Technology Licensing and Entry in Vertically-Related Markets

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This paper investigates the optimal licensing strategy of an insider licensor, which produces and sells an intermediate good in a vertically related market. The licensor can adopt either fixed-fee or royalty licensing. It is found that the licensor firm may prefer fixed-fee to royalty licensing as the former is more likely to induce downstream entry which expands the derived demand. Moreover, even if downstream entry takes place under both regimes, fixed-fee licensing could still be superior to royalty licensing, because the licensor, in order to make room for the entry, cannot enjoy the full cost advantage under royalty licensing.

Keywords: optimal licensing, entry, intermediate good markets
JEL classification: L13, L24

1 Introduction

Technology licensing is a common practice among firms and has grown dramatically over the last two decades. Nadiri (1993) shows that, from 1970 to 1988, the payments for patents have increased by about 400% in Japan and the U.K., 550% in France and the U.S., and by over 1,000% in West Germany. The literature on technology licensing can be dated back to Arrow

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(1962) who shows that a licensor can earn more profits by licensing its innovation to competitive firms than to a monopolist. Recently, many scholars have been interested in optimal licensing contracts and have made a good contribution to the literature. When discussing optimal licensing contracts, they mainly focus on the following two types: royalty licensing vs. fixed-fee licensing. Licensors can be either outsider or insider. When a licensor does not (does) compete with the licensees in the product market, it is called an outsider (insider) licensor.

In the literature of insider licensing, Wang (1998) and Kamien and Tauman (2002), among others, show that a licensor always prefers a royalty to a fixed-fee contract if the products produced by the licensor and the licensee(s) are homogeneous.[1] The literature has been extended in a variety of ways and come up with different results. In particular, Wang (2002) assumes that the licensor and the licensee produce differentiated products and concludes that fixed-fee is better than royalty in terms of the licensor's profit if the products are sufficiently differentiated. Furthermore, in models with a homogeneous product, Fosfuri and Roca (2004) and Poddar and Sinha (2010) also find that the licensor may prefer a fixed fee to a royalty. The former is due to the assumption that the licensor cannot license its innovation to all competitors in the market, and the latter is due to the one that the technology is licensed from a high-cost firm to a low-cost firm.

While each of these papers has enriched the literature, it is worth mentioning that their analyses are all confined to technology licensing in final good markets. Nevertheless, licensing activities, in reality, are also prevalent in intermediate good markets, as evidenced by Anand and Khanna (2000) and Grindley and Teece (1997). They find in their empirical studies that most of licensing activities are concentrated in chemical, computer, semiconductor and electronics industries. In these industries, licensors and licensees are firms producing intermediate goods rather than final goods. The aim of this paper is therefore to analyze the optimal licensing contract, being royalty or fixed fee, for an insider licensor in an intermediate good market and to check if the results derived by Wang (1998) and Kamien and Tauman (2002) are still robust.

To this end, we shall set up a model with vertically related markets,

[1]This kind of comparison is in line with empirical findings. By using Spanish data, Macho-Stadler et al. (1996) find that 59% of the contracts have royalty payments alone, 28% is fixed fee alone, and 13% contains both the royalty and fixed fees.

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which consists of an upstream market and a downstream market. Assume that the upstream market is duopolistic. One of the upstream firms (the licensor) possesses a process innovation which can be licensed to its rival upstream firm (the licensee) by means of a fixed fee or a royalty contract. Furthermore, the downstream market by contrast has two incumbents and one potential entrant. This entrant will enter the market only if its operating profit from the market can at least cover its fixed entry cost. The setting of potential entrant is common to models with vertically-related markets, and that the downstream market structure is strategically affected by actions of firms in the upstream market. For example, Song and Kim (2001) analyze the strategic effect of vertically integrated firms on downstream entry. Antelo and Bru (2006) examine the merger incentive of an upstream firm in the presence of downstream entry. In our paper, the focus is on the relationship between the downstream entry and the optimal licensing contract in the upstream market.[2]

We shall show that the optimal licensing strategy of a licensor in an intermediate good market is quite different from that in a final good market. In our model, the upstream licensor adopts a fixed-fee contract if the entry cost of the downstream entrant is moderate; otherwise, it prefers royalty. The intuition is as follows. First, fixed-fee licensing is more likely to accommodate the downstream entry. Specifically, for some range of the entry cost, the potential downstream firm enters the market under fixed-fee licensing but not under royalty licensing. This entry will shift out the derived demand and hence the profits of the licensor firm. Second, even if downstream entry takes place in both fixed-fee and royalty licensing, the profits of the licensor firm could still be higher under fixed-fee licensing as it, if choosing royalty licensing, has to charge a lower royalty rate so as to make room for the entry. This lower royalty rate erodes its licensing revenue and profits earned from the product market, making royalty licensing inferior to fixed-fee licensing.

This paper is also related to the recent literature on technology licensing in vertically related markets, such as Arya and Mittendorf (2006), Mukherjee (2010) and Mukherjee and Pennings (2011), among others. They all assume the existence of an upstream market in their models, and examine how it affects technology licensing in *downstream markets*, which is quite dif-

[2]The existence of potential entrant is crucial to our main results. It is worth pointing out that the main finding of Wang (2002) and Kamien and Tauman (2002) remain unchanged if we add a potential entrant to their models.

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ferent from the focus of our paper. In addition, Mukherjee and Ray (2007) examine a monopolistic input supplier's incentive to engage in outsourcing and R&D. They find that it is profitable for a monopolistic input supplier to create an outside source for its input as it can attract new buyers and expand the derived demand. Even though they also point out that the upstream monopolist can benefit from an expansion in derived demands, they do not address the issue of optimal licensing contract, which is the main focus of our paper.

The remainder of this paper is organized as follows. Section 2 introduces the model. The equilibrium profits, input price and entry decision of the downstream entrant under fixed-fee licensing and royalty licensing are explored in Section 3. Section 4 investigates the optimal licensing contract of the upstream licensor. Section 5 concludes this paper.

2 The Model

Assume there is a vertically-related market, which consists of one upstream market and one downstream market. In the upstream market, there are two upstream firms, Firm U_1 and Firm U_2, producing and selling a homogeneous intermediate good to downstream firms. In the downstream market, there are two incumbents, Firm D_1 and Firm D_2, and one potential entrant, Firm D_e. If the entrant enters the market, it has to incur a fixed entry cost E. The downstream firms use the intermediate good to produce a homogeneous final good to be sold in the final good market. Suppose that the inverse demand function of the final good is $P = a - Q$, where P and Q represent, respectively, the market price and output of the final good, and $a > 0$ is the intercept of the demand curve.

Without loss of generality, we assume that producing one unit of the final good requires one unit of the intermediate good. Denote the price of the intermediate good as w, which is also the marginal cost of the downstream firms for producing the final good. Moreover, the number of the downstream firms, denoted by K, may take the value of 2 or 3, depending on the entry decision by the potential entrant D_e. That is, if the potential entrant enters the downstream market, $K = 3$, otherwise, $K = 2$.

We hereafter use superscript i to indicate that the variable is associated with the respective licensing regime with $i = N$, F or R standing for no licensing, fixed-fee licensing or royalty licensing, respectively. Suppose that the marginal cost of Firm U_1 is $c - \varepsilon$, where $\varepsilon > 0$ represents its cost-

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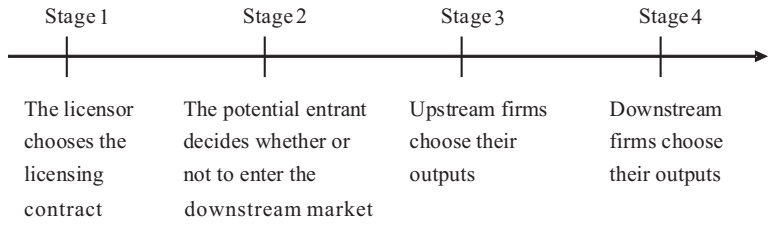


Figure 1: The time line of the game

reducing innovation. Firm U_1 may license the innovation to its rival, Firm U_2, whose marginal cost is $c^N = c$ if the licensing does not occur. Assume that Firm U_1 can adopt either a fixed-fee contract or a royalty contract to license the innovation. Under fixed-fee licensing, it charges Firm U_2 a fixed-upfront fee f and the marginal cost of Firm U_2 becomes $c^F = c - \varepsilon$. By contrast, under royalty licensing, it charges Firm U_2 a royalty rate r per unit of the output which changes the effective marginal cost of Firm U_2 to $c^R = c - \varepsilon + r$.

The model is illustrated by a four-stage game as shown by Figure 1. In the first stage, Firm U_1 chooses its optimal licensing contract and offers a take-it-or-leave-it contract to Firm U_2 by means of either a fixed-fee or a royalty. If Firm U_2 accepts the contract, it acquires the innovation and pays the licensing fee to the licensor. In the second stage, by taking the licensing outcome in the upstream market as given, the potential entrant D_e decides whether or not to enter the downstream market. The potential entrant will enter the market if its profit is non-negative. In the third stage, in anticipating the derived demand for the intermediate good, the upstream duopolists choose their outputs in Cournot fashion. In the final stage, the K downstream firms decide their outputs of the final good in Cournot fashion. K takes the value of either 2 or 3, depending on the entry decision of the potential entrant. We shall use backward induction to solve the subgame perfect Nash equilibrium (SPNE).

We start the analysis by first solving the final-stage game. In this stage of the game, the downstream firms choose their optimal outputs simultaneously. The downstream incumbent firms' profit functions are defined as $\pi_j^i = [P(Q^i) - w^i]q_j^i$, $j = D_1, D_2$, where Q^i is the total output of the downstream market, and q_j is the output for incumbent firm j. If the potential entrant enters the market, its profit is: $\pi_e^i = [P(Q^i) - w^i]q_e^i - E$,

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where q_e is its output.

Given the number of the downstream firms, K, by symmetry and routine calculation, we can derive the output of each downstream firm as $(a - w^i)/(K + 1)$ and the total output of the downstream market as follows:

$$Q^i = \frac{K(a - w^i)}{K + 1}. \tag{1}$$

By inverting (1), we can derive the inverse derived demand for the intermediate good as follows:

$$w^i = a - \frac{(K + 1)}{K} Q^i. \tag{2}$$

With this derived demand, the upstream firms decide their optimal outputs in Cournot fashion.

By using (2), we now turn to solve the equilibrium in the third-stage game. The profit functions for the two upstream firms are defined as $\pi^i_{U1} = [w^i(Q^i) - c + \varepsilon]x^i_1$ and $\pi^i_{U2} = [w^i(Q^i) - c^i]x^i_2$ where $Q^i = X^i = x^i_1 + x^i_2$ is the total output of the upstream market, and x^i_1 and x^i_2 are the outputs of Firm U_1 and Firm U_2, respectively. By solving the Cournot game, we can obtain the equilibrium outputs of the two firms and the input price as follows: $x^i_1 = K[a - 2(c - \varepsilon) + c^i]/3(K + 1)$, $x^i_2 = K[a - 2c^i + (c - \varepsilon)]/3(K+1)$ and $w^i = (a+c-\varepsilon+c^i)/3$.[3] The profits of the two upstream firms are also derivable as follows:

$$\pi^i_{U1} = \frac{K}{9(K + 1)} \left[a - 2(c - \varepsilon) + c^i\right]^2, \tag{3}$$

$$\pi^i_{U2} = \frac{K}{9(K + 1)} \left[a - 2c^i + (c - \varepsilon)\right]^2. \tag{4}$$

By substituting the input price $w^i = (a + c - \varepsilon + c^i)/3$ into the profit function of the downstream entrant, we can derive its profit as follows:

$$\pi^i_e = \frac{\left[2a - (c - \varepsilon) - c^i\right]^2}{144} - E. \tag{5}$$

From (5), we can examine the entry decision of the potential entrant. If π^i_e is non-negative, Firm D_e will enter the downstream market, otherwise, it

[3]To ensure that the innovation is non-drastic, we assume $\varepsilon \leq (a - c)/2$. An innovation is non-drastic if it does not force rival firms out of the market; see Arrow (1962).

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will not. After the entry decision of Firm D_e is made, we can use (3) and (4) to derive and rank the optimal licensing contracts in terms of a fixed fee or a royalty.

Before deriving the optimal contracts, let us first derive the break-even entry cost for Firm D_e if there is no licensing. Under such a circumstance, the marginal cost of Firm U_2 is $c^N = c$. By substituting this into (5) and setting it to zero, we can derive the break-even entry cost as follows:[4]

$$E^N = \frac{(2a - 2c + \varepsilon)^2}{144}. \tag{6}$$

If $E \leq E^N$, Firm D_e enters the downstream market and there will be three firms in the downstream market (i.e., $K = 3$). Otherwise, Firm D_e does not enter and there are only two firms in the downstream market (i.e., $K = 2$).

3 Licensing Contracts and the Entry Decision

In this section, we shall derive the optimal fixed fee and royalty rate for any given entry cost in the downstream market. As we shall see, the two forms of optimal licensing contract may result in different break-even entry costs and downstream market structures. This result is crucial to the determination of the optimal contract which will be discussed as follows.

3.1 The Entry Decision and the Optimal Fixed Fee

In this subsection, we assume that the upstream licensor adopts fixed-fee licensing and derive the optimal fixed fee. With licensing, the marginal cost of Firm U_2 is $c^F = c - \varepsilon$. If Firm D_e enters the downstream market, we can substitute $K = 3$ into (3) to (5) to derive the profits of the upstream firms and the downstream entrant as follows:

$$\Pi_{U1}^F = \pi_{U1}^F + f = \frac{(a - c + \varepsilon)^2}{12} + f, \tag{7}$$

$$\Pi_{U2}^F = \pi_{U2}^F - f = \frac{(a - c + \varepsilon)^2}{12} - f, \tag{8}$$

$$\pi_e^F = \frac{(a - c + \varepsilon)^2}{36} - E. \tag{9}$$

[4] A break-even entry cost is the entry cost which makes the profit of the entrant equal to zero.

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Firm D_e will enter the final good market if the entry cost does not exceed the break-even entry cost E^F which is derivable from (9) as follows:

$$E^F = \frac{(a - c + \varepsilon)^2}{36}. \tag{10}$$

By comparing (10) with (6), we have $E^F > E^N$. Hence, if the entry cost E falls within the range of $E^F > E > E^N$, the downstream entry occurs once fixed-fee licensing is introduced. If $E \leq E^F$, the entrant enters the market and the profits of the two upstream firms are those in (7) and (8). If $E > E^F$, the potential entrant does not enter the market (i.e., $K = 2$) and the upstream profits using (3) and (4) are derivable as follows:

$$\Pi_{U1}^F = \frac{2(a - c + \varepsilon)^2}{27} + f, \tag{11}$$

$$\Pi_{U2}^F = \frac{2(a - c + \varepsilon)^2}{27} - f. \tag{12}$$

Furthermore, the optimal fixed fee is derivable by solving the following profit maximization problem:

$$\max_f \Pi_{U1}^F \text{ subject to } \Pi_{U2}^F = \pi_{U2}^F - f \geq \pi_{U2}^N.$$

The optimal fixed fee is subject to the licensee firm's incentive constraint — the profit of the licensee firm after licensing is no less than that before the licensing. As the profit function of the licensor firm increases with the fixed fee, the optimal fixed fee has a corner solution. Given the licensee's incentive constraint, the licensor firm will maximize its profit by charging the fixed fee up to $\pi_{U2}^F - \pi_{U2}^N = 0$. Obviously, the optimal licensing fee is dependent on the entry cost. If the entry fee exceeds E^F (i.e., $E > E^F$), the entrant will not enter the market and the optimal licensing fee is $\pi_{U2}^F(K = 2) - \pi_{U2}^N(K = 2)$. If $E^N < E \leq E^F$, the entrant enters the market only if licensing takes place. Under such a circumstance, the optimal fixed fee is equal to $\pi_{U2}^F(K = 3) - \pi_{U2}^N(K = 2)$. If $E \leq E^N$, the entrant always enters the market and the optimal fixed fee is $\pi_{U2}^F(K = 3) - \pi_{U2}^N(K = 3)$. By using equation (4), we can derive the optimal fixed fees for different entry costs. They are summarized in the following lemma:

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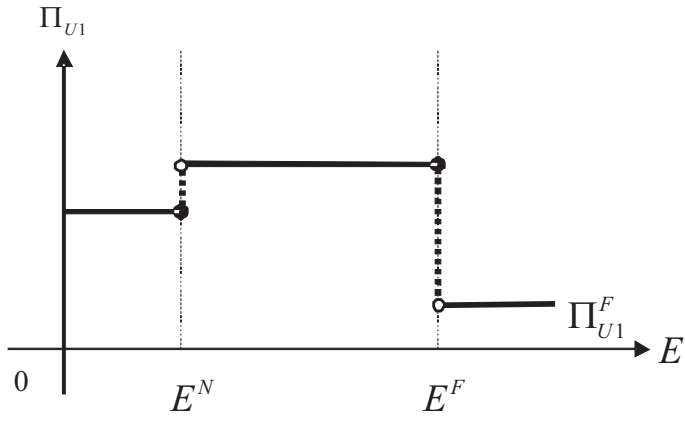


Figure 2: Licensor's profits under fixed-fee licensing

Lemma 1. Under fixed-fee licensing, the optimal fixed fee is as follows:

(i) If the entry cost is high such that $E > E^F$, there is no entry and the optimal fixed fee is $8\varepsilon(a-c)/27$.

(ii) If the entry cost is moderate such that $E^N < E \leq E^F$, downstream entry occurs and the optimal fixed fee is $[(a-c-\varepsilon)^2 + 36\varepsilon(a-c)]/108$.

(iii) If the entry cost is low such that $E \leq E^N$, downstream entry occurs and the optimal fixed fee is $\varepsilon(a-c)/3$.

By substituting optimal fixed fees in Lemma 1 into the licensor's profit function in (7) or (11), we can derive the equilibrium profit of the upstream licensor as follows:

$$\Pi^F_{U1} = \begin{cases} \frac{1}{27}\left(2(a-c+\varepsilon)^2 + 8\varepsilon(a-c)\right) & \text{if} \quad E > E^F, \\ \frac{1}{54}\left((a+5\varepsilon-c)(5a+\varepsilon-5c)\right) & \text{if} \quad E^N < E \leq E^F, \\ \frac{1}{12}\left((a-c+\varepsilon)^2 + 4\varepsilon(a-c)\right) & \text{if} \quad E \leq E^N. \end{cases} \tag{13}$$

From (13), we can draw the licensor's profit against entry costs under fixed-fee licensing in Figure 2.

This figure shows that the profit of the licensor under fixed-fee licensing is not monotonically related to the entry cost. As shown in Lemma 1, when the entry cost is moderate ($E^N < E \leq E^F$), the licensor charges the highest fixed fee. The economic explanation is as follows. In this case, entry occurs

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only if licensing exists and such entry expands the derived demand for the intermediate good, raising the licensee's profit as well as its willingness to pay for the innovation. With full bargaining power, the licensor can extract the licensee's rents from both the lower production cost and the expanded derived demand. Hence, relative to optimal fixed fees for low or high entry costs, the optimal fixed fee is highest when the entry cost is moderate. By contrast, when the entry cost is low or high, the downstream market structure is unaffected by the upstream licensing. As a result, the fixed fee would be lower as it can only serve the purpose of extracting the rent of the licensee from the lower production cost. Furthermore, the profit of the licensor is higher under $E \leq E^N$ than under $E > E^F$, as entry occurs only in the former.

3.2 The Entry Decision and the Optimal Royalty Rate

We now turn to investigate the licensing equilibrium if the upstream licensor adopts royalty licensing. If the licensor chooses royalty licensing, the marginal cost of Firm U_2 is $c^R = c - \varepsilon + r$. We shall show that the optimal royalty rate is affected by the level of the downstream entry cost.

If $E \leq E^N$, the entrant enters the market. By setting $K = 3$, we can derive the optimal royalty rate to be $r = \varepsilon$ and the corresponding profit of the licensor as follows:

$$\Pi_{U1}^R = \frac{(a - c + 2\varepsilon)^2}{12} + \frac{\varepsilon(a - c - \varepsilon)}{4}. \tag{14}$$

Furthermore, if $E > E^N$, the downstream entry may or may not occur, depending on the royalty rate. Specifically, if the licensor charges the full royalty rate, i.e., $r = \varepsilon$, entry does not occur; it may occur if the licensor does not charge the royalty rate to its full extent, i.e., $r < \varepsilon$. The optimal royalty rate is found by maximizing the profit of the licensor subject to the entry condition of the potential entrant. To derive this optimal royalty rate, we first define the profit function of the potential entrant for a given royalty rate as follows:

$$\pi_e^R = \frac{[2(a - c + \varepsilon) - r]^2}{144} - E.$$

If the upstream licensor prefers to accommodate the entry, it will set the royalty rate just low enough to attract the downstream entry. That is, the royalty rate is derivable by setting the entrant's profit equal to zero, which yields:

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$$\hat{r} = 2(a - c + \varepsilon) - 12\sqrt{E}.$$

The resulting profit of the licensor is as follows:

$$\Pi_{U1}^{R} = \frac{3}{4}\left(20\sqrt{E}\left(a - c + \varepsilon - 4\sqrt{E}\right) - (a - c + \varepsilon)^2\right). \tag{15}$$

On the other hand, if the licensor does not accommodate the entry, we have $K = 2$. The upstream licensor will set the full royalty rate, i.e., $r = \varepsilon$ and make the following profit:

$$\Pi_{U1}^{R} = \frac{2(a - c + 2\varepsilon)^2}{27} + \frac{2\varepsilon(a - c - \varepsilon)}{9} \tag{16}$$

Whether or not the licensor should accommodate the entry depends on the profits in (15) and (16). By setting the two profits equal to each other, we can derive the following critical entry cost $\hat{E}$:

$$\hat{E} = \frac{1}{12960}\Big[227(a - c - \varepsilon)^2 + 828\varepsilon(a - c) + 9(a - c + \varepsilon)\sqrt{245(a - c - \varepsilon)^2 + 180\varepsilon(a - c)}\Big].$$

If $E \leq \hat{E}$, the optimal royalty rate is $\hat{r}$, the entry takes place and the licensor's profit is that in (15). On the other hand, if $E > \hat{E}$, the royalty rate is ε, the downstream entry does not occur and the licensor's profit is that in (16).

By summarizing the above discussions, we can establish the following lemma:

Lemma 2. Under royalty licensing, the optimal royalty rate is as follows:

(i) If $E > \hat{E}$, the optimal royalty rate is equal to the cost reduction of the innovation (i.e., $r = \varepsilon$) and the entry does not occur.

(ii) If $E^N < E \leq \hat{E}$, the optimal royalty rate is less than the cost reduction of the innovation (i.e., $r = 2(a - c + \varepsilon) - 12\sqrt{E}$) and the entry occurs.

(iii) If $E \leq E^N$, the optimal royalty rate is again equal to the innovation (i.e., $r = \varepsilon$) and the entry occurs.

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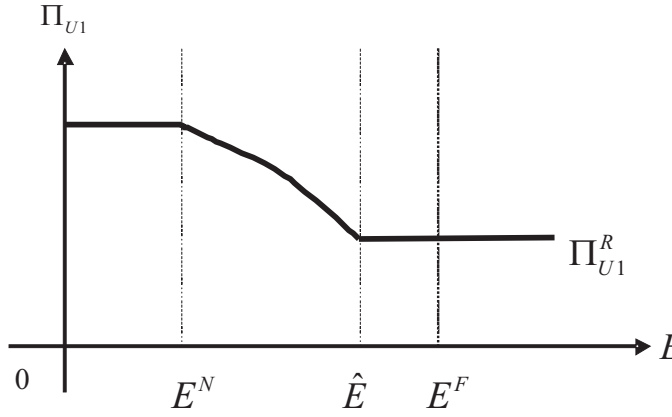


Figure 3: The profits of the licensor under royalty licensing

It shows that, to accommodate entry, the licensor may not always raise its royalty rate to the level of maintaining its cost advantage (i.e., $r = \varepsilon$). Instead, it may sacrifice part of its licensing revenue in exchange for an entry in the downstream market. This occurs when the entry cost is moderate (i.e., $E^N < E \leq \hat{E}$). If the entry cost is higher or lower than this interval, the licensor always raises its royalty rate to the full extent to leave the licensee's effective marginal cost unchanged after licensing.

By combining the profits of the licensor firm in (14), (15) and (16), we can derive the licensor's profit against the entry cost under royalty licensing as follows:

$$\Pi_{U1}^{R} = \begin{cases} \frac{1}{27}\left(2(a-c+2\varepsilon)^2 + 6\varepsilon(a-c-\varepsilon)\right) & \text{if} \quad E > \hat{E}, \\ \frac{3}{4}\left(20\sqrt{E}\left(a-c+\varepsilon-4\sqrt{E}\right)\right. & \\ \quad \left. -(a-c+\varepsilon)^2\right) & \text{if} \quad E^N < E \leq \hat{E}, \\ \frac{1}{12}\left((a-c+2\varepsilon)^2 + 3\varepsilon(a-c-\varepsilon)\right) & \text{if} \quad E \leq E^N. \end{cases} \tag{17}$$

From (17), we can draw Figure 3 to depict the relationship between the licensor firm's profits and the entry costs under royalty licensing. Unlike the curve under fixed-fee licensing, the one under royalty licensing is not increasing with the entry cost.

From the discussions in this and the previous sections, we find that the downstream market structure depends on not only the fixed entry cost but also the type of the licensing contract. If the entry cost is lower than $\hat{E}$,

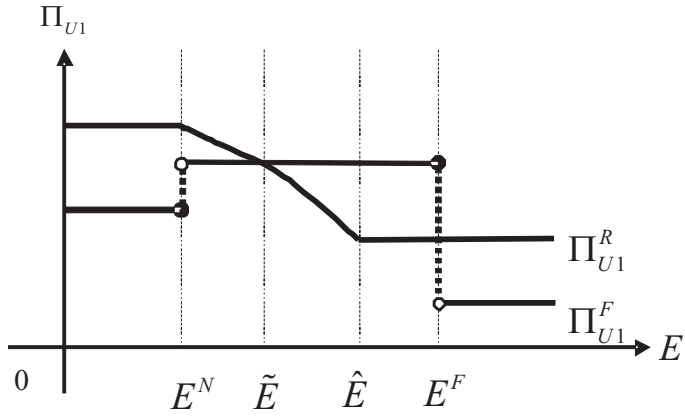


Figure 4: The profits of the licensor under fixed-fee and royalty licensing

Firm D_e enters under either of the licensing contracts. If the entry cost is moderate such that $\hat{E} < E \leq E^F$, Firm D_e will enter under fixed-fee licensing but will stay outside under royalty licensing. Finally, if the entry cost is high such that $E > E^F$, Firm D_e will not enter under either of the licensing contracts. We summarize these results in the following proposition:

Proposition 1. When the entry cost is moderate (i.e., $\hat{E} < E \leq E^F$), downstream entry takes place under fixed-fee but not royalty licensing. Otherwise, the entry outcome is the same under the two licensing contracts.

The intuition behind the proposition is explained as follows. Relative to royalty licensing, fixed-fee licensing results in a lower input price which makes downstream entry more likely to happen. This possibility becomes insignificant when the entry cost is sufficiently low (or high).

4 The Optimal Licensing Contract

We are now in a position to compare the profits of the licensor under the two licensing regimes to determine the optimal contract in the first-stage game. By combining Figures 2 and 3, we can compare the profits of the licensor under the two licensing regimes for a given entry cost. This is shown in Figure 4.

Figure 4 shows that if the entry cost is low or high (i.e., $E \leq E^N$ or $E > E^F$), royalty licensing is superior to fixed licensing from the licen-

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sor's perspective. This result is along the lines of the standard conclusion in the existing literature; see for example, Wang (1998). Under such a circumstance, the entry decision of the downstream entrant is not affected by the licensing contract and the licensor is better off to license out its innovation via royalty licensing. Nevertheless, if the entry cost is moderate such that $E^N < E \leq E^F$, fixed-fee licensing could become superior to royalty licensing for the licensor. Three cases emerge in this interval. First, if $E^N < E \leq \tilde{E}$,[5] royalty licensing is still the optimal form of licensing because the licensor can enjoy most of the cost advantage after licensing and also benefit from the expanded derived demand due to the entry. Second, if $\tilde{E} < E \leq \hat{E}$, downstream entry takes place under both licensing regimes. However, fixed-fee licensing is superior to royalty licensing as the licensor, if choosing royalty licensing, has to lower its royalty rate significantly to be able to attract entry. This lower royalty rate intensifies competition in the upstream market, thereby making royalty licensing unprofitable to the licensor. Third, if $\hat{E} < E \leq E^F$, the downstream entry occurs *only* under the fixed-fee licensing. This entry increases the derived demand and raises the licensor's profit, making the licensor firm prefer fixed-fee to royalty licensing. We summarize the above results in the following proposition:

Proposition 2. If the entry cost of the downstream entrant is moderate, the upstream licensor prefers fixed-fee to royalty licensing. Otherwise, it prefers royalty to fixed-fee licensing.

This result is in sharp contrast to the findings in the literature on technology licensing which concludes that royalty licensing is optimal for an insider licensor if the products of the two firms are either homogeneous or not too differentiated. In our model, the intermediate goods supplied by the two upstream firms are homogeneous. Following the literature, we should expect royalty licensing to be optimal. However, due to the potential entry in the downstream market, the above result is reversed if the entry cost is moderate.

5 Conclusions

In this paper we have examined the optimal licensing contract of an upstream firm when there is a potential entrant in the downstream market. It

[5] See the Appendix for the derivation of $\tilde{E}$.

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is found that the optimal licensing contract is that of fixed-fee licensing if the entry cost is moderate. This finding is in sharp contrast to that in the literature which shows that an insider licensor always prefers royalty to fixed-fee licensing if the products in the market are homogeneous. In our model, the products produced by the licensor and licensee firms are homogeneous, but the licensor may still prefer fix-fee licensing for two reasons. First, fixed-fee licensing is superior from the perspective of the licensor as it can better accommodate the entry. That is, the downstream entry could take place under fixed-fee but not royalty licensing which makes fixed-fee licensing superior to royalty licensing. Moreover, even if both licensing contracts accommodate the entry, fixed-fee licensing can still be better than royalty licensing as the licensor needs to lower its royalty rate to attract the entry, but this does not happen in the case of fixed-fee licensing. Those results reveal that the implications of technology licensing based on upstream markets are very different from those based on downstream markets.

There are several ways in which this paper could be extended for future studies. First, we could relax the assumption of homogeneous goods in the upstream or the downstream markets to see how sensitive our results are to product differentiation in the two markets. Second, we have assumed that the upstream market is duopolistic and that the upstream licensor licenses its innovation to the other upstream firm. It is of interest to extend the analysis to oligopoly. With this extension, we could examine the relationship between the optimal number of licensees and how the optimal contract form is affected. These extensions are reserved for future research.

Appendix

By subtracting the corresponding profit in (13) from that in (17), we have the profit difference of the licensor under the two licensing contracts as follows:

$$\Delta\Pi_{U1} = 15\sqrt{E}(a-c+\varepsilon) - 60E - \frac{1}{108}\left[91(a-c+\varepsilon)^2 + 32\varepsilon(a-c)\right].$$

By definition, at $\tilde{E}$, the profit difference disappears. Hence, by setting the above equation to zero, we can derive $\tilde{E}$ as follows:

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$$\tilde{E} = \frac{1}{12960}\Big[223(a-c-\varepsilon)^2 + 828\varepsilon(a-c) + 9(a-c+\varepsilon)\sqrt{205(a-c-\varepsilon)^2 + 180\varepsilon(a-c)}\Big].$$

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垂直相關市場的技術授權與進入

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本文探討在垂直相關市場下產業內技術授權廠商的最適授權決策。此一授權廠商生產並出售一中間財貨給予下游廠商, 且可採用單位權利金 (royalty licensing) 或固定權利金 (fixed-fee licensing) 的方式將其技術授權給另一家上游的競爭廠商。本文發現技術授權廠商的最適授權方式可能爲固定權利金; 藉此下游的潛在廠商較可能進入最終財市場並提高中間財的衍伸性需求。此外, 即使這兩種授權方式皆導致下游的潛在廠商進入市場, 固定權利金仍可能優於單位權利金。其原因在於: 當採用單位權利金的方式來授權時, 技術授權廠商必須降低單位權利金來使下游的潛在廠商進入市場, 而導致其利潤下降。

關鍵詞: 最適授權, 廠商進入, 中間財市場
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