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Strategic Outsourcing with Technology Transfer under Cournot Competition

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Abstract

This paper seeks to show that even though a product market competitor holds the least cost input production technology, it may outsource its input production to an independent input producer and buy inputs from the firm at a higher price instead of producing inputs in-house for itself. Technology transfer in the form of patent sale acts as a commitment. Assuming Cournot competition in the product market the paper shows that such an outsourcing occurs when the initial technological gap between the input producing firms is small. Under such strategic outsourcing, however, consumer welfare as well as social welfare goes down.

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1. Introduction

Traditional literature on the theory of firm generally focuses on the choice between integration and outsourcing based on cost consideration. Accordingly, if a firm can buy an input from outside at a price lower than its in-house cost of production, the firm should go for outsourcing.[1] Of late, the researchers have focused attention to the outsourcing decision of a firm in the context of imperfectly competitive market and found different strategic reasons for outsourcing, which were not based on cost consideration alone.[2] It is in this context we provide a theory of strategic outsourcing based on a new dimension of technology transfer.

In a recent paper Arya, Mittendorf and Sappington (2008) have shown that given the choice between outsourcing and in-house production of inputs, a firm may go for outsourcing even though it can produce inputs in-house at a lower cost. There are three firms with one whole sale input supplier and two product market competitors. One of the competitors, say firm 1, has capability to produce the input in-house. The input supplier sets input prices sequentially to firm 1 first and then to the other competitor. The paper shows that even though firm 1 can produce the input at a cost less than the input price charged by the whole sale input supplier, firm 1 will outsource to take advantage in the output market, where the competition is a la Cournot. Outsourcing by firm 1 occurs whenever its production cost of input is greater than that of the whole sale input supplier. Firm 1 strategically opts for outsourcing to raise rival's cost and in the process may also get a favorable treatment in terms of a lower price for input for some parameter values. However, outsourcing never occurs in their model when the input production cost of firm 1 is strictly lower than that of the whole sale input supplier. In this paper, we allow for the possibility of technology transfer and show that outsourcing may occur even when firm 1 has a better technology of input production than the independent input supplier.

In Arya et al. (2008), the sequential and discriminating price offer seems crucial and motivating factor behind the strategic outsourcing. This discriminatory treatment by the input supplier may be realistic but is not very robust. A better assumption would be that input supplier fixes a price and anyone willing to pay that price should receive the input supply. In their model the independent input supplier possesses the least cost input production technology. Hence simply on the cost consideration firm 1 could go for outsourcing. Most importantly, it is not clear how, in the presence of firm 1, a higher price to firm 2 above firm 1's marginal cost is sustained. Finally, if firm 1 could possess the superior technology, in their model there would be no possibility of outsourcing.

Hence the purpose of the present paper is to reestablish their main result but under more appealing conditions. We retain their three firm structure and market competition but assume firm 1 to have the superior input production technology compared to that of the independent input supplier. We get rid of their sequential contracting for inputs with the final good producers and introduce a single price setting input market condition. Yet, we show, there are parametric situations where firm 1 will go for outsourcing. Clearly, under the usual cost consideration outsourcing should never occur. Hence we provide a stronger version of the

[1] For the literature of firm theory see, for instance, Coase (1937), Grossman and Hart (1986), Hart and Moore (1990), Grossman and Helpman (1999) and Gibbons (2005).

[2] There are a number of other interesting contributions on strategic outsourcing. A subset of this literature comprises Shy and Stenbacka (2003), Buehler and Haucap (2006), Chen, Dubey and Sen (2011), Chen (2011), and Mukherjee and Tsai (2010, 2013). A brief outline of these works can be found in Kabiraj (2013).

result, that is, even when a firm possesses the least cost input production technology, a firm may opt for outsourcing and buying inputs from outside at a higher price may be profitable.

Another interesting aspect of our paper is that we have introduced sale of patent of the input production technology in the context of outsourcing. Patent sale in our model acts as a commitment that the firm, in spite of initially having the superior technology, will buy inputs from outside. This is absolutely a new dimension in the strategic outsourcing literature.

The layout of the paper is the following. Section 2 provides the analytical framework. Sections 3 and 4 discuss respectively the case of in-house production and outsourcing. Finally, section 5 concludes the paper.

2. Analytical Framework

Consider three firms interaction. Firm 0 is an independent input supplier. Firm 1 and firm 2 are product market competitors with having identical technology to produce a homogeneous good which requires a non-specific key input and they compete a la Cournot in the product market. Firm 1 also possesses input production technology which is superior to that of firm 0. Firm 2 has to depend on either firm 0 or firm 1 for inputs. Let c_0 and c_1 be the per unit cost of producing inputs by firm 0 and firm 1 respectively, and $0 \le c_1 < c_0$. To simplify the analysis we further assume that one unit of the key input is required to produce one unit of the final good, and no other inputs are required, hence the cost of producing final good is the cost of inputs only. Let the inverse market demand for the final good be linear and given by

$$P = a - (q_1 + q_2), \tag{1}$$

where P is the price of the product and q_i is the supply of the i-th firm, $i = 1, 2$, and $a > c_0$.

We consider the following three-sage game.

Stage 1: Firm 1 decides whether it will outsource the input production to the independent input supplier or produce inputs in-house. The outsourcing decision is associated with the offer of sale of its patent of input production technology on a take-it-or-leave-it basis against a fee which firm 0 can either accept or reject. Firm 1's option of not selling the patent can be thought of as making an unacceptable offer.

Stage 2: Patent sale leads to monopoly of firm 0 in the input market. It decides its input price and sells inputs to firm 1 and firm 2. Under in-house production firm 1 decides whether to compete in the input market with the independent input seller to sell inputs to firm 2 or stay away from input market competition. In the latter case firm 0 will supply inputs to firm 2.

Stage 3: The final good producers compete in quantities in the final good market.[3]

At this stage we need to explain the role of patent sale in the context of outsourcing. First note that in our model licensing of the input production technology cannot occur because after licensing the technology, firm 1 retains its right to produce inputs and compete in the

[3] We retain here the Arya et al. (2008) framework. For the case of price competition in the product market see Kabiraj and Sinha (2014).

input market, and given price competition in the input market firm 0 will not agree to pay any positive license fee for the technology. Moreover, under licensing, firm 1 cannot commit that it will not produce inputs for itself. On the other hand, patent sale by firm 1 to firm 0 strips the right of firm 1 to use the technology; hence in our model patent sale acts as a credible commitment that firm 1 will not produce inputs by itself, which essentially means that firm 1 will buy the input from the input market where firm 0 would be the monopoly seller. Our purpose is to show that firm 1, may choose outsourcing rather than in-house production of the input to maximize its profits. Although firm 1 will have to pay a higher price under outsourcing for the input, but under some parametric conditions the loss of profits for firm 1 will be overcompensated by the revenue from patent sale.

3. In-house production

Under in-house production firm 1 is to decide whether it will compete in the input market with firm 0 to supply inputs to firm 2 or leave the input market to firm 0. However, we show that not-competing by firm 1 in the input market will not be credible; hence in equilibrium both firm 0 and firm 1 will compete in the input market.

If firm 1 could commit not to compete in the input market, then firm 0 would charge a price $w^b = \frac{a + c_1 + 2c_0}{4}$ for inputs sale to firm 2 (see *Appendix*). The corresponding payoff of firm 1 would be

$$\pi_1^b = \frac{(5a - 7c_1 + 2c_0)^2}{144} \tag{2}$$

The above is derived on the assumption that both firm 1 and firm 2 are active by producing positive output in the output market. In particular, at the input price w^b, firm 2's output is $q_2^b = (a - 2c_0 + c_1)/6$. Hence the relevant condition is:,

$$\text{(A1)} \qquad c_0 < \frac{a + c_1}{2} \equiv \bar{c}$$

Now consider the scenario when firm 1 not only produces for itself but also competes in the input market with firm 2. Given their input production technologies and price competition, the optimal input price will be the limiting price $w^C = c_0$ at which firm 1 will supply inputs to firm 2.[4] The equilibrium payoffs in this subgame (under input market competition) are:

$$\Pi_1^C = \frac{(a - 2c_1 + c_0)^2}{9} + (\mathrm{c}_0 - \mathrm{c}_1)\frac{(a - 2\mathrm{c}_0 + \mathrm{c}_1)}{3} \tag{3a}$$

[4] Given the open set problem in Bertrand competition we assume that the firm with the lower cost matches the price quoted by the higher cost firm and gets the entire demand in the market. Under asymmetric cost Bertrand competition there exists another possibility that the cost efficient firm charging monopoly price could be an equilibrium if the monopoly price is below the cost of the inefficient rival firm. This possibility is ruled out due to the parameter restrictions considered here.

$$\pi_2^C = \frac{(a - 2c_0 + c_1)^2}{9} \quad \text{and} \quad \pi_0^C = 0 \tag{3b}$$

Note that input market competition leads to a lower price of inputs for firm 2, which makes firm 2 a stronger rival in the final good market. This reduces firm 1's profit earning from the final good market (the first term in the expression of Π_1^C). Since input supply to firm 2 is done by firm 1, it earns some extra profit from input sales (the second term in the expression of Π_1^C). The net overall benefit of input market participation can go either way. Thus, it is quite possible that firm 1 may not like to participate in the input market and does better by simply undertaking the in-house production for itself only. We can easily check that,

$$\pi_1^b > \Pi_1^C \;\Leftrightarrow\; c_0 < \frac{3a + 11c_1}{14} \equiv \tilde{c} \tag{4}$$

We can write then the following proposition.

Proposition 1: *In case it is possible for firm 1 to commit not to enter into input market competition with the independent input supplier, it would do so for all* $c_0 \in [c_1, \tilde{c}]$. *And for* $c_0 \in (\tilde{c}, \bar{c})$ *firm 1 would like to participate in the input market competition.*

Now we argue that though firm 1 would prefer not to participate in the input market competition for small technology gap, but it cannot credibly commit to do so (that is, it is not subgame perfect). The following lemma proves that.

Lemma 1: *There does not exist any subgame perfect equilibrium where firm 1 stays out of the input market competition and produces the input in-house for itself.*

Proof: Suppose there exists a subgame perfect equilibrium where firm 1 does not compete in the input market but it produces inputs in-house. Now consider the following deviation. Suppose firm 0 charges an input price, w. Then for any $w > c_1$, firm 1 has incentive to enter the input market by matching w, thereby it can supply the entire demand of firm 2. This does not change the outcome of the final good market, but by matching the price quoted by firm 0 it can always increase its payoff from selling input to its rival. Thus, firm 1 can retain its payoff π_1^b from the final good market, and get an additional profit from the input market by entering into the input market competition. Hence, the lemma is proved. ■

In view of Lemma 1, the only possible outcome under in-house production will be that both firm 1 and firm 0 compete to supply inputs to firm 2. Given the cost advantage of firm 1 in input production, firm 1 charges the limiting price c_0, and firm 0 receives zero profit in equilibrium. Thus, under in-house production the payoffs of the firms will be given by (3).

4. Outsourcing decision

In this section we examine the possibility of outsourcing of inputs by firm 1 to firm 0. We have already explained that outsourcing decision is associated with the sale of patent of firm 1's input production technology to firm 0. Then firm 0 emerges as monopoly in the input

market. Under this scenario the optimal input price to be charged by firm 0 will be $w^O \equiv \frac{a+c_1}{2}$. The corresponding payoffs of the firms will be

$$\pi_1^O = \pi_2^O = \frac{(a-c_1)^2}{36} \text{ and } \pi_0^O = \frac{(a-c_1)^2}{6} \tag{5}$$

Given firm 0's disagreement payoff to be zero, assume that firm 1 will be able to extract all surplus payoff of firm 0 as fee for patent sale. Hence, firm 1's total payoff under outsourcing will be

$$\Pi_1^O = \pi_1^O + \pi_0^O = \frac{7(a-c_1)^2}{36} \tag{6}$$

Then outsourcing will occur if and only if $\Pi_1^O > \Pi_1^C$. We can show that

$$\exists c^*,\ c_1 < c^* < \bar{c},\ |\ \Pi_1^O > \Pi_1^C \Leftrightarrow c_0 < c^* \tag{7}$$

where $c^* = 0.18377a + 0.81623c_1$.

Thus, for low c_0, outsourcing is the optimal strategy for firm 1. Hence, we have the following proposition.

Proposition 2: *Firm 1 will outsource the input production to the independent input seller for all* $c_0 \in (c_1, c^*)$ *and it will undertake in-house production if* $c_0 \in [c^*, \frac{a+c_1}{2})$.[5]

Thus, firm 1 would like to outsource for small technology gap but it would not do so if the technology gap is large. Note that as the technological advantage increases, the in-house production becomes more and more attractive for two reasons: First, firm 1 can make more profit from selling the input and would have more strategic cost advantage at the final good production stage. It should be clear that the strategic advantage of outsourcing stems mainly from the advantage of the input production technology of firm 1. Second, when firm 1 sells the patent in order to outsource from firm 0, it removes the input market competition. This increases the input price in the input market thereby softening the competition in the final good market. This advantage of extra profit from the final good market and the opportunity to extract the surplus from firm 0 due to patent sale make the outsourcing strategically advantageous for small technology gap. Note that under outsourcing firm 1 buys inputs from firm 0 at a price w^O which is much higher than its in-house input production cost c_1 per unit. Thus, we establish the possibility of outsourcing even when a firm has better input production technology. The reason for this result stems from the possibility of technology transfer in our model. More specifically, even though input outsourcing is more costly than the in-house production, the firm may be willing to outsource because it can compensate the loss with the revenue from the patent sale.

[5] Note that we are considering the outright sale of the patent and hence it is natural that the payment would be settled upfront. Therefore, we have considered a fixed price for the sale of the patent. However, allowing for a two-part tariff payment (fixed fee and royalty as considered in the technology licensing context) for the sale of patent we find that the optimal payment structure will be fixed price only.

5. Conclusion

In this paper we have shown the possibility that although a firm possesses a superior input producing technology, it outsources the crucial input from outside at a much higher price than its in-house production cost under some parametric configurations. More specifically, the outsourcing occurs when the technological gap between its in-house input production and that of the outside input supplier is not large and it would produce the input in-house and also supply to its rival when the technology gap is large. Outsourcing leads to a high input price, which softens the competition in the final good market. We have introduced the issue of technology transfer in the outsourcing literature and provided a new strategic reason for outsourcing, which was hitherto not recognized in the literature.

We have analyzed the problem in a setting where an integrated firm competes in the final good market with a rival that has to depend on the input market for input supply and the independent input producer has an inferior input producing technology. The integrated firm by selling off the patent of its technology to the independent input supplier credibly commits to purchase inputs from the latter. This raises not only the firm's own production cost but also that of the rival. The outsourcing firm then captures the surplus profit of the input supplier by means of a fee for the transferred technology, and outsourcing becomes profitable. In our set up, however, both industry profit and consumers' welfare fall. Our analysis therefore raises a serious policy concern over the strategic outsourcing.

Appendix

Given the demand function by (1), if firm 0 charges an input price w to firm 2, the output stage equilibrium quantities are $q_1 = \frac{a - 2c_1 + w}{3}$ and $q_2 = \frac{a - 2w + c_1}{3}$, and the corresponding payoffs are $\pi_1 = \frac{(a - 2c_1 + w)^2}{9}$ and $\pi_2 = \frac{(a - 2w + c_1)^2}{9}$. Then the optimal w is solved from

$$\max_w \pi_0 = (w - c_0)q_2 = (w - c_0)(a - 2w + c_1)/3.$$

This yields the optimal input price $w = w^b \equiv \frac{a + c_1 + 2c_0}{4}$. The corresponding equilibrium quantities are $q_1^b = \frac{5a - 7c_1 + 2c_0}{12}$ and $q_2^b = \frac{a - 2c_0 + c_1}{6}$, and the payoffs of the firms: $\pi_1^b = \frac{(5a - 7c_1 + 2c_0)^2}{144}$, $\pi_2^b = \frac{(a - 2c_0 + c_1)^2}{24}$, and $\pi_0^b = \frac{(a - 2c_0 + c_1)^2}{24}$.

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