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Profit enhancing competitive pressure in vertically related industries*

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Abstract

Under a simple Cournot model with vertical relations, when downstream firms engage in process R&D, the profits of upstream firms in which upstream competition exists may be *larger* than those in which each upstream firm has a bilateral monopoly relation with its buyer (downstream firm).

JEL classification numbers: L13, O31.

Key words: upstream firm, competition, bilateral oligopoly

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1 Introduction

A standard view concerning market competition posits that more intense market competition, measured in almost any way, reduces firm profit. Consequently, it should be in the best interest of profit-maximizing firms to reduce the degree of market competition. One way to do this is to gain market power through product differentiation. Another way, although it is sometimes subject to legal restrictions, is to reduce the number of competitors in a given market by such means as collusion, entry deterrence, predation and horizontal mergers. In any event, firms are expected to earn higher profits if they can place themselves in less competitive environments.

We investigate how upstream competition affects the profitability of firms and incentives for downstream firms to invest in cost-reducing R&D. The model in this paper is set as follows. There are two upstream and two downstream firms. Each downstream firm produces a final product, and must buy input from upstream firms. Each downstream firm engages in process R&D. Each upstream firm faces competitive pressure from potential suppliers.

The model setting is motivated by the following situation. Many manufacturers have relationships with many input suppliers. For instance, in the aircraft industry, the jet (turboprop) engine and aircraft industries are vertically related. To produce a product, aircraft firms must procure suitable equipment. Engine companies also have relations with many buyers, and potentially with all of them (Bonaccorsi and Giuri (2001)). In the automobile industry, Toyota procures electric parts from many input suppliers including Denso, which is one of the largest auto part manufacturers. Denso supplies other automobile manufacturers, for instance, Daimler Chrysler (Ahmadjian and Lincoln (2001)). Thus, electric parts may be used in automobiles from different manufacturers. When manufacturers make products, they may face constraints that stem from the technological capacities of suppliers. When the manufacturers are able to negotiate with many suppliers of suitable inputs, they can procure such inputs at reasonable prices. Conversely, when there are only few suitable suppliers, the manufacturers must pay them higher prices. That is, competitiveness in input markets affects the procurement conditions of manufacturers.

We show that upstream competition always leads to higher investment levels by downstream firms. We also show that the wholesale price for which each upstream firm faces competitive pressure may be *higher* than that in which each upstream firm has a bilateral monopoly relation with its buyer. Moreover, the profit of each upstream firm when it faces competitive pressure may be *larger* than when it has a bilateral monopoly relation with its buyer. In other words, competition pressures on the upstream firms do not always harm their profitability.

This paper is related to the discussion on how vertical structure affects incentives of upstream and/or downstream firms to undertake innovative activities. In the context of vertical market structures and competition environments, Ishii (2004) and Milliou (2004) discuss spillover effects of R&D investments. Banerjee and Lin (2003), Brocas (2003), and Buehler and Schmutzler (2008) focus on the relation of vertical market structure and cost-reducing investment in an oligopoly. Those papers do not consider how competitiveness in upstream markets affects profitability of upstream firms when downstream firms engage in process R&D.

Several recent studies have discussed instances where an increase in competitive pressure (the number of firms) may actually increase firm profit. Coughlan and Soberman (2005), Chen and Riordan (2007), and Ishibashi and Matsushima (2009) belong to this strand, but the underlying mechanism of our model differs substantially from theirs. In these previous studies, market entry works as a commitment device to soften market competition, so that the market actually becomes less competitive as more firms enter it. Ishida *et al.* (2008) also show a market condition in which an increase in the number of firms may increase the profit of a firm. They consider a simple Cournot model with strategic R&D investments wherein an efficient (dominant) firm competes against less efficient (fringe) firms. Asymmetry among the firms is a key factor to derive their main result, whereas the main mechanism to derive ours is quite different.

The paper proceeds as follows. The next section outlines the basic environment. Section 3 provides an analysis of the model. Finally, Section 4 offers conclusion.

2 The model

We consider a market with two downstream and two upstream firms. There is only one factor of production, which we refer to as the input. Each firm produces a differentiated final good in a constant-returns-to-scale process where one unit of the input is turned into one unit of the final good. Each downstream firm is able to do this conversion at no cost.

We assume that the two downstream firms compete in quantity. Now let x_i denote i's sales. The inverse demand function is given by

$$p = 1 - x_1 - x_2,$$

where p is the price of the final good.

Let z_i denote the amount of the input supplied to firm i. Each input supplier sets a wholesale price

w_i to maximize its profit function:

$$\pi_{Ui} = w_i z_i,\ i = 1, 2.$$

The fact that the input suppliers unilaterally set the wholesale prices implies that they possess full bargaining power.

In this paper, we consider two cases concerning the technologies of upstream firms:

1. Neither upstream firm faces a competitor.

2. Each upstream firm faces competitors that are potentially able to supply each downstream firm. If a competitor incurs a marginal cost, k, it is able to supply its input to downstream firm i, where k is a positive constant.

The first case means that each upstream firm has a monopoly position with its trading partner. The second case means that each upstream firm faces potentially harmful competitive forces. Those competitive forces include the upstream firms supplying to the downstream firm (that is, upstream firm i is a potential competitor of upstream firm j $(i = 1, 2,\ i \neq j)$). For instance, in the aircraft industry, while Rolls Royce and CFM International sometimes exclusively supply highly specific turbofan engines to Airbus and Boeing respectively, these engine suppliers are potential suppliers of either company.

We consider the downstream firm's investments in process R&D. We assume that the constant marginal cost of firm i is determined by firm i's investment in process R&D, denoted by c_i $(i = 1, 2)$. The marginal cost of firm i is $c - c_i$. The cost of process R&D is given by $G(d_i) = \phi c_i^2$ (ϕ is a positive constant). The game structure in this section is as follows.

1. Each downstream firm engages in process R&D.

2. Each upstream input supplier sets its wholesale price(s).

3. Given those prices, each firm simultaneously chooses quantities.

3 Analysis

3.1 Case 1: no potential supplier

In this case, neither upstream firm faces a competitor. Upstream firm i unilaterally offers its wholesale price w_i $(i = 1, 2)$ to downstream firm i.

The profits of firms 1 and 2 are

$$\pi_{Di} = (1 - x_i - x_j - w_i - (c - c_i))x_i, \quad i \neq j.$$

The first-order conditions lead to

$$x_i = \frac{1 - c - 2(w_i - c_i) + (w_j - c_j)}{3}, \quad i \neq j. \tag{1}$$

The profit of the input supplier is

$$\pi_{Ui} = \frac{w_i(1 - c - 2(w_i - c_i) + \gamma(w_j - c_j))}{3}, \quad i \neq j.$$

The first-order conditions lead to

$$\widetilde{w}_i = \frac{5(1-c) + 7c_i - 2c_j}{15}, \quad i \neq j. \tag{2}$$

The profits of downstream firms are:

$$\pi_{Di} = \frac{4(5(1-c) + 7c_i - 2c_j)^2}{2025} - \phi c_i^2, \quad i \neq j. \tag{3}$$

The first-order conditions lead to

$$c_1^N = c_2^N = \frac{28(1-c)}{405\phi - 28}. \tag{4}$$

The equilibrium profits of the upstream and downstream firms are

$$\pi_{U1}^N = \pi_{U2}^N = \frac{12150(1-c)^2\phi^2}{(405\phi - 28)^2}, \quad \pi_{D1}^N = \pi_{D2}^N = \frac{4(1-c)^2\phi(2025\phi - 196)}{(405\phi - 28)^2}. \tag{5}$$

The wholesale prices are

$$w_1^N = w_2^N = \frac{135(1-c)\phi}{405\phi - 28}. \tag{6}$$

3.2 Case 2: potential suppliers

In this case, potential suppliers can sell their input to both downstream firms. If k is insufficiently large, upstream firm i faces a constraint that its wholesale price for downstream firm i cannot be larger than k because potential suppliers can undercut this price and deprive it of the demand of downstream firm i. Therefore, when we consider the determination of the wholesale prices, we must take this constraint into account.

Upstream firm i unilaterally offers its wholesale prices w_i $(i = 1, 2)$ to downstream firm i. Given the wholesale prices, the quantities supplied by the downstream firms are equivalent to the previous case, x_i in (1). We now concentrate our discussion on the case in which the constraint $w_i \leq k$ is binding for each firm. Therefore, the wholesale prices are

$$w_1 = w_2 = k.$$

The profits of the downstream firms are:

$$\pi_{Di} = \frac{((1-c-k)+2c_i-c_j)^2}{9} - \phi c_i^2, \quad i \neq j.$$

The first-order conditions lead to

$$c_1^{PS} = c_2^{PS} = \frac{2(1-c-k)}{9\phi-2}. \tag{7}$$

The equilibrium profits of the upstream and the downstream firms are

$$\pi_{U1}^{PS} = \pi_{U2}^{PS} = \frac{3\phi(1-c-k)k}{9\phi-2}, \quad \pi_{D1}^{PS} = \pi_{D2}^{PS} = \frac{(1-c-k)^2\phi(9\phi-4)}{(9\phi-2)^2}. \tag{8}$$

We must ascertain whether the constraint $w_i \leq k$ is binding when the upstream firms face the constraints. Given the values of c_i^{PS}, if the optimal wholesale price of each upstream firm is larger than k, the constraint is binding. Substituting c_i^{PS} into $\widetilde{w}_i$ in (2), we have the condition that the constraint is binding ($\widetilde{w}_i > k$):

$$k < \frac{9(1-c)\phi}{27\phi-4} \equiv \bar{k}. \tag{9}$$

We now concentrate our discussion on the case in which $k < \bar{k}$.

3.3 Comparison

We now compare the equilibrium outcomes in the cases discussed above.

Investment We first compare c_i^N (no potential supplier) with c_i^{PS} (potential suppliers). After some calculus, we find that for any $k < \bar{k}$, $c_i^{PS} > c_i^N$. That is, upstream competition always enhances the downstream firms' incentives to invest. When there is no potential supplier, no upstream firm can commit not to set a higher price given that each downstream firm has already invested. Anticipating this exploitation, the downstream firms diminish their efforts to invest. Price competition acts as a commitment to set their wholesale prices at a lower level. Those low prices encourage the downstream firms to invest.

Wholesale price We compare w_i^N with w_i^{PS}. There exists k such that $w_i^{PS} = k > w_i^N \equiv k^w$ because the following inequality satisfies (see Figure 1):

$$\bar{k} - w_i^N = \frac{288(1-c)\phi}{(405\phi-28)(27\phi-4)} > 0.$$

Although price competition restricts the ability of upstream firms to set their wholesale prices freely, it may lead to higher wholesale prices than in the case without potential suppliers. When there is no potential supplier, the investment levels of the downstream firms are low. This low investment prevents the upstream firms from setting higher wholesale prices because the expansion in demand induced by the investments is small. Therefore, when price competition between the upstream firms is not intense (k is large), the wholesale prices are higher than those in the firm-specific input case.

Upstream firm We now compare π_{Ui}^{N} with π_{Ui}^{PS}. After some calculus, we find that $\pi_{Ui}^{PS} > \pi_{Ui}^{N}$ if and only if $k > k^{U}$ where

$$k^{U} \equiv \frac{(405\phi - 28 - \sqrt{18225\phi^2 + 9720\phi + 784})(1-c)}{2(405\phi - 28)}.$$

After some calculus, we find that k^{U} is smaller than $\bar{k}$ (see Figure 1). That is, for $k^{U} < k < \bar{k}$, price competition leads to higher upstream profits. In other words, competition between upstream firms and potential suppliers may enhance the profitability of the upstream firms. The existence of potential suppliers induces higher levels of investment by the downstream firms. The increases in investment increase the quantities supplied to the downstream firms. Moreover, when k is large, the wholesale prices caused by price competition are larger than in the case without potential suppliers. Because the demand and the wholesale price are larger than in the case without potential suppliers, the profit of each upstream firm is larger.

4 Conclusion

We investigate how upstream competition affects incentives for downstream firms to make cost reducing R&D investments and the profitability of the firms. We show that upstream competition always leads to higher investment levels by downstream firms. We also show that the wholesale price at which each upstream firm faces competitive pressures may be higher than when it has a bilateral monopoly relation with its buyer. Moreover, the profit of each upstream firm when it faces competitive pressure may be larger than when it has a bilateral monopoly relation with its buyer. In other words, competition pressures on the upstream firms do not always harm their profitability.

[2009.2.4, 907]

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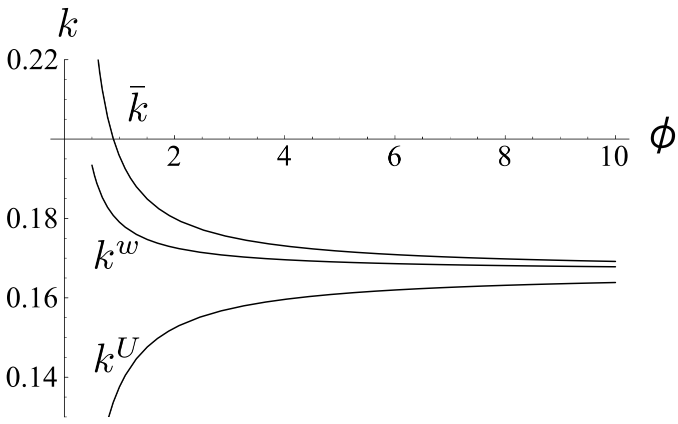

Figure 1: The threshold values ($c = 1/2$).