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Technology licensing and innovation☆

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HIGHLIGHTS

- Showing the effects of technology licensing on innovation.
- A fixed-fee licensing contract may either decrease or increase innovation.
- Licensing increases innovation under a two-part tariff licensing contract.
- Licensing does not reduce social welfare irrespective of its effect on innovation.

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ABSTRACT

We show that under a fixed-fee licensing contract if the licenser and the licensee bargain over the licensing fee, licensing decreases (increases) innovation by decreasing (increasing) the strategic (non-strategic) benefit from innovation. However, licensing increases innovation under a two-part tariff licensing contract. Licensing does not reduce social welfare.

1. Introduction

Gallini and Winter (1985) (henceforth GW) show that the availability of technology licensing encourages innovation if the *firms' initial costs are close* but it discourages innovation if the initial costs are sufficiently asymmetric. We show that the availability of licensing can discourage innovation even in industries with *initially symmetric costs* firms if the firms bargain over the licensing fee.

We show that licensing decreases (increases) R&D investment under a fixed-fee licensing contract if the cost of innovation is moderate but low (high), since it decreases (increases) the strategic (non-strategic) benefit from innovation.[1] Licensing increases innovation under a two-part tariff licensing contract. Licensing does not reduce social welfare.

With an innovating firm and n non-innovating firms, Chang et al. (2013) show that licensing may reduce *marginal profits* from innovation and the R&D investments. They also show that lower R&D investment in the presence of licensing may reduce welfare compared to no licensing. In contrast, we consider all innovating firms and show that bargaining powers of the licenser and the licensee play important role in affecting the *total profits* and the R&D investments of the firms.

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[1] A firm's non-strategic (strategic) benefit from innovation is given by its payoff from innovation, net of its payoff from no innovation, when the competitor firm does not innovate (innovates) (Roy Chowdhury, 2005).

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Table 1
The payoffs of firms 1 and 2.

		Firm 2	
		Innovation	No innovation
Firm 1	Innovation	$\pi_1(0,0)-k, \pi_2(0,0)-k$	$\pi_1(0,c)-k, \pi_2(0,c)$
	No innovation	$\pi_1(c,0), \pi_2(c,0)-k$	$\pi_1(c,c), \pi_2(c,c)$

2. R&D and production without licensing

There are two firms, 1 and 2, competing like Cournot duopolists with homogeneous products. Each firm has a technology corresponding to the constant marginal cost of production (MC) c. Each firm can invest k amount in R&D to reduce its MC to c_l, which is normalized to 0. This is a simplified version of GW. To show the effects of licensing on innovation in an industry with initially symmetric cost firms, we assume that both firms have the same technology to start with.

Assume that the inverse market demand function is $P = a - q$, where P is price and q is the total output. We assume that $c < \frac{a}{2}$, ensuring positive equilibrium outputs of the firms.

We consider the following game. At stage 1, the firms decide simultaneously whether to invest in R&D or not. At stage 2, the firms determine their outputs simultaneously and the profits are realized. We solve the game through backward induction.

If neither firm innovates, the equilibrium output and the profit of the ith firm, $i = 1, 2$, are $q_i^*(c, c) = \frac{(a-c)}{3}$ and $\pi_i(c, c) = \frac{(a-c)^2}{9}$ respectively.[2] If both firms innovate, the equilibrium output and the net profit of the ith firm, $i = 1, 2$, are $q_i^*(0, 0) = \frac{a}{3}$ and $\pi_i(0, 0) = \frac{a^2}{9} - k$ respectively. If only firm 1 (firm 2) innovates, the equilibrium outputs of firms 1 and 2 are $q_1^*(0, c) = \frac{(a+c)}{3}$ and $q_2^*(0, c) = \frac{(a-2c)}{3}$ ($q_1^*(c, 0) = \frac{(a-2c)}{3}$ and $q_2^*(c, 0) = \frac{(a+c)}{3}$) respectively, and the corresponding equilibrium net profits are $\pi_1(0, c) = \frac{(a+c)^2}{9} - k$ and $\pi_2(0, c) = \frac{(a-2c)^2}{9}$ ($\pi_1(c, 0) = \frac{(a-2c)^2}{9}$ and $\pi_2(c, 0) = \frac{(a+c)^2}{9} - k$).

The equilibrium R&D decisions follow easily from the payoff Table 1. We consider only pure strategy equilibria.

Neither firm innovates if

$$\pi_1(0, c) - \pi_1(c, c) = \pi_2(c, 0) - \pi_2(c, c) \equiv Y < k. \tag{1}$$

Condition (1) shows a firm's non-strategic benefit from innovation, i.e., a firm's benefit from innovation when the other firm does not innovate.

Both firms innovate if

$$\pi_1(0, 0) - \pi_1(c, 0) = \pi_2(0, 0) - \pi_2(0, c) \equiv X > k. \tag{2}$$

Condition (2) shows a firm's strategic benefit from innovation, i.e., a firm's benefit from innovation when the other firm innovates.

Given the demand and cost specifications, we get $X < Y$, which gives the following result immediately.[3]

Proposition 1. *Both firms innovate if $k < X$. Only one firm innovates if $X < k < Y$. Neither firm innovates if $Y < k$.*

On the one hand, innovation helps to increase the product-market profit of the innovating firm and reduces the product-market profit of the non-innovating firm. On the other hand, it imposes a cost on the innovating firm. If the cost of innovation is small, the benefit from higher product-market profit encourages both firms to innovate. However, if innovation is very costly, it discourages both firms from innovating. For moderate cost of innovation, if one firm innovates, the net gain from innovation to the other firm is negative, and only the former firm innovates.

3. Licensing ex-post innovation

If only one firm innovates, it creates the avenue for technology licensing ex-post R&D. If either no firm innovates or both firms innovate, there is no possibility of technology licensing.

We consider the following game. At stage 1, the firms decide simultaneously whether to innovate or not. If only one firm innovates at stage 1, at stage 2, the innovating firm decides whether to license the technology or not. At stage 3, the firms compete like Cournot duopolists and the profits are realized. We solve the game through backward induction.

We will consider two types of licensing contracts. We consider a fixed-fee licensing, such as in Katz and Shapiro (1985) and Marjit (1990), in Section 3.1. Fixed-fee licensing is appropriate if either the licensee can imitate or 'invent around' the licensed technology or there is lack of information about the licensee's output that is necessary for making output royalty feasible. We consider a two-part tariff licensing in Section 3.2. We assume that price of the licensed technology is determined by bargaining between the licenser and the licensee (see, e.g., Mukherjee, 2002 and Yang and Maskus, 2009).

3.1. Fixed-fee licensing

Under a fixed-fee licensing, the licenser charges an up-front fixed-fee. Since the firms are symmetric, without the loss of generality, consider the problem of firm 1 as a licenser. If only firm 1 innovates in stage 1, the equilibrium gross profits (which includes the cost of innovation) under no licensing are $\pi_1(0, c)$ and $\pi_2(0, c)$. However, under a fixed-fee licensing, the equilibrium gross profits (which include the cost of innovation and the fixed-fee of licensing) are $\pi_1(0, 0) = \pi_2(0, 0)$. The following maximization problem determines the non-negative licensing fee, F:

$$\underset{F}{\text{Max}} \, [\pi_1(0, 0) + F - \pi_1(0, c)]^{\alpha} \times [\pi_2(0, 0) - F - \pi_2(0, c)]^{(1-\alpha)}, \tag{3}$$

where $\alpha \in [0, 1]$ (resp. $(1 - \alpha)$) shows the bargaining power of the licenser (resp. licensee).[4] The equilibrium licensing fee is $F^* = \alpha[2\pi_1(0, 0) - \pi_1(0, c) - \pi_2(0, c)] + [\pi_1(0, c) - \pi_1(0, 0)]$.

If firm 1 licenses its technology to firm 2, firm 1's gain from licensing is $\pi_1(0, 0) - \pi_1(0, c) + F^* = \alpha[2\pi_1(0, 0) - \pi_1(0, c) - \pi_2(0, c)]$ and firm 2's gain from licensing is $\pi_2(0, 0) - \pi_2(0, c) - F^* = (1 - \alpha)[2\pi_1(0, 0) - \pi_1(0, c) - \pi_2(0, c)]$, since $\pi_1(0, 0) = \pi_2(0, 0)$. The firms will opt for licensing if neither firm is worse-off under licensing compared to no-licensing, implying that licensing is profitable if $2\pi_1(0, 0) > \pi_1(0, c) + \pi_2(0, c)$. Given our demand and cost conditions, licensing occurs if $c < \frac{2a}{5}$. The intuition for this result follows from Marjit (1990).

Following the procedure of Section 2, the equilibrium R&D strategies can be found from the payoff Table 2, showing the payoffs for $c < \frac{2a}{5}$.

2 We define the profit of the ith firm, $i = 1, 2$, in the product market by $\pi_i(\cdot, \cdot)$, where the first (second) argument in the profit function stands for the marginal cost of firm 1 (firm 2). Since the calculations are straightforward, we skip the details here.

3 We have $\pi_2(c, 0) - \pi_2(c, c) = \frac{(a+c)^2-(a-c)^2}{9}$ and $\pi_2(0, 0) - \pi_2(0, c) = \frac{a^2-(a-2c)^2}{9}$.

4 We assume that the bargaining power of the licenser and licensee do not depend on the identity of a firm, i.e., whether it is firm 1 or firm 2.