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MARKET EXPANSION
MAY HARM THE SUPPLIER
IN A BILATERAL MONOPOLY

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Market expansion may harm the supplier in a bilateral monopoly[*]

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Abstract

We consider a bilateral monopoly with a supplier and a buyer. Their trading terms are determined through negotiations, but affected by the buyer's efforts to search for outside suppliers. We find surprisingly that a market expansion may harm the supplier.

Keywords: Bilateral monopoly, Nash bargaining, outside suppliers

JEL Classification Numbers: L14, L22

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1 Introduction

Downstream firms in many industries often keep their outside supply sources to enhance the bargaining power over trading suppliers. In the context of the automobile industry, for instance, it has been emphasized that finding alternative suppliers is a useful tactic to enlarge profitability (e.g., Wu and Choi, 2005).[1] To capture this situation, we consider a bilateral monopoly where a supplier sells its input to a buyer which is able to improve its disagreement payoff through efforts (e.g., searching for other suppliers, improving its own input facility) before the supplier and the buyer negotiate a two-part tariff contract. The game considered here is quite simple: in the first stage, the downstream firm makes a search effort to improve its disagreement payoff; in the second stage, both firms bargain over the trading terms (a two-part tariff). If bargaining breaks down, the downstream firm obtains its disagreement payoff (e.g., by ordering input from the second-best supplier it searched in the first stage, or using its own input facility (similar to Inderst and Valletti, 2009)); in the third stage, the downstream firm sets the quantity of final output.

We show that a market expansion may harm the supplier, opposite to what one might conventionally expect. Intuitively, as the market size rises, the buyer raises its search effort to improve its disagreement payoff, weakening the bargaining position of the supplier. As a consequence, a market expansion while benefiting the downstream firm, can hurt the supplier. Furthermore, we reverse the roles of the upstream and downstream firms, and find our basic mechanism remains robust (this is available upon request).

Our simple model has a novel contribution to the literature of buyer-supplier relationships. Many researchers have investigated how disagreement payoffs influence realized outcomes in buyer-supplier relations (e.g., Davidson, 1988; Horn and Wolinsky, 1988; Inderst, 2007; Milliou and Petrakis, 2007; Iozzi and Valletti, 2014). Most of the papers discuss market structures in which at least one of the upstream and the downstream markets consists of more than

[1] See Matsushima and Zhao (2018) for a more detailed discussion of the literature.

one firm. Our paper shows that disagreement payoffs can influence firm profitabilities in an unconventional way even under the simplest bilateral monopoly setting.[2]

2 Bilateral Monopoly

Consider a downstream firm and an upstream firm without any production cost for simplicity, whose outputs are related in a one-to-one ratio. The downstream firm has an outside option: by incurring a fixed cost F, it can procure the input from a different source at price $w(e)(> 0)$ if negotiation with the upstream firm breaks down, where e is the search effort of the downstream firm to improve the value of its outside option, at a cost of $S(e)$. We assume $w'(e) < 0$, $w''(e) \geq 0$; and $S'(e) > 0$, $S''(e) > 0$. In sum, the assumptions concerning outside options follow those in Inderst and Valletti (2009) although here we endogenize the price $w(e)$.

Let us investigate the simplest game structure: in the first stage, the downstream firm makes a search effort e to improve its outside option; in the second stage, both firms bargain over the trading terms (a two-part tariff, $mq + T$, where m is the wholesale price, q is quantity and T is the fixed payment). If bargaining breaks down, the downstream firm executes its outside option at the fixed cost F, with a marginal cost of $w(e)$ (similar to Inderst and Valletti, 2009); finally, in the third stage, the downstream firm sets the quantity of final output.[3] The game is solved by backward induction.

To keep the model simple and clean, we assume the search cost to be sunk, in a way similar to R&D investments in innovation models, where actual production and any price or profit negotiation occurs afterwards.[4] Let the inverse demand function in the downstream market

[2] Recently, Inderst and Shaffer (2018) show the possibility that channel coordination in a vertical relationship can fail if some of the downstream firms have outside options.

[3] In the next section, we show that the size of the fixed cost F does not affect the main finding.

[4] An alternative is to let the two parties bargain first and then the downstream firm search if bargaining breaks down. In that case, however, because search begins after bargaining breaks down, delay of production occurs, which is costly to the downstream firm. In order to avoid such delay cost, the downstream firm thus chooses to search before bargaining occurs. Furthermore, our model formulation endogenizes the outside opportunity of the

be $p(q;a)$, where a is a positive parameter that can shift up the demand, such as market size, income, etc.

In the last stage, the downstream firm chooses the final quantity q to maximize its profits $(p(q;a) - m)q - T$, resulting in the following first-order and second-order conditions:

$$\text{F.O.C.} \qquad p(q;a) - m + p_q(q;a)q = 0,$$
$$\text{S.O.C.} \qquad 2p_q(q;a) + p_{qq}(q;a)q < 0,$$

where $p_q(q;a) = \partial p(q;a)/\partial q$ and $p_{qq}(q;a) = \partial^2 p(q;a)/\partial q^2$.

Let $q(m;a)$ denote the equilibrium quantity in which the wholesale price is m. Then the gross profits of the downstream and the upstream firms (excluding the search costs of the downstream firm) in the second stage are given as respectively,

$$\pi_D = [p(q(m;a);a) - m]q(m;a) - T; \quad \pi_U = mq(m;a) + T,$$

The firms' outside options are respectively,

$$\pi_D^O = [p(q(w(e);a);a) - w(e)]q(w(e);a) - F; \quad \pi_U^O = 0.$$

During bargaining, they jointly maximize

$$G = \{\pi_D - \pi_D^O\}\{\pi_U - 0\}.$$

downstream firm along the lines of Inderst and Valletti (2009).

The first-order conditions $\partial G/\partial T = 0$ and $\partial G/\partial m = 0$ can be reexpressed as:

$$\begin{aligned}
& \pi_D - \pi_D^O - \pi_U = 0, \\
& (\pi_D - \pi_D^O)[q(m;a) + mq_m(m;a)] - \pi_U q(m;a) \\
= \; & (\pi_D - \pi_D^O - \pi_U)q(m;a) + (\pi_D - \pi_D^O)mq_m(m;a) = (\pi_D - \pi_D^O)mq_m(m;a) = 0,
\end{aligned}$$

where $q_m(m;a) = \partial q(m;a)/\partial m$. From the above, we obtain

$$m = 0; \;\; T = \frac{p(q(0;a);a)q(0;a) - [p(q(w(e);a);a) - w(e)]q(w(e);a) + F}{2}.$$

Because bargaining is efficient, the two firms set the wholesale price equal to the marginal cost of the upstream firm, i.e., $m = 0$, to maximize their joint profits first; and then, they split the overall profits through the lump-sum payment, T. As such, the "double marginalization" problem in a standard bilateral-monopoly situation is avoided. Expecting the bargained outcome, the profits of the two firms respectively become

$$\begin{aligned}
\Pi_D(e) &= [p(q(m);a) - m]q(m;a) - T - S(e) \\
&= \frac{[p(q(0;a);a)]q(0;a) + [p(q(w(e);a);a) - w(e)]q(w(e);a) - F - 2S(e)}{2}, \\
\Pi_U(e) &= \frac{[p(q(0;a);a)]q(0;a) - [p(q(w(e);a);a) - w(e)]q(w(e);a) + F}{2}.
\end{aligned}$$

Then in the first stage, the downstream firm chooses search effort, satisfying the following first-order condition,

$$\frac{\partial \Pi_D(e)}{\partial e} = 0 \Leftrightarrow -\frac{w'(e^*)q(w(e^*);a) + 2S'(e^*)}{2} = 0. \quad (1)$$

3 Market size expansion

As promised, we now investigate how a marginal increase in parameter a (e.g., market size or income) affects the equilibrium outcome. Applying the envelop theorem yields

$$\frac{2\partial\Pi_U(e^*)}{\partial a} = p_a(q(0;a);a)q(0;a) - p_a(q(w(e^*);a);a)q(w(e^*);a) + w'(e^*)q(w(e^*);a)\frac{de^*}{da}. \quad (2)$$

where $p_a \equiv \partial p(q;a)/\partial a$ and e^* is the equilibrium level of search effort. Total differentiation of (1) gives

$$\frac{de^*}{da} = \frac{w'(e^*)q_a(w(e^*);a)}{-\{w''(e^*)q(w(e^*);a) + [w'(e^*)]^2 q_m(w(e^*);a) + 2S''(e^*)\}},$$

where $q_m \equiv \partial q(m,a)/\partial m$. It is easy to show $de^*/da > 0$, because the denominator is derived from the second-order condition of (1).

Let us examine (2) in detail. If $w(e^*)$ is sufficiently small (e.g., approaching zero), the first and second terms on the RHS cancel out, leaving only the third term and hence $\partial\Pi_U(e^*)/\partial a < 0$. Hence,

Proposition 1 *An increase in the parameter a decreases* $\Pi_U(e^*)$ *if* $w(e^*)$ *is sufficiently small.*

This Proposition implies that a market expansion actually harms the upstream firm, opposite to what one might conventionally expect. Intuitively, as the market size rises, the downstream firm raises its search effort, which then weakens the bargaining position of the upstream firm, leading to our result.

To summarize, positive shocks such as market size increases enlarge the pie and could bring potential gains for all players. However, if some players can raise their outside options, they can take away more than the increase of the pie, leaving others worse off. Also note that the same logic applies to a setting with n outside options, where the firm would use the best one of them and the rest of the options $(n-1)$ becomes irrelevant.

Example Assume that $p = a - q$, $w(e) = w - e$, and $S(e) = \gamma e^2/2$, with a and γ being positive constants. The second stage net profits of the two firms are then given as

$$\Pi_D(e) = \frac{1}{8}\left(a^2 + [a - w(e)]^2 - 4F\right) - S(e), \;\; \Pi_U(e) = \frac{1}{8}\left(a^2 - [a - w(e)]^2 + 4F\right)$$

In the first stage, the first-order condition of the downstream firm is

$$\frac{\partial \Pi_D(e)}{\partial e} = \frac{a - w - (4\gamma - 1)e}{4} = 0 \;\; \rightarrow \;\; e^* = \frac{a - w}{4\gamma - 1}.$$

Because the quantity under which bargaining breaks down, $(a - w(e^*))/2$, is smaller than when agreement is reached, we require $a < 4\gamma w$. Substituting e^* into $\Pi_U(e)$ gives

$$\Pi_U(e^*) = \frac{[(8\gamma - 1)a - 4\gamma w](4\gamma w - a)}{8(4\gamma - 1)^2} + \frac{F}{2}.$$

The first term is positive if

$$\frac{4\gamma w}{8\gamma - 1} < a < 4\gamma w.$$

Differentiating $\Pi_U(e^*)$ with respect to a yields

$$\frac{\partial \Pi_U(e^*)}{\partial a} = \frac{16\gamma^2 w - (8\gamma - 1)a}{4(4\gamma - 1)^2},$$

that is negative if and only if

$$\frac{16\gamma^2 w}{8\gamma - 1} < a < 4\gamma w,$$

under which a rise in market size a *decreases* the profit of the upstream firm.

4 Conclusion

The present paper while simple, generates novel results that match the real practices of many firms on vertically related production networks, such as automobile makers and parts suppliers. We have explicitly demonstrated conventionally counterintuitive situations when the supplier may lose from a market expansion. This mechanism has wide applications under different circumstances, for instance, suppliers' incentives in cost reduction, quality improvement, upstream collaboration and technology spillovers, and even worker training in the labor market.

In a companion paper, Matsushima and Zhao (2018) generalize this paper's setup to the case of a *bilateral duopoly*, again with outside options of buyers, and incorporating cost-reducing investments (e.g., R&D) by suppliers which could strengthen their bargaining position. This extended setup is often seen in some Japanese manufacturers such as in the automobile industry. Matsushima and Zhao (2018) find surprisingly that each supplier has an incentive to *unilaterally* generate a technology spillover to its rival for free, if its own downstream buyer can find cheap alternative sourcing. Such a strategy causes a market-size shrink within the vertical chain, which can hurt the downstream buyer but benefit the supplier, via the bargaining mechanism described above.

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Appendix (for reference only) Reversing the Roles of the Up- & Down-stream Firms

In Appendix, we switch the roles of the upstream and the downstream firms in the basic model, and prove a similar result will arise when the upstream (instead of the downstream) firm has better outside options.

Again assume the two firms' outputs are related by a one-to-one ratio, with the upstream firm's marginal cost being constant at c. As its outside option, the upstream firm can supply a final product directly, of quality $v(e)$, if negotiation with the downstream firm breaks down, where e is its effort to improve the value ($v'(e) > 0$ and $v''(e) < 0$), at a cost of $S_U(e)$ with $S'_U(e) \geq 0$ and $S''_U(e) > 0$.

The game structure is as follows: in the first stage, the upstream firm makes an effort e to improve its outside options; in the second stage, both firms bargain over the trading terms; finally, in the third stage, the downstream firm sets the quantity of final output. The game is solved by backward induction as before.

As in the benchmark, when the upstream firm uses a two-part tariff contract, it sets the wholesale price at its marginal cost, c. The fixed payment from the downstream firm to the upstream firm is T_d. In an abstract form, the gross profit of the downstream firm is $\pi_d(c)$, where $\pi'_d(c) < 0$ and $\pi''_d(c) > 0$.

On the other hand, its outside option is when the upstream firm directly enters the downstream market and supplies the final product, with a gross profit of $\pi_o(c, v)$, where $\partial\pi_o(c, v)/\partial c < 0$ and $\partial^2\pi_o(c, v)/\partial c^2 > 0$; that is, an increase in c diminishes the gross profit, at a decreasing rate. But the converse holds for quality, $\partial\pi_o(c, v)/\partial v > 0$ and $\partial^2\pi_o(c, v)/\partial v^2 > 0$. The cross partial derivative is $\partial^2\pi_o(c, v)/\partial c\partial v < 0$.

Thus, T_d is chosen to satisfy

$$\pi_d(c) - T_d = T_d - \pi_o(c, v).$$

Then the firms' net profits in the second stage are respectively

$$\begin{aligned}
\Pi_D &= \frac{\pi_d(c) - \pi_o(c, v(e))}{2}, \\
\Pi_U &= \frac{\pi_d(c) + \pi_o(c, v(e))}{2} - S_U(e).
\end{aligned}$$

And in the first stage, the upstream firm's maximization problem leads to:

$$\frac{\partial \pi_o(c, v(e))}{\partial v} \cdot v'(e) - 2S'_U(e) = 0.$$

Total differential of the above yields

$$\left[\frac{\partial^2 \pi_o(c, v(e))}{\partial v^2} \cdot (v'(e))^2 + \frac{\partial \pi_o(c, v(e))}{\partial v} \cdot v''(e) - 2S''_U(e)\right] de + \left[\frac{\partial \pi_o(c, v(e))}{\partial c \partial v} \cdot v'(e)\right] dc = 0,$$

which gives $de/dc < 0$ because the terms in the first brackets are the second-order conditions and negative, and the last term in the second brackets is also negative.

Finally, we examine how the upstream firm's marginal cost affects the downstream firm's profit.

$$\begin{aligned}
\frac{2d\Pi_D}{dc} &= \pi'_d(c) - \frac{\partial \pi_o(c, v(e))}{\partial c} - \frac{\partial \pi_o(c, v(e))}{\partial v} \cdot v'(e) \frac{de}{dc} \\
&= \underbrace{\pi'_d(c)}_{(-)} \underbrace{- \frac{\partial \pi_o(c, v(e))}{\partial c}}_{(+)} \underbrace{- 2S'_U(e) \frac{de}{dc}}_{(+)}.
\end{aligned}$$

If the third term is strong enough, the sign of $d\Pi_D/dc$ becomes positive. That is, the efficiency improvement of the upstream firm can harm the downstream firm, even though it generates a bigger pie, analogous to the result in the basic model.

Example Assume that $p = a - q$, $v(e) = v + e$, and $S(e) = \gamma e^2/2$, with a, v, and $\gamma(> 1/4)$ being positive constants. The second stage net profits of the two firms are then given as

$$\Pi_D(e) = \frac{1}{8}\Big((a-c)^2 - [v(e)-c]^2 + 4F\Big), \quad \Pi_U(e) = \frac{1}{8}\Big((a-c)^2 + [v(e)-c]^2 - 4F\Big) - S(e).$$

In the first stage, the first-order condition of the upstream firm is

$$\frac{\partial \Pi_U(e)}{\partial e} = \frac{a - w - (4\gamma - 1)e}{4} = 0 \quad \rightarrow \quad e^* = \frac{v - c}{4\gamma - 1}.$$

Because the quantity under which bargaining breaks down, $(v(e^*) - c)/2$, is smaller than when agreement is reached, we require $c > a - 4\gamma(a - v)$. Substituting e^* into $\Pi_D(e)$ gives

$$\Pi_D(e^*) = \frac{[(4\gamma-1)a + 4\gamma v - (8\gamma-1)c]((4\gamma-1)a - 4\gamma v + c)}{8(4\gamma-1)^2} + \frac{F}{2}.$$

The first term is positive if

$$-(4\gamma-1)a + 4\gamma v < c < \frac{(4\gamma-1)a + 4\gamma v}{8\gamma - 1}.$$

Differentiating $\Pi_D(e^*)$ with respect to c yields

$$\frac{\partial \Pi_D(e^*)}{\partial c} = \frac{-(4\gamma-1)^2 a + 16\gamma^2 v - (8\gamma-1)c}{4(4\gamma-1)^2},$$

that is positive if and only if

$$-(4\gamma-1)a + 4\gamma v < c < \frac{-(4\gamma-1)^2 a + 16\gamma^2 v}{8\gamma - 1},$$

under which a decrease in c *decreases* the profit of the downstream firm.