The Effect of a Licensing Option Agreement in Vertically-related Markets

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Abstract

We employ a simple successive monopoly model to investigate the effect of a licensing option agreement in vertically-related markets. By providing licensing options to the licensee, the innovator can resolve the hold-up problem in vertically-related markets by making the input monopolist aware that its pricing will affect the downstream firm's incentive on exercising the licensing option. The input monopolist can thus encourage technology licensing to happen by determining a low input price. At equilibrium, both the innovator's profit and the social welfare with the licensing option are higher than that without.

Key words: ***Licensing, Vertically-related Markets, Option, Hold-up Problem***

JEL Classification: *L12, L24*

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1. Introduction

A licensing option agreement is a prevalent business behavior nowadays as it provides higher flexibility to the licensee.[1] Before entering into a full license contract, the licensee can evaluate the profitability of the technology over a period of time, which usually is between six months to one year, by paying an option fee to the licensor. After the valuation, the licensee chooses whether to exercise the option into a full license agreement or not. A question hence arises: Why does the innovator provide a higher flexibility to the licensee by offering licensing options?

There is no answer to this question in the technology licensing literature as most related studies focus on how the competition mode, the market structure, and whether the innovator is an inside competitor or an outside independent firm will affect the optimal licensing contract. Arya and Mittendorf (2006), Mukherjee et al. (2008), and Mukherjee (2010) investigate the issue of technology licensing in vertically-related markets. In their model, fixed-fee licensing creates a hold-up problem between the input monopolist and the licensee. Once the licensee has invested in such a new technology, the fixed fee in fact becomes a sunk cost, thus implying the input monopolist holds up the licensee. As fixed-fee licensing lowers the licensee's marginal cost and increases the final outputs, the derived demand for inputs will shift outward. The input monopolist can then extract part of the licensing rents by raising the input price. This in turn restricts the fixed fee that the innovator can charge, but the innovator in fact loses a first-mover advantage against the input monopolist under

[1] Many universities provide licensing option agreements, such as UCLA, Stanford University, Harvard University, etc.

fixed-fee licensing.

Royalty licensing, on the other hand, avoids the hold-up problem since the licensee does not need to pay any fee in advance. Moreover, the innovator can manipulate the marginal cost of the licensee by adjusting the royalty rate. This suppresses the derived demand for inputs from shifting outward and prevents the licensing rent from being extracted by the input monopolist.

From the above review, we know that the innovator prefers royalty licensing to fixed-fee licensing in vertically-related markets. This paper therefore employs a successive monopoly model to investigate the effect of a licensing option agreement on the hold-up problem between the input monopolist and the licensee.

2. The Model

We assume there are one input monopolist, firm U, and one downstream monopolist, firm D, in an industry, as well as one unit of input to produce one unit of output. Firm U sells its input to firm D for w per unit of input. Without loss of generality, the marginal production cost of firm U is assumed to be zero, and the marginal production cost of firm D is c. The inverse market demand function for the final product is $P(Q) = a - bQ$, where Q is the quantity of the final product.

There is now an outside innovator that sells its advanced technology to firm D. With this advanced technology, the marginal production cost of firm D drops from c to $c - \varepsilon$, where ε stands for the innovation level. The innovator licenses its technology via a two-part tariff contract: a per-unit royalty rate, r, and a fixed licensing fee, F. Following the assumption in the literature, we assume the innovator has full bargaining power and can extract all the licensing rents from the licensee.

We investigate herein the effect of a licensing option agreement in vertically-related markets. To this aim, the game structure in our simple successive monopoly model is as follows. In the first stage, the innovator provides a licensing option agreement to firm D, which provides firm D a period of time to evaluate the technology. The innovator determines (r, F) in this stage to maximize its licensing revenue. In the second stage, after realizing the licensing option agreement, firm U determines its input price, w. In the third stage, depending on (r, F) and w, firm D determines whether to exercise the licensing option agreement or not. Once firm D decides to exercise the option, it then enters into a full license agreement with the innovator. In the final stage, firm D determines its output, Q, to maximize its profits. We use backward induction to solve the sub-game perfect equilibrium.

In the final stage, the profit function of firm D is:

$$\pi = \begin{cases} \left[P(Q) - w - c\right]Q & \text{if} \quad \text{licensing option is not exercised,} \\ \left[P(Q) - w - c + \varepsilon - r\right]Q - F & \quad\quad \text{licensing option is exercised.} \end{cases} \tag{1}$$

Differentiating (1) with respect to Q and setting it to zero, we derive the profit-maximizing output for firm D in the final stage as:

$$Q = \begin{cases} \dfrac{a - w - c}{2b} & \text{if} \quad \text{licensing option is not exercised,} \\ \dfrac{a - w - c + \varepsilon - r}{2b} & \quad\quad \text{licensing option is exercised.} \end{cases} \tag{2}$$

Substituting (2) into (1), the equilibrium profit of firm D in the final stage is:

$$\pi = \begin{cases} \dfrac{\left(a - w - c\right)^2}{4b} & \text{if} \quad \text{licensing option is not exercised,} \\ \dfrac{\left(a - w - c + \varepsilon - r\right)^2}{4b} - F & \quad\quad \text{licensing option is exercised.} \end{cases} \tag{3}$$

In the third stage, after observing (r, F) and w, firm D decides whether to exercise the licensing option or not. Firm D exercises the licensing option if and only if its profit is higher. From (3), we see that:

$$\pi = \frac{\left(a-w-c+\varepsilon-r\right)^2}{4b} - F \ge \frac{\left(a-w-c\right)^2}{4b}, \tag{4}$$

which is equivalent to:

$$w \le \frac{2a-2c+\varepsilon-r}{2} - \frac{2bF}{\varepsilon-r} \equiv \overline{w}, \tag{5}$$

where $\overline{w}$ denotes the critical input price such that firm D is indifferent from exercising the licensing option or not. From (4), we note that for any $F \ge 0$, the royalty rate cannot exceed the innovation level (i.e., $r \le \varepsilon$) under technology licensing. Moreover, (5) shows that if $w > \overline{w}$, then firm D will not exercise the licensing option agreement.

In the second stage, firm U determines w in order to maximize profit. From (2) and (5), the derived demand for inputs facing firm U is as follows:

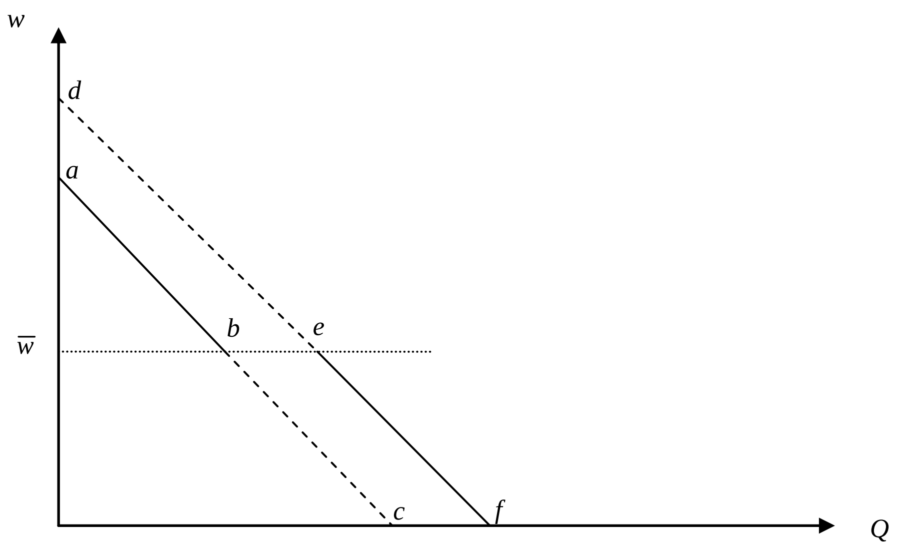

Figure 1. The derived demand facing firm U under the licensing option.

In Figure 1, without (with) technology licensing, the derived demand for inputs facing firm U is $\overline{ac}$ ($\overline{df}$). Moreover, firm U is aware that its pricing will largely affect firm D's decision on whether to exercise the licensing option or not. If $w > \overline{w}$, then firm D will not exercise the licensing option. On the other hand, if $w \le \overline{w}$, then firm D will exercise the licensing option into a full license agreement. Therefore, the derived demand for inputs facing firm U under a licensing option agreement is $\overline{ab}$ for $w > \overline{w}$ and $\overline{ef}$ for $w \le \overline{w}$.

The profit maximization problem of firm U is accordingly:

$$\max_{w} \Omega = \begin{cases} w\left(\dfrac{a-w-c+\varepsilon-r}{2b}\right) & if \quad w \le \overline{w}, \\ w\left(\dfrac{a-w-c}{2b}\right) & \quad\;\; w > \overline{w}. \end{cases} \tag{6}$$

By solving (6), the profit-maximizing input price and the profit of firm U are respectively:

$$w = \begin{cases} \dfrac{a-c+\varepsilon-r}{2} & 0 \le F \le \hat{F}, \\ \overline{w} \qquad if & \hat{F} < F \le \overline{F}, \\ \dfrac{a-c}{2} & F > \overline{F}, \end{cases} \tag{7}$$

$$\Omega = \begin{cases} \dfrac{\left(a-c+\varepsilon-r\right)^2}{8b} & 0 \le F \le \hat{F}, \\ \dfrac{\left(\varepsilon-r\right)\left(2a-2c+\varepsilon-r\right)}{8b} + \dfrac{F\left[(\varepsilon-r)(a-c)-2bF\right]}{\left(\varepsilon-r\right)^2} \quad if & \hat{F} < F \le \overline{F}, \\ \dfrac{\left(a-c\right)^2}{8b} & F > \overline{F}, \end{cases}$$

where $\hat{F} \equiv (a-c)(\varepsilon-r)/4b$ is the fixed licensing fee such that $\dfrac{a-c+\varepsilon-r}{2} = \overline{w}$, and $\overline{F} \equiv \left[(a-c)+\sqrt{(\varepsilon-r)(2a-2c+\varepsilon-r)}\right](\varepsilon-r)\Big/4b$ is the critical fixed licensing fee such that firm U is indifferent between whether the licensing option will be exercised or not (i.e., $\dfrac{\left(\varepsilon-r\right)\left(2a-2c+\varepsilon-r\right)}{8b} + \dfrac{F\left[(\varepsilon-r)(a-c)-2bF\right]}{\left(\varepsilon-r\right)^2} = \dfrac{(a-c)^2}{8b}$).

Note that since $r \le \varepsilon$, from (7), it is straightforward to show that:

$$\frac{\partial \overline{w}}{\partial F} = -2b/(\varepsilon - r) < 0 .$$

A higher F will shift $\overline{w}$ in Figure 1 downward, and firm U has to determine a lower input price to encourage firm D to exercise the licensing option. However, if $F > \overline{F}$, then it is unprofitable for firm U to set a low input price to encourage firm D to exercise the licensing option. We present this result as the following proposition.

Proposition 1. Under the licensing option agreement, the input monopolist is aware that its pricing will affect whether technology licensing happens or not. Moreover, if $\hat{F} < F < \overline{F}$, then the input monopolist has the incentive to suppress its input price to encourage the downstream firm to exercise the licensing option.

The result we find is different from Mukherjee (2010) and others, whereby the input price is irrelevant to the fixed licensing fee. The licensing option agreement makes firm U mindful that its pricing will determine firm D's decision on whether to exercise the licensing option, which changes the shape of derived demand for the inputs facing firm U and resolves the hold-up problem in technology licensing since the fixed fee is not a sunk cost for firm D. In order to encourage firm D to exercise the licensing option to shift the derived demand for inputs outward, firm U has the incentive to determine a low input price when the innovator charges a high fixed fee. This also implies the innovator can avoid firm U from extracting the licensing rents by setting a high fixed licensing fee.

In the first stage, the outside innovator chooses (r, F) to maximize profit. The innovator's profit function is thus:

$$\Lambda = rQ + F \ . \tag{8}$$

Substituting (2) and (7) into (8), we can rewrite the innovator's profit function as:

$$\Lambda = \begin{cases} \dfrac{r\left(a-c+\varepsilon-r\right)}{4b}+F & \\ & if \\ \dfrac{r(\varepsilon-r)}{4b}+\dfrac{\varepsilon}{\varepsilon-r}F & \end{cases} \begin{array}{c} 0 \le F \le \hat{F} \\ \\ \hat{F} < F \le \bar{F}. \end{array} \tag{9}$$

Since we assume the innovator has full bargaining power and can extract all the licensing rents from the licensee, the fixed licensing fee is thus:

$$F = \begin{cases} \hat{F} & \\ & if \\ \bar{F} & \end{cases} \begin{array}{c} 0 \le F \le \hat{F} \\ \hat{F} < F \le \bar{F}. \end{array} \tag{10}$$

By substituting (10) into (9), the innovator's profit function is:

$$\Lambda = \begin{cases} \dfrac{(a-c)\varepsilon + r(\varepsilon-r)}{4b}, \\ \dfrac{(a-c)\varepsilon + r(\varepsilon-r)}{4b} + \dfrac{\varepsilon\sqrt{(\varepsilon-r)(2a-2c+\varepsilon-r)}}{4b}. \end{cases} \tag{11}$$

From (11), given *r*, it is straightforward to show that the innovator would charge $F = \bar{F}$ since the profit is necessarily higher. Differentiating it with respect to *r* yields:

$$\begin{aligned} \frac{d\Lambda}{dr} &= \frac{-\varepsilon(a-c+\varepsilon-r)+(\varepsilon-2r)\sqrt{(\varepsilon-r)(2a-2c+\varepsilon-r)}}{4b} \\ &= \frac{-\varepsilon\left[(a-c+\varepsilon-r)-\sqrt{(\varepsilon-r)(2a-2c+\varepsilon-r)}\right]-2r\sqrt{(\varepsilon-r)(2a-2c+\varepsilon-r)}}{4b} \\ &< 0. \end{aligned}$$

Therefore, the optimal two-part tariff licensing contract and the innovator's profit are:

$$\left(r=0, F=\frac{\varepsilon}{4b}\left[(a-c)+\sqrt{\varepsilon(2a-2c+\varepsilon)}\right]\right) \quad \text{and}$$

$$\Lambda = \frac{\varepsilon}{4b}\left[(a-c)+\sqrt{\varepsilon(2a-2c+\varepsilon)}\right]. \tag{12}$$

We present this result as the following proposition.

Proposition 2. Under the simple successive monopoly model, an optimal licensing contract includes only a pure fixed-fee when the licensee has the licensing option.

The intuition behind this proposition is clear. First, fixed-fee licensing increases the final output since the production efficiency of the downstream firm is higher. Second, from Proposition 1, the input monopolist has the incentive to determine a low input price when the fixed licensing fee is high, thus limiting the rent-extracting power of the input monopolist. These two effects together make the optimal licensing contract include only a pure fixed fee.

By substituting (12) into (7), the equilibrium input price is:

$$w = \frac{1}{2}\left[a - c + \varepsilon - \sqrt{\varepsilon(2a - 2c + \varepsilon)}\right] < \frac{a-c}{2}.$$

We present this result as the following lemma.

Lemma 1. The equilibrium input price under a licensing option agreement is even lower than that without technology licensing.

Note that the social welfare under the licensing option agreement necessarily rises as the production efficiency of firm D increases, and that the problem of double marginalization eases up as well (by Lemma 1). Moreover, it is straightforward to show that the innovator's profit and the social welfare with the licensing option are higher than that without.

The intuition behind the above finding is as follows. First, without the licensing option, the input monopolist can hold up the downstream firm and extract part of the licensing rent by determining a higher input price, which results in a more severe problem of double marginalization than that with the licensing option. Both the innovator's profit and the social welfare decrease. The innovator can only avoid this rent-extracting effect by charging a per-unit royalty. Second, with this royalty rate, the production efficiency of the downstream firm is distorted, which decreases both the aggregate industry profit and the social welfare. These two effects together make the licensing option agreement better from the perspective of the innovator and the social welfare. We present this result as the following proposition.

Proposition 3. The licensing option agreement can further increase the innovator's profit and the social welfare.

3. Conclusions

The licensing option agreement helps the innovator to avoid the hold-up problem in vertically-related markets by making the input monopolist aware that its pricing behavior will affect the downstream firm's incentive on exercising the licensing option. The input monopolist would like to suppress its input price and encourage technology licensing to be upheld when the fixed licensing fee is high (i.e., $\hat{F} < F \leq \bar{F}$). At equilibrium, the input price under the licensing option is even lower than that before technology licensing, which eases the problem of double marginalization. Moreover, the optimal licensing contract includes only a pure fixed fee, which increases the production efficiency of the downstream firm. Therefore, both the innovator's profit and the social welfare under the licensing option agreement are higher than that without.

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