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Abstract

We construct a model to show that outsourcing of a crucial input can occur even though it can be produced in-house at a lower cost. There are two firms producing differentiated goods and competing in prices, and only one of them possesses input production technology which is superior to that of an independent input supplier. We show that if the degree of product differentiation is small or the technological gap between two input producing firms is small, strategic outsourcing will occur. Technology transfer in the form of patent sale will act as a commitment that the firm will outsource. While the outsourcing firm gains, consumers' welfare as well as social welfare goes down. Interestingly, sometimes rival firm's profit might increase. The paper brings into focus some competition policy concerns.

JEL Classifications: D43; L22; L23; L24.

Keywords: outsourcing; patent transfer; price competition; welfare; competition policy.

1. Introduction

Outsourcing is a widespread phenomenon in modern business. Almost all firms and business houses are involved in outsourcing activities. In the last two decades the outsourcing activities are growing over 30% per annum. Nokia, for example, depends on more than 300 domestic subcontractors and similar number of foreign subcontractors. In computer industry *Sun* purchases about 75% of components from other companies. The aircraft giant Boeing outsources products of over 34000 components from different manufacturers for its production of 747 passenger aircraft. The 1998 Annual Report of WTO estimate shows that only 37% of the production value of a representative American car is generated domestically in the US. A little search in the internet will reveal many more such information. Recently, R&D outsourcing is also growing fast.[1]

What is outsourcing? Broadly speaking, it refers to a contracting made by a firm with another firm or organization regarding performing of some business function (viz., input production) which is ultimately purchased back as a service. So outsourcing decision is the outcome of the choice problem between in-house production of inputs within the vertical structure of the firm and buying inputs from outside decentralized market sources. The traditional literature mostly focuses on cost consideration; accordingly, if a firm can buy an input from outside at a price lower than its in-house cost of production, it is reasonable that the firm will go for outsourcing of production of such an input.[2] It is in this context that we raise the question as to whether outsourcing of a crucial input can occur even when the in-house production cost is lower.

Motivation behind the question is the following. In an imperfectly competitive market structure how a firm will organize its production and whether it will buy some crucial inputs from outside instead of producing in-house are the outcomes of the subtle and complex

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[1] See Beladi et al. (2012), for instance.

[2] The literature on the theory of firm defines the boundaries and limitations of vertical and horizontal extension of a firm. This leads to the choice of production organization based on cost consideration. The problem is explained in terms of transaction costs, specificity of factors, incomplete contracting and property rights. One may look at the works of Coase (1937), Grossman and Hart (1986), Grossman and Helpman (1999, 2002), Hart and Moore (1990), Holmstrom and Roberts (1998) and Williamson (1985). Gibbons (2005) provides a nice survey on the theory of firm.

decisions involving significant strategic considerations. Here `cost' is not the only consideration; it is not then surprising that a firm might outsource a key input from an outside supplier even though the input can be produced cheaply in-house. In this paper we focus on such a scenario of outsourcing. There are in fact evidences to show that a firm outsources crucial inputs even when its in-house production is less expensive. For example, the aircraft giant Boeing had entered into a series of outsourcing agreements with three Japanese firms (Mitsubishi Heavy Industries, Kawasaki Heavy Industries Ltd., and Fuji heavy Industries) regarding supply of some goods related to aircraft production, including R&D, during 2000s when these firms showed interest in entering the market for commercial aircrafts. It was observed that costs in Japan were no less, hence Boeing's outsourcing decision cannot be justified based on cost-saving. Outsourcing contracts between Boeing and Lockheed is another example.[3]

We analyze the problem of outsourcing vs. in-house production in a setting where two firms produce differentiated products and compete in prices in a Bertrand fashion, but only one of them (say, firm 1) has the relevant input production technology to produce a crucial input. There is a third firm (call firm 0) which cannot compete in the final goods market but possesses an input producing technology. Hence both firm 0 and firm 1 can compete in the input market for selling the input to firm 2, the other product market competitor. Assume that firm 1 possesses a superior input production technology compared to that of firm 0, but both firm 1 and firm 2 have symmetric final goods producing technology. In this setting we analyze the decision of firm 1 between outsourcing the input from the independent input suppler and producing it in-house. Since firm 1 has lower cost of in-house input production, in the absence of any strategic consideration firm 1 would never like to outsource the input production. But since firm 1 possesses the superior technology, it has the option to sell out its patent of the superior technology to the independent input producer. The sale of patent entails that once the patent is sold, firm 1 foregoes rights to produce inputs for itself, and the independent input producer emerges as monopolist in the input market. Thus firm 1 can induce the input supplier to charge a monopoly price for inputs to all product market competitors. Firm 1 can overcompensate the loss of profits due to the higher input price by means of charging a fee for the transferred technology. The higher input price also relaxes

[3] See in Chen (2011).

product market competition. We show that such strategic outsourcing of input production is profitable to the outsourcing firm if either the degree of product differentiation is small or the technological gap between two firms producing inputs is not large. On the other hand, in-house production is optimal if the degree of product substitution is small but the technological asymmetry is sufficiently large.

In the present paper we thoroughly examine the implications of the possibility of outsourcing. We find that strategic outsourcing always reduces consumers' welfare as well as overall welfare. However, under outsourcing equilibrium the overall industry profit will be higher when the goods are relatively close substitutes but lower when the goods are highly differentiated. Our model is closely related to the idea of raising rivals' costs as illustrated in Salop and Scheffman (1983, 1987). However, in the standard literature on raising rival's cost the rival is adversely affected. On the contrary, surprisingly in our model we show that the rival's profit may be higher even though firm 1's outsourcing strategy raises input cost for firm 2. This brings into focus that both firms might like the outsourcing arrangement although the society as a whole will be worse off. Thus it is desirable for the competition authority to carefully scrutinize the transfer of low cost input production technology, which is otherwise an encouraging phenomenon for the society.

There are a number of works which focus on strategic outsourcing.[4] Among these, one paper which is very closely related to ours is by Arya, Mittendorf and Sappington (2008a). They have constructed a three-firm model with one wholesale input supplier and two product market competitors, of which one firm, say firm 1 has capability to produce the input in-house but the other firm has only output production technology. 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 gain strategic advantage. The whole seller decides the prices to be charged to firm 1 and firm 2 sequentially. Then firm 1 by its strategic outsourcing decision can induce a higher input price for its product market rival, and in the extreme this might deter entry of the rival. Our paper is different from theirs on many counts. First and foremost, Arya et al. (2008a) does not have the possibility of technology transfer

[4] See, for instance, Shy and Stenbacka (2003), Buchler and Haucap (2006), Arya, Mittendorf and Sappington (2008a, 2008b), 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).

whereas in our paper it acts as the motivating factor for outsourcing. Second, in our model in case of outsourcing the monopoly input supplier does not discriminate input prices, but price discrimination with sequential offer is a feature in Arya et al. model. Third, in our case when firm 1, with having a superior technology of input production, decides to produce the input in-house, not only it produces for itself but also it sells inputs in equilibrium to its product market rival. In contrast, in Arya et al. firm 2 gets inputs only from the independent input supplier. Another crucial assumption in their paper is that the independent input supplier possesses the least cost input production technology, without which outsourcing would not occur. But in our model firm 1 owns the superior input production technology; still outsourcing can be an optimal decision. Finally, we have considered price competition in final goods market whereas Arya et al. assume quantity competition.[5]

Another closely related paper is by Chen (2011), which shows that the outsourcing decision of an incumbent might prevent entry of a potential entrant as the incumbent can commit to an aggressive post entry competition. There is no entry deterrence story in our model, and the final goods market is always duopoly; it is the input market which becomes monopoly under outsourcing. Thus, our work complements the works of Arya et al. (2008a) and Chen (2011). However, no other paper in the literature has considered technology transfer as an integrated decision of the outsourcing strategy.[6]

The rest of the paper is presented according to the following scheme. Section 2 describes the structure of the model and the game. Then section 3 and 4 present respectively the equilibrium outcomes of the decisions of in-house production and outsourcing. Section 5 discusses the choice between outsourcing and in-house production. Section 6 provides a welfare analysis of our results. Then section 7 discusses some related issues. Finally, section 8 concludes the paper.

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[5] We shall also discuss the results in case the firms play Cournot in the product market (see Kabiraj and Sinha (2014) for details).

[6] Two papers, viz., Pack and Saggi (2001) and Peirce and Sen (2012), have talked about technology transfer and outsourcing, but their focus is completely different. In Pack and Saggi, the DC firm by means of technology transfer buys back final goods from the LDC transferee. Given the possibility of imitation and leaking out of knowledge, they discuss the issues of diffusion and competition in this context. Peirce and Sen, on the other hand discuss strategic interactions and implications of the policies of outsourcing and technology transfer in a Hotelling model.

2. The Model

There are three firms, two of which are competing in the product market. These product market competitors, denoted by firm 1 and firm 2, are producing differentiated products and competing in prices in a Bertrand fashion. Production of final goods, however, requires a non-specific key input. It is assumed that firm 1 has input production technology to produce the input in-house but firm 2 does not have, although both firms have knowledge to produce their respective final goods. The third firm, call it firm 0, is an independent input supplier which can produce the key input but cannot produce any final goods. It is further assumed that its technology is inferior to that of firm 1 in the sense that the unit cost of producing inputs by firm 0 is larger compared to that by firm 1. Therefore, firm 2 can get the input either from firm 0 or from firm 1. While final goods production may involve other inputs but for simplicity we normalize the cost of those inputs to be zero. So the cost of producing the final good is the cost of the key inputs required in production. Assume that one unit of the key input is required to produce one unit of output. Let c_1 and c_0 be the unit cost of producing one unit of input by firm 1 and firm 0, respectively; $0 \le c_1 < c_0$. We assume that the input production technology of firm 1 is fully transferable by means of licensing or by selling out the patent of the technology with no additional cost.

Let the market demand for final goods in inverted form, as faced by firm i, be given by[7]

$$p_i = a - q_i - \gamma q_j; \;\; \mathrm{i, j} = 1, 2; \;\; \mathrm{i} \neq \mathrm{j}$$

where γ represents the degree of product differentiability; $\gamma = 0$ implies two goods are independent of each other, $\gamma = 1$ implies goods are perfect substitutes. So we assume, $0 < \gamma < 1$. Without loss of generality, and to simplify calculations and expressions, we further assume

$$a = 1 \text{ and } c_1 = 0.$$

With this the direct demand functions can be written as:

[7] Such a demand function is derived from the utility function $U(q_i, q_j) = a(q_i + q_j) - (1/2)(q_i^2 + q_j^2) - \gamma q_i q_j$.

$$q_i = \frac{(1-\gamma) - p_i + \gamma p_j}{1-\gamma^2};\ i, j = 1,2;\ i \neq j \quad (1)$$

Game Structure

The firms play the following three-stage game. In the first stage firm 1 decides whether it will sell the patent of the technology to the independent input supplier (firm 0), and accordingly give a take-it-or-leave-it contract.[8] The independent input supplier will either accept or reject the offer. We consider that only fixed payment from firm 0 to firm 1 would be made. Firm 1's option of neither selling the patent nor licensing the technology can be thought of as making an unacceptable offer by firm 1 to firm 0.

In case firm 1 has sold the patent of the technology in the first stage, then in the second stage both the final goods producers will buy the required amount of key input at the price charged by the monopoly input supplier. On the other hand, if the technology is not sold and firm 1 decides to produce the input in-house, then only firm 2 buys input from the input market and firm 1 and firm 0 will compete to sell inputs to firm 2. We assume that input market competition takes place in prices. Finally, in the third stage, firm 1 and firm 2 compete in prices to serve the final goods market.

As far as the first stage decision of firm 1 is concerned, a justification for patent sale vis-a-vis licensing the technology is in order. Patent sale implies foregoing the right to use the technology any further, whereas under licensing firm 1 can retain its right to use the technology. Therefore, patent sale is a commitment on the part of firm 1 that firm 1 will not produce inputs for itself or for the market by using the technology and will have to depend on the independent input supplier if it wants to serve the final goods market. Thus patent sale will make firm 0 monopoly in the input market. This is tantamount to choosing the option of outsourcing the input from the independent input supplier. In case of technology licensing, on the other hand, firm 1 has the option of using the technology for its in-house production as well as producing for the input market. Then under licensing the input market will have two firms competing to supply inputs to firm 2, and firm 1 cannot commit to firm 0 in the licensing contract that it will not participate in the input market competition. We also show

[8] We can see that in the context of the present model licensing cannot occur.

that it is always tempting for firm 1 to sell input in the market when it is undertaking the in-house production. Thus, given the positive incentive to breach such a contract of non participation in the input market, such commitment, even if written in the contract, has no value. When the contract is breached, the government would not be willing to enforce such a contract in the court of law as it is anti-competitive. Hence, in the absence of commitment technology licensing will not occur.

3. In-house Production with Input Market Competition

Both firm 1 and firm 0 own the input production technology, hence they can compete to supply input to firm 2. However, firm 1 has the option of not competing at all in the input market; if it likes, it can allow firm 0 to supply inputs alone to firm 2. But given that input market competition takes place in prices, and firm 1 has superior input production technology, it can always compete out firm 0 and grab the whole market. Then we have the following result.

Proposition 1: *Not competing in the input market by firm 1 cannot be a subgame perfect equilibrium.*

Proof: For any input price charged by firm 0, firm 1 can always undercut and grab the market for input supply to firm 2 without affecting its own product market profit. QED

Given the above proposition, the input price will be determined through an interaction of firm 1 and firm 0 in the input market. If firm 2 buys inputs at price c_2, the outcome of the third stage play will be:

$$p_1 = \frac{1-\gamma}{2-\gamma} + \frac{\gamma c_2}{4-\gamma^2} \quad \text{and} \quad p_2 = \frac{1-\gamma}{2-\gamma} + \frac{2c_2}{4-\gamma^2} \tag{2}$$

$$q_1 = \frac{1}{1-\gamma^2}\left(\frac{1-\gamma}{2-\gamma} + \frac{\gamma c_2}{4-\gamma^2}\right) \quad \text{and} \quad q_2 = \frac{1}{1-\gamma^2}\left(\frac{1-\gamma}{2-\gamma} - \frac{c_2(2-\gamma^2)}{4-\gamma^2}\right) \tag{3}$$

The corresponding payoffs of firm 1 and firm 2 from the final goods market competition are:

$$\pi_1 = \frac{1}{1-\gamma^2}\left(\frac{1-\gamma}{2-\gamma} + \frac{\gamma c_2}{4-\gamma^2}\right)^2 \tag{4}$$

$$\pi_2 = \frac{1}{1-\gamma^2}\left(\frac{1-\gamma}{2-\gamma} - \frac{c_2(2-\gamma^2)}{4-\gamma^2}\right)^2 \tag{5}$$

We assume duopoly in the product market. Hence the input price must be below a critical level, that is, $c_2 < 1 - \frac{\gamma}{2-\gamma^2} \equiv \phi(\gamma)$. In our model two relevant parameters are c_0 and γ. Hence we restrict our analysis to the following parameter space:

$$\Omega = \{(c_0, \gamma) \mid c_0 < \phi(\gamma) \ \ and \ \ 0 < \mathrm{c}_0, \gamma < 1\} \tag{6}$$

Now under price competition, given $c_1 = 0 < c_0$, firm 1 will win the race to sell inputs to firm 2. Then for any c_2, firm 1's total payoff will be.

$$\Pi_1^I(c_2, \gamma) = \frac{1}{1-\gamma^2}\left(\frac{1-\gamma}{2-\gamma} + \frac{\gamma c_2}{4-\gamma^2}\right)^2 + \frac{c_2}{1-\gamma^2}\left(\frac{1-\gamma}{2-\gamma} - \frac{c_2(2-\gamma^2)}{4-\gamma^2}\right) \tag{7}$$

where the first part of the RHS is the profit coming from the final goods market competition (see (4)) and the second part is due to input sale at price c_2 (see (3)). The optimal c_2 will then be solved from

$$\max_{c_2} \Pi_1^I(c_2, \gamma) \ \text{ s.t. } \ c_2 \le c_0$$

This leads to the following lemma.

Lemma 1: *Let* c_m *be the free maximization value of* c_2 *that maximizes* $\Pi_1^I(c_2, \gamma)$. *Then the optimal value of* c_2 *under input market competition will be:* $c_2^* = \min\{c_m, c_0\}$ *where* $c_m = \frac{8-8\gamma^2-\gamma^3+\gamma^4}{16-14\gamma^2+2\gamma^4} \equiv g(\gamma)$.

Thus under input market competition, firm 1 will charge the unrestricted monopoly price $g(\gamma)$ for inputs, given γ, if $g(\gamma) < c_0$, and will charge the restricted monopoly input price

c_0 otherwise. Hence with in-house input production (and input market competition), firm 1's payoff will be:

$$\begin{array}{ll} \Pi_1^I(c_0,\gamma) & \text{if } c_0 \le c_m \\ \Pi_1^I(c_m,\gamma) & \text{if } c_0 > c_m \end{array} \quad (8)$$

Clearly, $\Pi_1^I(c_m,\gamma) \ge \Pi_1^I(c_0,\gamma)\ \forall \gamma$.The payoff of firm 0 is 0, and firm 2's payoff is derived using its payoff function (5) for an appropriate input price.

4. Outsourcing with Technology Transfer

In this section we examine outsourcing strategy as an alternative to in-house input production. Since firm 1 possesses superior input production technology, it is necessary to establish first that firm 1 will commit purchasing inputs from firm 0. We have already discussed that in our model, with price competition in the input market, technology licensing will not occur, because firm 1 cannot commit not to participate in input market competition. On the other hand, if firm 1 decides to sell its patent of the superior input production technology to firm 0, it acts as a credible commitment not to produce inputs by itself, which essentially means that firm 1 will outsource the input production to firm 0 because firm 1 foregoes the right to produce inputs after patent sale.

Then under firm 1's outsourcing strategy associated with patent sale, firm 0 emerges as monopoly in the input market and decides the input price optimally. Now, for any price w charged by firm 0 for its inputs to both firms, total input demand under price competition is: $q_1 + q_2 = \frac{2(1-w)}{(2-\gamma)(1+\gamma)}$. Then the optimal input price charged by firm 0 (which is also the per unit production cost of final goods) under outsourcing is: $w^* = (1/2)$. With this input price, firm 0's profit from input sale is: $\frac{1}{2(2-\gamma)(1+\gamma)}$. And each of firm 1 and firm 2's profit from the product market operation will be:

$$\frac{1-\gamma}{4(2-\gamma)^2(1+\gamma)} \quad (9)$$

Now assume that firm 1 makes a take it or leave it offer of technology sale to firm 0. Then, firm 1 will extract all surplus payoff of the independent input supplier from the sale of patent of the superior technology. Therefore, firm 1's total profit under outsourcing strategy will be:

$$\Pi_1^O(\gamma) = \frac{1-\gamma}{4(2-\gamma)^2(1+\gamma)} + \frac{1}{2(2-\gamma)(1+\gamma)} = \frac{5-3\gamma}{4(2-\gamma)^2(1+\gamma)} \qquad (10)$$

5. Outsourcing vs. In-house Production

Now we are in a position to discuss the optimal decision of firm 1 regarding the choice of production organization, that is, given any parameter situation, $(c_0,\gamma)\in\Omega$, firm 1 is to choose between outsourcing and in-house production of inputs. Consider Figure 1. The parameter space defined by Ω in (6) is given by the area ORST (excluding the boundary points). The concave downward sloping line RST represents the equation, $c_0 = \phi(\gamma)$. And the locus of (c_0,γ) satisfying $c_0 = g(\gamma)$ is the downward sloping curve line RZMN which divides the parameter space into two parts.[9] Then for all $(c_0,\gamma)\in\Omega$ left of RZMN, the optimal input price under input market competition is c_0 and for all $(c_0,\gamma)\in\Omega$ right of RZMN the optimal input price will be c_m.

Now consider the locus of (c_0,γ) satisfying the relation[10] $\Pi_1^I(c_0,\gamma) = \Pi_1^0(\gamma)$, ignoring for the time being that $\Pi_1^I(c_0,\gamma)$ is defined only for $c_0 \le c_m$. The locus is given by the inverted U-shaped curve UMV with its peak at $M\ (c^* = 0.4403, \lambda^* = 0.6287)$ (approximately).[11] We can get the following lemma.

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[9] Note that a little portion of the relation is lying outside the feasible space of Ω. This happens for very small values of c_0.

[10] $\Pi_1^I(c_0,\gamma) - \Pi_1^0(\gamma) = \frac{1}{4(\gamma^2-1)(\gamma^2-4)^2}[4c_0^2\gamma^4 - 28c_0^2\gamma^2 + 32c_0^2 - 4c_0\gamma^4 + 4c_0\gamma^3 + 32c_0\gamma^2 - 32c_0 - \gamma^4 - 4\gamma^3 - 3\gamma^2 + 4\gamma + 4]$.

[11] Note that the relation $c_0 = g(\gamma)$ (i.e., the curve RZMN) must pass through the point M.

Lemma 2: *Given any* c_0 *, we have: (a)* $\Pi_1^I(c_0,\gamma)<\Pi_1^0(\gamma)$*) if (i) either* $\gamma \geq \gamma^*$*, or (ii)* $\gamma<\gamma^*$*,* $\exists\, \underline{c}(\gamma),\bar{c}(\gamma)$ *and* $c_0 \notin (\underline{c}(\gamma),\bar{c}(\gamma))$*; (b) if* $\gamma<\gamma^*$ *and* $c_0 \in [\underline{c}(\gamma),\bar{c}(\gamma)]$*, then* $\Pi_1^I(c_0,\gamma)>\Pi_1^0(\gamma)$.

This states that if c_0 be the input price in the input market, outsourcing would be strictly preferred to in-house production for large value of γ (i.e., for $\gamma \geq \gamma^*$). Outsourcing would also be preferred for a small γ provided c_0 is small. On the other hand, in-house production would yield a larger payoff compared to outsourcing if γ is not large and c_0 takes an intermediate value.

Note that the above comparison between $\Pi_1^I(c_0,\gamma)$ and $\Pi_1^0(\gamma)$ is valid only for $c_0 \leq c_m$. For any $(c_0,\gamma)\in\Omega$ to the right of RZMN, the relevant input price is c_m and thus, by comparing the profit expressions we find that outsourcing yields greater payoff than in-house production for firm 1 if $\gamma \geq \gamma^*$=0.6287. Thus, by combining two scenarios with respect to input price, we find the curve UMS to clearly divide the parameter space Ω into two optimal modes choice for firm 1. For any $(c_0,\gamma)\in\Omega$ to the left or above the curve UMS in Figure 1 the optimal choice for firm 1 is to outsource the input whereas for any $(c_0,\gamma)\in\Omega$ to the right or below the curve UMS the optimal choice is in-house input production.

The reason for above characterization stems from the way the input price is charged under in-house production. Clearly, under in-house production (and input market competition) the optimal input price to be charged by firm 1 will be either c_0 or c_m depending on whether the point is on the left of the line RZMN or right of it.. Now consider the points below UMS. For all points which lie left of RZMN (i.e., points in the area UMN), the optimal input price (to be charged to firm 2) under in-house production is c_0, hence in-house production (with input price c_0) is preferred to outsourcing. And for the points which are on the right side of the curve RZMN (i.e., in the area NMST), the optimal choice of production organization is again in-house production, but the optimal input price under in-house production is c_m. Hence we can write our central proposition.

Proposition 2: *Outsourcing will occur if either the degree of product differentiation is small (i.e., γ is large), or product differentiation is large but technological gap between two input producing firms is small. In-house production will be the optimal decision if both the degree of product differentiation and technological asymmetry are large.*[12]

Let us try to understand the intuition of the result. First note that as γ increases, that is as the degree of substitution between the products goes up, competition between the product market competitors increases. This has negative effect on the competitors' profits. On the other hand, as cost asymmetry between the firms increases, this benefits firm 1 at the cost of firm 2. However, if both firms face the same cost and cost increases, the product prices go up symmetrically. Then for large γ, the output effect will be smaller compared to the case of low γ (see the expression (1)). Therefore symmetric increase of cost will have relatively smaller (negative) effect on profit. Finally, the input price under outsourcing is much larger than that under in-house production, that is, $(1/2) > \min\{c_m, c_0\}$ (and c_m falls as γ increases). Now suppose that γ is large (i.e., $\gamma \geq \gamma^*$). Then under in-house production, firm 1 will charge firm 2 an input price of c_m (or, $c_0 < c_m$). Therefore under in-house production, firm 1's profit from final goods market as well as the revenue from input sale to firm 2 will not be very large. On the other hand, under outsourcing both firms face an input price ½ which is much higher than the input price under in-house production. To some extent higher cost reduces the intensity of price competition. Moreover, the resulting price will have relatively small effect on input demand, hence net revenue from input sale accrued to the independent input suppler will be large enough so that although firm 1's profit from product market operation will fall, but when this is added with firm 0's profit, which firm 1 can grab as patent fee, the resulting net payoff of firm 1 becomes larger than the payoff under in-house production. Hence for a large γ, outsourcing will always yield a larger profit than the in-house production does.

Now consider low γ so that products are highly differentiated and the intensity of competition is less. This also means that firm 2's price-quantity will have smaller effect on

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[12] To be more formal, outsourcing occurs if either $\gamma \geq \gamma^*$, or $0 < \gamma < \gamma^*$ but $c_0 < \underline{c}(\gamma)$; when $\gamma < \gamma^*$ and $c_0 \geq \underline{c}(\gamma)$, in-house production will be the outcome.

firm 1's price-quantity. Therefore under in-house production firm 1's profit from market operation is large; and now if c_0 is large, firm 1 can earn a lot of revenue from input sale to firm 0 at an input price c_m or c_0, whichever is smaller. So low c_0 means revenue is less. In case of outsourcing, as before, both firms will have to buy input at a higher input price. Since γ is small, total output (input demand) is large, hence total revenue from input sale is also large. So if c_0 is small, in-house production generates less profits compared to that under outsourcing whereas if c_0 is above a critical level in-house production will dominate outsourcing from the perspective of firm 1.

6. Welfare Analysis

Outsourcing under price competition has interesting welfare implications vis-à-vis the in-house production (i.e., input market competition). To compare profits and welfare meaningfully between these two production organizations we would restrict ourselves to the scenarios where outsourcing is profitable over input market competition, that is, either γ is large or c_0 is small. Let $\Theta \subset \Omega$ be the set of (c_0, γ) such that outsourcing is preferred over in-house production. In Figure 2 (extracted from Figure 1), Θ is given by the area OUMSR.

In our paper under outsourcing, firm 1 sells out the patent of its input production technology to the independent input supplier (firm 0) which emerges as monopoly in the input market to sell inputs to the product market competitors, viz., firm 1 and firm 2. Thus firm 1, by its outsourcing decision raises production cost for its competitor as well as for itself. In the literature on raising rivals' costs, such an action is beneficial to the firm to the extent this hurts the rival. But in our paper, under outsourcing the rival faces less competition, hence, as we show below, firm 2 can be better off under certain parameters. This is clearly a distinct result in the literature.

Under input market competition if c_2 be the input price (where $c_2 = \min\{c_0, c_m\}$), then firm 2's payoff is given by (5), that is,

$$\pi_2^I(c_2,\gamma) = \frac{1}{1-\gamma^2}\left(\frac{1-\gamma}{2-\gamma} - \frac{c_2(2-\gamma^2)}{4-\gamma^2}\right)^2$$

where $c_2 \le c_m$. Given γ, $\pi_2^I(c_2,\gamma)$ is falling in c_2, with its minimum value being $\pi_2^I(c_m(\gamma),\gamma)$. And the payoff of firm 2 from outsourcing is $\pi_2^O = \frac{1-\gamma}{4(2-\gamma)^2(1+\gamma)}$. We can then show that the difference in payoffs $[\pi_2^O(\gamma)-\pi_2^I(c_m,\gamma)]$ is an inverted U-shaped curve in γ over (0,1), and $[\pi_2^O(\gamma)-\pi_2^I(c_m,\gamma)]>0\ \forall\gamma\in(0,1)$. Hence if the input price is high (this is of course the case if $c_0 > c_m$), outsourcing benefits firm 2, whatever be the degree of product differentiation. On the other hand, when c_2 is very small, $[\pi_2^O(\gamma)-\pi_2^I(c_m,\gamma)]<0\ \forall\gamma\in(0,1)$. To characterize it further let us consider the locus of (c_2,γ) satisfying $\pi_2^O(\gamma)=\pi_2^I(c_2,\gamma)$ given by the curve RHN in Figure 2. Then for any $(c_2,\gamma) \in \Theta$ to the right of RHN we have $\pi_2^O(\gamma)>\pi_2^I(c_2,\gamma)$, and to the left of RHN, $\pi_2^O(\gamma)<\pi_2^I(c_2,\gamma)$. Thus, we have the following proposition.

Proposition 3: *If the input market competition leads to a high enough input price, then under outsourcing equilibrium the rival firm will always benefit.*

High input price under input market competition means that firm 2, with its high cost of production, competes with firm 1 which has 0 cost of production. Under outsourcing input price is even higher, but now both the firms face the same high cost of production. This benefits firm 2.

To know the effect of outsourcing on industry profit note that firm 0 is left with zero net payoff after firm 1 extracts firm 2's surplus payoff as the fee for the transferred technology. Whenever firm 1 opts for outsourcing, its net payoff must be larger under outsourcing. On the other hand, firm 2 may be poorer under outsourcing (it occurs when the input price under input market competition is small enough). Therefore, whenever the input price under input market competition is sufficiently large, industry profit under outsourcing must go up compared to the case of in-house production. To show it more formally, we may directly compare industry profits under two production organizations. The industry profit under outsourcing is given by

$$\Pi^0(\gamma) = \Pi_1^0 + \pi_2^0 = \frac{(3-2\gamma)}{2(1+\gamma)(2-\gamma)^2)}$$

and that under input market competition is

$$\Pi^{I}(c_2,\gamma) = \Pi_1^{I} + \pi_2^{I}$$

$$= \frac{\left(3c_2^2\gamma^2 - 4c_2^2 - c_2\gamma^4 - 3c_2\gamma^3 + 4c_2\gamma + 2\gamma^4 + 4\gamma^3 - 6\gamma^2 - 8\gamma + 8\right)}{(1-\gamma^2)(\gamma^2-4)^2}$$

Now consider the locus of (c_2, γ) satisfying $\Pi^0(\gamma)$=$\Pi^{I}(c_2,\gamma)$. In Figure 2, the locus is given by the curved line LL′, which divides the space of Θ into two parts such that in the upper part we have $\Pi^0(\gamma)$> $\Pi^{I}(c_2,\gamma)$ and in the lower part $\Pi^0(\gamma)$<$\Pi^{I}(c_2,\gamma)$. In particular, for $c_2 = c_m$, we have $\Pi^0(\gamma)$> $\Pi^{I}(c_2,\gamma)$ $\forall \gamma > \gamma^*$.

Proposition 4: *In outsourcing equilibrium, industry profit under outsourcing is larger for higher values of* γ*, and lower for smaller values of* γ*.*

We now compare consumers' surplus between these two production organizations. Consumers' surplus is defined to be the consumers' gross utility from the goods minus actual payment, that is, $S = U(q_1, q_2) - p_1 q_1 - p_2 q_2$,

where $U(q_1,q_2) = (q_1 + q_2) - (1/2)(q_1^2 + q_2^2) - \gamma q_1 q_2$ in our model. We can then derive the consumer surplus under outsourcing and input market competition as follows:

$$S^{O}(\gamma) = \frac{1}{4(1+\gamma)(2-\gamma)^2}$$

$$S^{I}(c_2,\gamma) = \frac{(8 - 3{c_2}^2\gamma^2 + 4{c_2}^2 + 2c_2\gamma^3 + 6c_2\gamma^2 - 8c_2 - 2\gamma^3 - 6\gamma^2)}{2(1-\gamma^2)(4-\gamma^2)^2}$$

$$S^{I}(c_m,\gamma) = \frac{4\gamma^6 + 23\gamma^5 + 9\gamma^4 - 88\gamma^3 - 76\gamma^2 + 80\gamma + 80}{8(1+\gamma)(\gamma^4 - 7\gamma^2 + 8)^2}$$

All these expressions are increasing in γ and it can be shown that

$$S^{I}(c_2,\gamma) > S^{I}(c_m,\gamma) > S^{O}(\gamma) \quad \forall c_2 < c_m$$

The first part of the inequality tells us that as the price in the input market for the firm 2 goes up, the consumers' surplus falls. Then the consumers' surplus under outsourcing is unambiguously less than the input market competition. This is due to the fact that under outsourcing the input price is higher than that under input market competition, and as a result, the total output level is lower and output prices are higher under outsourcing than under input market competition.

We are now in a position to compare the overall welfare under these two production organizations, where welfare is defined as the sum of consumers' surplus and producers' surplus. In our paper both under outsourcing and in-house production, in equilibrium all production takes place using the most efficient technology. Given that the most efficient technology has 0 marginal cost of production, it is then easy to show that welfare expressions will be reduced to just the gross utility of the consumers, that is,

$$W^0(\gamma) = U(q_1^0 + q_2^0) = \frac{(7-4\gamma)}{4(1+\gamma)(2-\gamma)^2}$$

For $c_2 \leq c_m$,

$$W^I(c_2, \gamma) = U(q_1^I + q_2^I)$$

$$= \frac{(3c_2^2\gamma^2 - 4c_2^2 - 2c_2\gamma^4 - 4c_2\gamma^3 + 6c_2\gamma^2 + 8c_2\gamma - 8c_2 + 4\gamma^4 + 6\gamma^3 - 18\gamma^2 - 16\gamma + 24)}{2(1-\gamma^2)(4-\gamma^2)^2}$$

$$W^I(c_m, \gamma) = \frac{(304+112\gamma-484\gamma^2-176\gamma^3+234\gamma^4+85\gamma^5-32\gamma^6-12\gamma^7)}{8(1+\gamma)(8-7\gamma^2+\gamma^4)^2}$$

It can be shown that $W^I(c_m,\gamma) - W^O(\gamma) > 0 \ \forall \gamma$. Further, $W^I(c_2,\gamma) > W^I(c_m,\gamma)$ for all $c_2 < c_m$.

Hence, we have the following result.

Proposition 5: *Strategic outsourcing in our model reduces both consumers' welfare and overall welfare.*[13]

This is indeed an important result because it raises serious policy concern. Whenever outsourcing occurs with a view to reaping benefits of lower input cost, it should enhance profits, as well as consumers' benefit. In our case outsourcing occurs even when in-house production is cheaper. Here outsourcing occurs to have a strategic gain. Under this situation consumers suffer due to higher final goods prices. In fact the apparently beneficial

[13] See also Mukherjee and Tsai (2010) and Kabiraj and Sinha (2011) for welfare reducing outsourcing in a Cournot set up.

technology transfer in a vertically related industry may have an ulterior motive for firm 1 not to participate in the input market competition which reduces social welfare. Typically, the competition authorities in most countries though have very detailed guidelines and restrictions for vertical mergers but vertical technology transfer is always encouraged. It should be noted that under certain parameter configurations even firm 2 gains under outsourcing and thus even the rival firm would be interested in the strategic outsourcing for firm 1 to happen and would not raise any objection to the competition authority regarding this behavior of the outsourcing firm that leads to the monopoly in the input market. Thus, our model demonstrates that a close scrutiny by the competition authority is desirable even in cases when the technology transfer from the final goods producers to input producers happens as it might have an implicit motive for not producing the input in-house, and as a result, ultimately the economy suffers.

7. Discussion

In this section we consider some variation of our assumptions and see their effects.

1. In our model we have assumed that firm 1 has low cost input production technology. Suppose, on the contrary, that firm 0 has technological advantage over firm 1 (i.e. $0 \leq c_0 < c_1$). In such a scenario, clearly firm 1 has no scope of transferring its technology. It still has the option of outsourcing or in-house production purely based on the consideration of cost minimization. Given the price competition in the input market, the prevailing price would be c_1, and firm 0 would be able to serve the entire input demand that comes to the input market. In such a situation firm 1 is indifferent between outsourcing (i.e., buying input from the market) and in-house production. This means, there is no strategic advantage of outsourcing for firm 1. One can ask whether there could be technology licensing or sale of patent from firm 0 to firm 1. Note that technology sale to firm 1 is equivalent to the acquisition of firm 0 by firm 1, and in that case firm 1 would have the option to foreclose firm 2 from supplying input.[14]

[14] See Arya et al. (2008, IJIO) in this context.

2. Our analysis is based on the assumption that firm 1 makes a take-it-or-leave-it offer for its technology sale. A natural question is whether a bargaining between the two parties on the amount of payment would make any qualitative difference to the results derived in the paper. Since bargaining over the fixed payment does not change the choice of input price, our analysis should hold as it is. The only difference is that the overall profit from the option of outsourcing would fall by the amount that would be appropriated by firm 0. As a result, the parameter zone for which the outsourcing would be preferred would shrink, unless the bargaining power of firm 0 is so high that firm1 would do better by not choosing that option for all parameter values.

3. Next consider the scenario when there are more than one independent input supplier. In this case technology licensing to one or more firms will not be possible due to the commitment problem of input market competition. However, sale of patent rights of the technology to one input supplier is possible, but the equilibrium price in the input market would then be c_0 and the firm which would buy the patent would serve the input market. However, firm 1 could then extract ($c_0 - c_1$) price-cost margin per unit of input demand. By in-house production firm 1, in fact, would do better because since its own cost of production would be low (i.e., c_1) and the profit from selling input to firm 2 would remain the same. Thus, it is easy to understand that by simply producing the input in-house and then by selling the input to its rival at the cost price of the other input suppliers, firm 1 does better than outsourcing.

4. Finally, consider the scenario when the product market is characterized by Cournot competition. In our earlier paper (Kabiraj and Sinha (2011)) we have considered quantity competition with homogeneous goods. It is shown that outsourcing occurs if the technological gap between two input producing firms is small. As the technological advantage of firm 1 increases, in-house production becomes more and more attractive, because earning from input sale will be larger and firm 1 will have more competitive advantage in the product market. To the extent products are differentiated, product market competition is relaxed.

8. Conclusion

In this paper we have shown the possibility that although a firm possesses a superior input producing technology, it outsources the key input from outside at a much higher price than its in-house production cost under some parametric configurations. More specifically, the outsourcing occurs if either the degree of product differentiation is low or the technological gap between the in-house input production by the efficient firm and that by the outside input supplier is not large. Outsourcing leads to 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 is hitherto not recognized in the literature.

We have analyzed the problem in a setting where the integrated firm competes in the final goods market with its rival which is dependent on the input market for inputs, and there is an independent input producer owning an inferior input producing technology. The integrated firm under outsourcing sells off the patent of its input production technology to the independent input producing firm and thereby it credibly commits to purchase inputs from the independent input supplier which emerges as a monopolist in the input market. This raises not only the production cost of the outsourcing firm but also that of the rival. However, by transferring its technology the firm captures the surplus profit of the input supplier by means of a fee. The higher input price in turn reduces product market competition. The higher input price and the resulting lower industry output under outsourcing reduce both the social welfare and the consumers' welfare, although there are situations when the industry profit goes up. More interestingly, the competing rival firm which now faces a higher production cost under outsourcing can come up with a higher profit. This happens when the final goods of the firms are close substitutes and the technological gap between the input producing firms is relatively large. This finding has significant implication for competition policy in the context of outsourcing and technology transfer. As it is evident from our result, all producers under outsourcing can benefit, but the social welfare falls. Our paper, therefore, calls for a closer scrutiny of technology transfer for input production.

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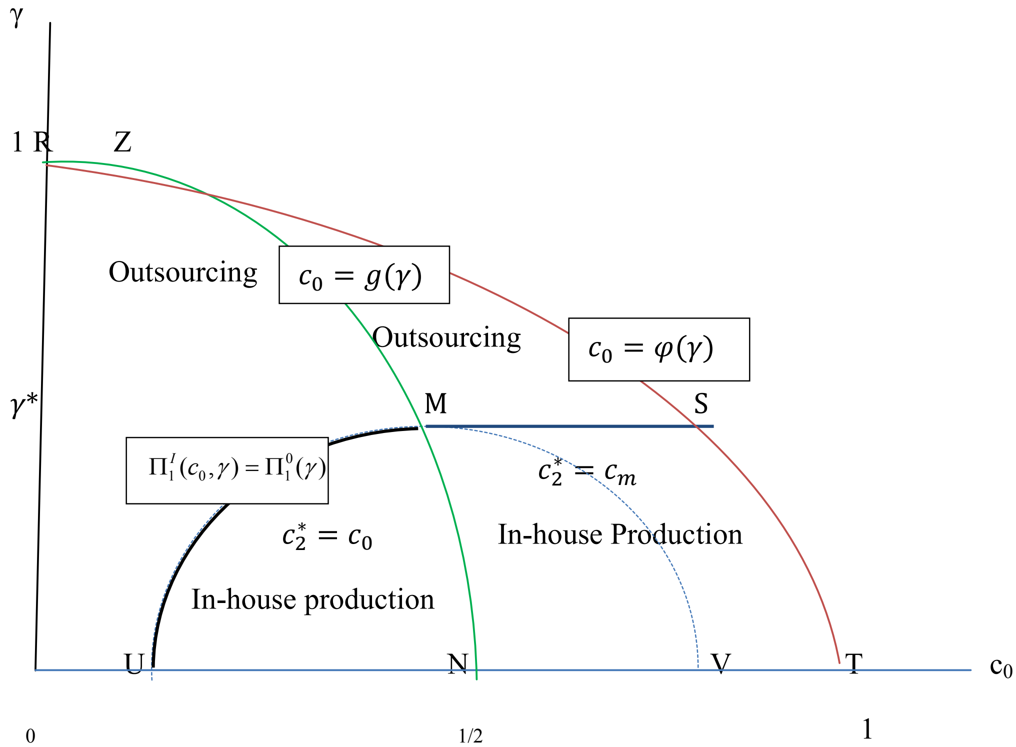

Figure 1: Choice of outsourcing and in-house production

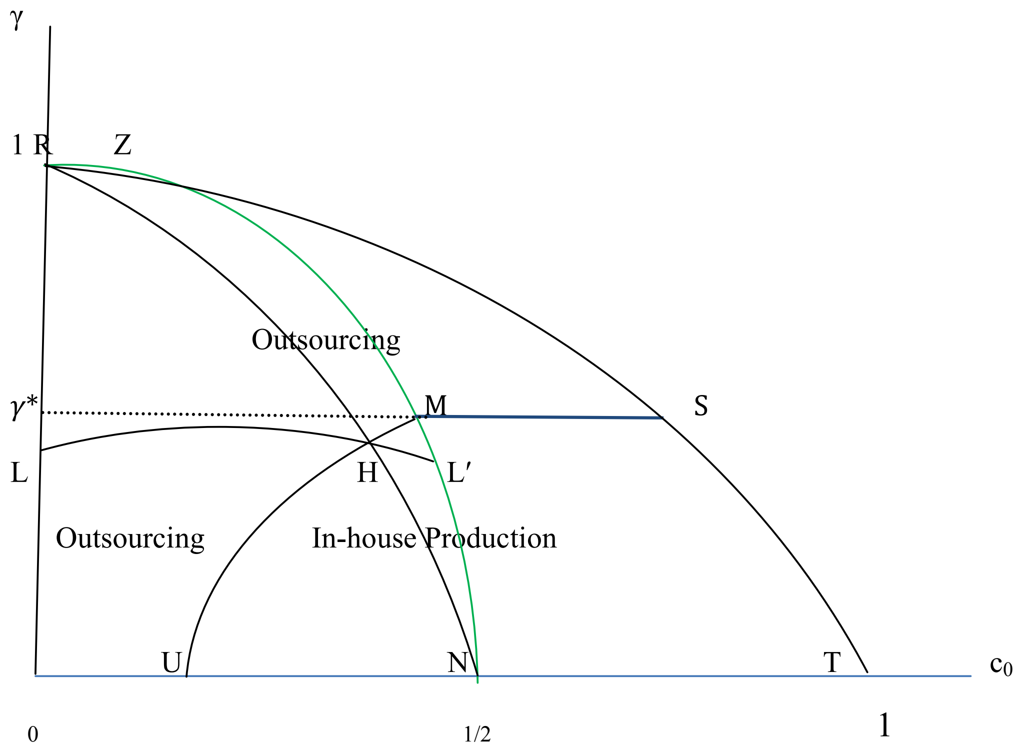

Figure 2: Profits and welfare comparison under outsourcing vis-à-vis in-house production