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Optimal Licensing Strategy: Royalty or Fixed Fee?

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Abstract

Licensing a cost-reducing innovation through a royalty has been shown to be superior to licensing by means of a fixed fee for an incumbent licensor. This note shows that this result relies crucially on the assumption that the incumbent licensor can sell its cost-reducing innovation to all industry players. If, for any reason, only some competitors could be reached through a licensing contract, then a fixed fee might be optimally chosen.

Key words: licensing contract; Cournot competition; strategic effects

JEL classification: D45

1. Introduction

In a linear demand Cournot framework with constant marginal production costs, we analyze the optimal two-part tariff licensing contract for a non-drastic cost-reducing innovation. An incumbent patent-holding firm licenses its low production cost technology to weaker rivals (initially endowed with a high production cost technology) by means of the optimal combination of a fixed fee and a royalty. The purpose of this note is to show that the choice between a fixed fee and a royalty critically depends on the existence (or absence) of other firms competing in the product market to which the incumbent licensor cannot sell its cost-reducing innovation. Specifically, if the low production cost firm faces no other competitors in the product market but the high production cost licensees, it is shown that the optimal licensing contract stipulates only a unit royalty. The royalty is set equal to the decrease in the unit production cost due to the cost-reducing innovation. This result

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was initially obtained by Rockett (1990) for a duopoly market and later generalized by Wang (1998) and Kamien and Tauman (2001) to the case of *n* high production cost rivals. However, the presence of other competitors in the product market (to which the incumbent licensor cannot sell its cost-reducing innovation) changes drastically the structure of the optimal licensing contract. It is shown that, in this case, the licensor chooses to use only a fixed fee and, hence, to charge a zero unit royalty.

The intuition behind this result can be understood by focusing on the two effects that licensing generates on the licensor's profit (Arora and Fosfuri, 2003): first, there are extra rents accruing to the incumbent licensor in the form of licensing payments (revenue effect); second, there is an increase in competition due to the presence of stronger rivals in the product market (rent dissipation effect). By strategically choosing the unit royalty, the licensor can offset the latter (negative) effect and still reap the reward of licensing. Indeed, by stipulating a royalty equal to the decrease in the unit production cost due to the cost-reducing innovation, the licensor would be able to maintain its rivals (licensees) at the same cost level they had before the contract was signed. However, when there are other established firms in the product market (to which the incumbent licensor cannot sell its cost-reducing innovation), by licensing the patent holder only pays part of the cost of increased competition, whereas it captures the whole increment in the licensees' profits. Hence, the licensor benefits from having more aggressive licensees that can steal market share from the other competitors. This makes a royalty less appealing since the licensees' market shares are inversely related to the royalty level. In this case, contrary to what is found in the existing literature (Wang, 1998), we show that a fixed fee is the optimal contractual arrangement to sell a cost-reducing innovation.

The issue addressed by this note is empirically relevant too. The chemical industry is a rich source of motivating examples. First, large established incumbents are often active licensors. For instance, Union Carbide has a long tradition in polypropylene licensing. BP is both a major player in the polyethylene market and a leading licensor of polyethylene technology. Second, rarely is a firm able to license its process technology to the whole industry. Some competitors might not be able to incorporate the cost-reducing innovation in their production process because of incompatibility or simply prohibitive costs. For instance, metallocene technology, based on new single site catalysts, has been adopted only in a relatively small share of the worldwide production of polyolefin. In other cases, some competitors might develop their own proprietary technology. There are, for instance, half a dozen firms with proprietary technologies for producing ammonia. In methyl tert butyl ethers (MTBE), UOP, Mobil-BP, and Phillips Petroleum actively compete in technology licensing. For more details on licensing in the chemical industry, see Fosfuri (2004).

The rest of this note is organized as follows. The next section describes our basic model and derives our main finding. Section 3 discusses a few extensions. Section 4 concludes.

2. The Model

Consider an industry consisting of three firms producing the same good with a linear cost function $f_i(q_i) = c_i q_i, i = 1, 2, 3$, where q_i is the quantity produced by firm i and c_i is the constant marginal cost of production. We use three firms, and not just two, to make the analysis fully comparable throughout the paper. Assume that one of the three producers has developed and patented a non-drastic cost-reducing innovation that lowers the marginal cost of production by an amount ε. Without further loss of generality, say that $c_1 = c - \varepsilon$ and $c_2 = c_3 = c$. The cost-reducing innovation is non-drastic in the sense that a firm with the old technology produces positive quantity at equilibrium, i.e., $\varepsilon < a - c$.

In stage 1, firm 1 may license to the other players using a contract that stipulates a per unit royalty (r) and a fixed fee (F). The licensor proposes the contract to each licensee as a take-it-or-leave-it offer. Following Kamien and Tauman (2001) we assume that the licensor offers symmetric payment schemes to all licensees. The fixed fee and royalty are restricted to be positive on the assumption that a negative fixed fee or royalty is likely to infringe antitrust regulations. The fixed fee is paid upfront. In stage 2, production takes place and royalties are paid. There are no information asymmetries and imitation by the licensees is ruled out by assumption. The firms are Cournot competitors in the output market. The inverse demand function for the good is given by $p = a - Q$, where $a > c$ and Q is the total industry output.

As usual we solve the model by backward induction. After licensing has taken place in stage 1, quantity competition in stage 2 occurs among the three firms whose constant marginal costs of production are respectively $c - \varepsilon$, $c - \varepsilon + r$, and $c - \varepsilon + r$. Profit maximization by each individual firm produces the following equilibrium quantities (q_i) and profits (π_i):

$$q_1 = \frac{a-c+\varepsilon+2r}{4}, q_2 = q_3 = \frac{a-c+\varepsilon-2r}{4};$$

$$\pi_1 = (\frac{a-c+\varepsilon+2r}{4})^2,\ \pi_2 = \pi_3 = (\frac{a-c+\varepsilon-2r}{4})^2.$$

We can now move a step backward and solve the optimization problem that faces the licensor when shaping the contract:

$$\max_{r,F} V = \pi_1 + (F + rq_2) + (F + rq_3) = 2F + 2r(\frac{a-c+\varepsilon-2r}{4}) + (\frac{a-c+\varepsilon+2r}{4})^2 \quad (1)$$

$$\text{subject to } (\frac{a-c+\varepsilon-2r}{4})^2 - F \geq (\frac{a-c-\varepsilon}{4})^2 \quad (2)$$

$$q_2, q_3, F, r \geq 0. \quad (3)$$

Equation (1) represents the profit function of the licensor, which is given by the sum of the profits from its own production and the revenues collected from the licensees. Constraint (2) is the participation constraint: licensees must prefer to accept the licensing contract than to reject it. Constraint (3) says that licensees' output must be positive and that the licensor cannot accept negative payments from the licensees.

Proposition 1: If the innovator can sell its cost-reducing innovation to all industry players, the optimal licensing contract stipulates $r = \varepsilon$ and $F = 0$.

Proof: Use constraint (2) with equality to obtain the maximum value of F that the licensor can extract from the licensees. Then, replace F in the objective function to obtain:

$$V = 2\left[\left(\frac{a-c+\varepsilon-2r}{4}\right)^2 - \left(\frac{a-c-\varepsilon}{4}\right)^2\right] + 2r\left(\frac{a-c+\varepsilon-2r}{4}\right) + \left(\frac{a-c+\varepsilon+2r}{4}\right)^2.$$

By maximizing the latter expression with respect to r one obtains the first order condition $\partial V/\partial r = ((a-c-\varepsilon)/4) - (1/2)r \geq 0$. Notice that $\partial^2 V/\partial r \partial r = -1/2 < 0$. Hence, licensor's profits are strictly increasing in r for any $r \in (0,((a-c+\varepsilon)/2))$. From constraint (2) we have that $r \leq \varepsilon < ((a-c+\varepsilon)/2)$, where the last inequality comes form the assumption of non-drastic innovation, i.e., $\varepsilon < a - c$. Hence, the licensor's profits are maximized at $r = \varepsilon$ and $F = 0$.

The licensees will be held to the same cost level as they had before the licensing contracts were stipulated (i.e., $c_2 = c_3 = c$). In turn, firm 1 captures the whole reduction in the licensees' production costs due to the cost-reducing innovation, i.e., $2\varepsilon((a-c-\varepsilon)/4)$.

Let us now assume that firm 1 cannot reach all competitors through licensing contracts. Say, for instance, that firm 3 cannot license in firm 1's cost-reducing innovation because of compatibility reasons that would raise adoption costs or because of transaction costs that would make the deal unfeasible. Let $c_3 \in (c-\varepsilon, c]$ be firm 3's constant marginal cost of production. Also, assume that the cost-reducing innovation does not drive firm 3 out of the market, i.e., $\varepsilon < ((a+2c-3c_3)/2)$. We proceed as above and solve for the last stage of the game. After licensing to firm 2 has taken place, equilibrium quantities and profits are respectively:

$$q_1 = \frac{a-2(c-\varepsilon)+c_3+r}{4}, q_2 = \frac{a-2(c-\varepsilon)+c_3-3r}{4}, q_3 = \frac{a+2(c-\varepsilon)-3c_3+r}{4};$$

$$\pi_1 = \left[\frac{a-2(c-\varepsilon)+c_3+r}{4}\right]^2, \pi_2 = \left[\frac{a-2(c-\varepsilon)+c_3-3r}{4}\right]^2, \pi_3 = \left[\frac{a+2(c-\varepsilon)-3c_3+r}{4}\right]^2.$$

At stage 1, the optimization problem for the licensor is similar to the one analyzed before:

$$\max_{r,F} V = \pi_1 + rq_2 + F = F + r\frac{a-2(c-\varepsilon)+c_3-3r}{4} + \left[\frac{a-2(c-\varepsilon)+c_3+r}{4}\right]^2 \tag{4}$$

$$\text{subject to } \left[\frac{a-2(c-\varepsilon)+c_3-3r}{4}\right]^2 - F \geq \left[\frac{a-2c-\varepsilon+c_3}{4}\right]^2 \tag{5}$$

$$q_2, F, r \geq 0\,. \qquad (6)$$

Proposition 2: If the innovator can sell its cost-reducing innovation to only one of the two potential licensees, then the optimal licensing contract stipulates $r = 0$ and

$$F = \left[\frac{a-2(c-\varepsilon)+c_3-3r}{4}\right]^2 - \left[\frac{a-2c-\varepsilon+c_3}{4}\right]^2.$$

Proof: Use constraint (5) with equality to obtain the maximum value of F that the licensor can extract from firm 2. Then, replace F in the objective function to obtain

$$V = \left[\frac{a-2(c-\varepsilon)+c_3-3r}{4}\right]^2 - \left[\frac{a-2c-\varepsilon+c_3}{4}\right]^2 + r\frac{a-2(c-\varepsilon)+c_3-3r}{4} + \left[\frac{a-2(c-\varepsilon)+c_3+r}{4}\right]^2.$$

By maximizing the latter expression with respect to r one obtains $\partial V/\partial r = -(1/4)r < 0$. Hence, the optimal licensing contract must stipulate $r = 0$. Use again constraint (5) with equality to find the optimal value of F.

To understand this result, start from the optimal contract derived in Proposition 1 (i.e., $r = \varepsilon$ and $F = 0$). Now, lower the unit royalty and consider how this affects the sum of licensor and licensee's profits. First, since the licensee has a lower marginal production cost, it will obtain a higher profit whereas the licensor, facing a more efficient rival in the product market, will experience a decrease in its own profit. In addition, the licensor and the licensee expand their combined market share to the detriment of the third incumbent. It turns out that the latter effect is sufficiently strong and the licensor wants to have a low production cost licensee in spite of increased industry competition. Put differently, licensing by means of a fixed fee generates a negative pecuniary externality on the third incumbent, which is not taken into account by the licensor. The licensor has now an incentive to make the licensee more aggressive in the product market because in so doing it will steal market share from the other competitor.

For completeness, let us compare total welfare in the case in which the licensor can sell its cost-reducing innovation to both firms (case I) vis-à-vis the case in which it can only sell to one of the existing rivals (case II). Let $c_3 = c$, so that the two cases are perfectly identical, except in the number of suitable licensees. Notice that consumer surplus is larger in case II since the licensor has an incentive to make the licensee more aggressive in the product market by using a fixed fee contract, and thus the price decreases. Indeed, consumer surpluses are respectively $CS^I = (1/32)(3a-3c+\varepsilon)^2$ and $CS^{II} = (1/32)(3a-3c+2\varepsilon)^2$. Total industry profits are respectively $\Pi^I = (1/8)(a-c-\varepsilon)^2 + (1/2)(a-c-\varepsilon)\varepsilon + (1/16)(a-c-3\varepsilon)^2$ and $\Pi^{II} = (1/16)(a-c-2\varepsilon)^2 + (1/8)(a-c+2\varepsilon)^2$. Although only one licensee can benefit from the cost-reducing innovation, total welfare will be greater in case II if $CS^{I} + \Pi^{I} < CS^{II} + \Pi^{II}$. After some straightforward simplifications one can show that this inequality holds if and only if $\varepsilon > 2(a-c)/7$, i.e., when the cost-reducing innovation is sufficiently large.

3. Extensions

We discuss here two generalizations of the simple model presented in Section 2. To save space, calculations and formal proofs have been omitted but are available from the authors upon request.

First, consider an industry populated by n high production cost firms and one low production cost incumbent licensor. If the licensor can stipulate a licensing agreement with all industry players, then it would optimally choose to charge a unit royalty equal to the reduction in marginal cost brought by the cost-reducing innovation. This result holds for $\varepsilon \geq 2(a-c)/n+2$ (see Kamien and Tauman, 2001). However, our Proposition 2 would hold unchanged if the licensor can only reach one high cost competitor. More generally, a fixed fee contract is preferred to a royalty agreement if the licensor can sell its cost-reducing innovation to $k < n$ competitors with k sufficiently low. Notice that our model in Section 2 is a special case of this more general framework where $k = 1$ and $n = 2$.

Second, consider the case in which two patent holders have independently developed a cost-reducing innovation. Both have the option to license their technology by choosing the optimal licensing payment scheme (royalty and fixed fee). Assume further that there are two weaker competitors in the product market (initially endowed with high production cost technology) and that, for technology compatibility reasons, each of them can only license in the cost-reducing innovation from one of the two innovators. This assumption rules out competition among licensors for suitable licensees. It is not difficult to show that the optimal contract for each cost-reducing innovator stipulates only a fixed fee. As in Section 2, the gains from making its own licensee more aggressive in the product market prevail over the losses due to increased competition. Again, the incumbent licensor does not fully internalise the negative externality of having a more efficient competitor (its licensee) in the product market. It is worthwhile noting that in equilibrium both innovators choose to license their cost-reducing technology by means of a fixed fee only. However, they would obtain higher profits if they could credibly commit themselves to royalty-based contracts.

4. Conclusion

The optimal licensing contract to sell a cost-reducing innovation has been extensively analyzed in the literature (see, for instance, Kamien and Tauman, 2001). When the innovator is also an incumbent producer, it has been shown that a royalty is superior to a fixed fee because it relaxes the competition exerted by the licensees (Wang, 1998). This note shows that, when the incumbent licensor cannot sell its cost-reducing innovation to all industry players but only to some of them, a fixed fee royalty might instead be optimally chosen. Indeed, the licensor has an incentive to make its licensees more aggressive in the product market in order to steal market share from other (non-licensee) rivals. In turn, this implies reducing the unit royalty as much as possible.

This note seems to fit well licensing dynamics within the chemical industry where incumbent producers are often licensing their technology to other potential rival firms, there are several sources for the technology to produce a given product, and rarely a licensor is able to sell its cost-reducing innovation to the whole market. A testable implication that follows directly from our model is that there is a positive relationship between the use of royalty-based schemes and the share of industry players employing the licensed technology.

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