then, for $7/(28-\pi) \le \delta < 15/(40-\pi)$,

i) there does not exist sustainale collusion $(p_A, \alpha_A, p_B, \alpha_B)$ such that $5 \le p_A \le 6$ and $5 \le p_B \le 6$, and
ii) (3, 1, 3, 0) is sustainable.

Proof: Suppose that $5 \le p_k \le 6$ and $0 \le \alpha_k \le 1$ for all $k = A, B$. Then

$$\sum_{i=1}^{2} I_i(p_A, \alpha_A, p_B, \alpha_B) = 50 + 2(\delta/(1-\delta))\pi + (p_A - 2)(10 - p_A) + (p_B - 2)(10 - p_B) - (1/(1-\delta))(p_A(10 - p_A) + p_B(10 - p_B) - 2(1-\alpha_A)(10 - p_A) - 2\alpha_B(10 - p_B)).$$

Hence,

$$\sum_{i=1}^{2} I_i(p_A, \alpha_A, p_B, \alpha_B) \ge \sum_{i=1}^{2} I_i(p_A, 1, p_B, 0) \ge \sum_{i=1}^{2} I_i(5, 1, 5, 0)$$
$$= 80 + 2(\delta/(1-\delta))\pi - 50/(1-\delta) > 0. \tag{5}$$

Therefore, i) holds. Also, ii) holds because $I_1(3, 1, 3, 0) = I_2(3, 1, 3, 0) = 28 + (\delta/(1-\delta))\pi - 21/(1-\delta) \le 0$.

We can assume (4) since in the unique perfect equilibrium of the static game the lower-cost firm obtains profit of 16 while the higher-cost firm earns zero profit. When $0 \le \pi \le 16$, $7/(28-\pi) < 15/(40-\pi)$.

In (5), the first inequality holds because increasing the lower-cost firms' market shares does not change each firm's maximum payoff from chiselling collusion but increase the sum of the two firms' profits in collusion. The second inequality holds because of the following reasons. Suppose that a market is monopolized by the lower-cost firm and that a decrease in price occurred in the interval between the two firms' optimal prices. The decrease in price does not change the higher-cost firm's profit in collusion and decreases its maximum profit from chiselling collusion. In addition, the decrease in price does not change the lower-cost firm's profit from chiselling collusion and increases its profit in collusion.

Collusion (3, 1, 3, 0) is more sustainable than (5, 1, 5, 0) because of the following reasons. The simultaneous decrease in price from 5 to 3 in both markets decreases each firm's maximum profit from chiselling collusion from 15 to 7 and decreases each firm's profit in collusion from 25 to 21. Hence, the decrease in each firm's maximum profit from chiselling collusion is more than proportionate to the decrease in each firm's profit in collusion. This cannot happen if the two firms serve only one market.

IV. Conclusion

When firms attempt to collude, they face a market-sharing problem. If the firms are independent specialists, they have minimum required market shares in sustaining collusion. However, multiproduct and/or multimarket firms do not have minimum required market shares in a single market in sustaining collusion.

By reciprocally increasing the market share of each firm in the market in which its margin is relatively higher, the two firms can increase both the sustainability and the profitability of collusion. Hence, they may be able to sustain collusion when independent specialists would not be able to do in either market. Furthermore, when independent specialists can sustain collusion in both markets, the two firms can sustain collusion better unless the ratios of their margins are the same in the two markets.

Unless the ratios of the two firms' margins are the same, some market is monopolized in collusion optimal to the firms. Monopolists in optimal collusion are the firms whose margins are *relatively* higher in the markets, and hence they are not necessarily the most efficient firms in the markets. In contrast to optimal collusion between two independent specialists, prices can be lower than the optimal prices of the lower-cost firms in optimal collusion between the two firms.

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