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Abstract

We show the impact of technology licensing on optimal patent policy. Strong patent protection that eliminates imitation may not be the equilibrium outcome in the presence of licensing. Depending on the cost of innovation, licensing may either increase or reduce the strength of the patent protection.

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1. Introduction

Industry cases show that there has been an increase in the number of collaborative ventures among firms in recent decades (Mowery 1988). One such activity is licensing of technology. Grindley and Teece (1997) point to the increasing use of licensing by firms such as IBM, Hewlett-Packard, Texas Instruments and AT&T. Arora et al. (2001) provide a comprehensive list on the size and sectoral composition of licensing.

However, licensing has not been adequately considered in the literature on patent design (see, e.g. Gilbert and Shapiro 1990, Klemperer 1990, and Gallini 1992). Hence, the patent policies prescribed in the existing literature may not be appropriate in industries where technology licensing is commonly observed. The present paper is a step to fill this gap.[1]

We consider two patent regimes: *(i)* weak patent protection, where knowledge spillover creates competition in the product market, and *(ii)* strong patent protection, where knowledge spillover does not occur, thus making the innovator a monopolist. We show that strong patent protection may not be the equilibrium outcome if licensing is an option. This result has an important implication for competition policy. It suggests that if firms have the option to increase profits through licensing, the government should not design the patent policy in a way that discourages licensing. Strong patent protection may dampen the incentive for licensing by preventing imitation. This, in turn, has a negative impact on welfare. Thus, licensing (compared with no licensing) induces weaker patent protection.

More interestingly, we also show that the presence of transaction costs in licensing may encourage a government to increase the strength of patent protection compared to a situation with no licensing. Because of transaction costs, firms may not engage in licensing under a weak patent regime, since the gain from licensing may be outweighed by its cost. Hence, a weak patent regime prevents society from capturing the benefit of licensing. To get around the problem, the government needs to strengthen patent protection.

2. Patent Regimes without Licensing

Consider an economy with an innovator, called firm 1 and an imitator, called firm 2. Firm 1 spends I to invent a technology corresponding to the marginal cost of production $\hat{c}$, which is normalized to 0. We consider two types of patent regimes: (i) strong patent regime, and (ii) weak patent regime. The main difference between the two regimes is that under a strong patent regime, imitation is not feasible and firm 1 is a monopolist, while imitation occurs under a weak patent regime and the firms compete as Cournot duopolists. The marginal cost of the imitator under a weak patent protection is $c > 0$, and it decreases with a weakening of the degree of patent protection.

We consider the following game. In stage 1, the government selects the degree of patent protection, denoted by c that maximizes welfare of the economy, which is the sum of net industry profit and consumer surplus. In stage 2, firm 1 decides whether to innovate or not. In stage 3, firm 2 decides whether to imitate or not. In stage 4, production takes place and the profits are realized. We solve the game through backward induction.

The inverse market demand function is

$$P = 1 - q \tag{1}$$

where P is price and q is the total output.

[1] Gallini and Winter (1985), Katz and Shapiro (1985), Kultti and Takalo (1998) and Mukherjee (2005) examine the effects of licensing on R&D but ignore the issue of patent protection. Mukherjee and Pennings (2004) consider the implications of imitation and licensing on patent protection but focus on technology adoption. Mukherjee (2006) shows whether patent protection increases innovation in the presence of licensing. However, it does not consider optimal patent policy.

2.1. Strong patents

Under this regime, firm 1 is a monopolist and its net profit is $\pi_1^{s,nl} = \frac{1}{4} - I$. In order to ensure that a monopolist has the incentive for innovation, we assume that $I < \frac{1}{4}$. If this assumption is violated, firm 1 has no incentive to innovate irrespective of the patent regime. Under strong patent, welfare of the economy is

$$W^{s,nl} = \frac{3}{8} - I. \tag{2}$$

2.2. Weak patents

Under this regime, the profits of firms 1 and 2 are $\pi_1^{w,nl} = \frac{(1+c)^2}{9} - I$ and $\pi_2^{w,nl} = \frac{(1-2c)^2}{9}$. Note that the patent system is called weak if it creates effective competition in the product market, which occurs if $c < 0.5$. Welfare under a weak patent is

$$W^{w,nl} = \frac{2(1+c)^2 + 2(1-2c)^2 + (2-c)^2}{18} - I. \tag{3}$$

Now determine the optimal patent policy. Let c^I be the degree of weak patent protection that makes firm 1 indifferent between innovating and not innovating. Hence, $(1+c^I)^2 = 9I$ and firm 1 innovates if $c > c^I$. Since $I < \frac{1}{4}$, c^I exists and lies between *0* and *0.5* whenever $I > \frac{1}{9}$. In particular, when $\frac{1}{9} < I < \frac{1}{4}$, c^I is given by

$$c^I = 3\sqrt{I} - 1.$$

It follows from (3) that $W^{w,nl}$ is convex in c for $c \in [0, 0.5]$. Further, $W^{w,nl} = W^{s,nl}$ at c = *0.5*, $W^{w,nl} > W^{s,nl}$ at c = *0*, and the minimum value of $W^{w,nl}$ is lower than $W^{s,nl}$. Hence, there exists a $c = c^*$ such that (i) $W^{s,nl} = W^{w,nl}$ at c^*, (ii) $W^{s,nl} < W^{w,nl}$ for $c \in [0, c^*)$, and (iii) $W^{s,nl} > W^{w,nl}$ for $c \in (c^*, 0.5]$. This is depicted in Figure 1 below.

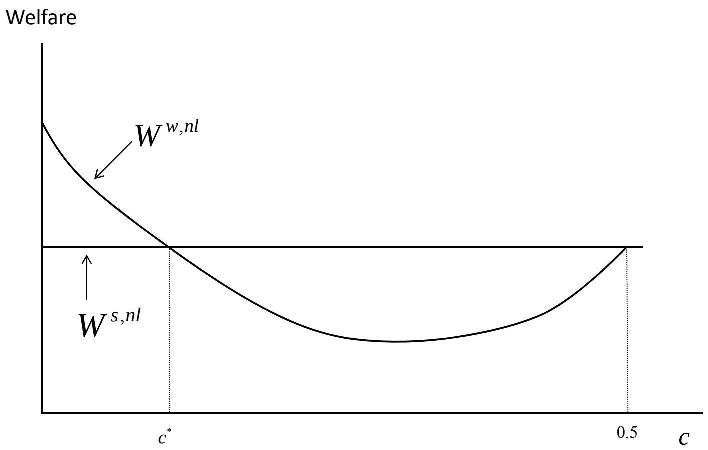

Figure 1: Welfare without Licensing

Proposition 1: *(a) If* $I < \frac{1}{9}$*, welfare maximizes at c = 0 (no protection).*

(b) If $I \in (\frac{1}{9}, \frac{(1+c^*)^2}{9})$*, welfare maximizes at* $c = c^I$ *(weak protection).*

(c) If $I \in (\frac{(1+c^*)^2}{9}, \frac{1}{4})$*, welfare maximizes at* $c \geq 0.5$ *(strong protection).*

Proof: (a) If $I < \frac{1}{9}$, firm 1 innovates even with no patent protection. Since $W^{w,nl} > W^{s,nl}$ at c = 0, the optimal value of c is 0 in this situation.

(b) If $I \in (\frac{1}{9}, \frac{(1+c^*)^2}{9})$, then $0 < c^I < c^*$. Hence, welfare maximizes at $c = c^I$, since $W^{s,nl} < W^{w,nl}$ for $c \in [0, c^*)$.

(c) If $I \in (\frac{(1+c^*)^2}{9}, \frac{1}{4})$, then $c^I > c^*$. Hence, welfare maximizes at $c \geq 0.5$ ■

3. Patent Regimes with Licensing

Now extend the above analysis with licensing. Under licensing, firm 1 makes a take-it-or-leave-it offer to firm 2 consisting of a fixed-fee *F* and a royalty rate *r*. Firm 2's effective marginal cost under licensing is *r*, since licensing reduces its production cost to *0*. We assume that licensing involves a transaction cost of *K*. As discussed in Teece (1976) and Arora et al. (2001), the source of such costs is the cost of writing contracts, the cost of enforcement, etc.

In this section, the timeline is the same as in the previous section for stages 1, 2 and 3. However, in stage 4, firm 1 decides whether to license its technology. If firm 1 offers a licensing contract, firm 2 accepts the offer if licensing does not make firm 2 worse off compared with no licensing. Finally, in stage 5, production takes place and the profits are realized. We solve the game through backward induction.

3.1. Strong patents

Under strong patent, firm 1 is a monopolist without licensing and has no incentive to license its technology. Therefore, the profits and welfare are similar to that of subsection 2.1.

3.2. Weak patents

Under weak patent, the profits of firms 1 and 2 are $\pi_1^{w,nl} = \frac{(1+c)^2}{9} - I$ and $\pi_2^{w,nl} = \frac{(1-2c)^2}{9}$ under no licensing, while the respective profits are $\pi_1^{w,l} = \frac{(1+r)^2}{9} + \frac{r(1-2r)}{3} + F - I$ and $\pi_2^{w,l} = \frac{(1-2r)^2}{9} - F$ under licensing. We assume for simplicity that the entire transaction cost is incurred by firm 1. However, this assumption does not matter, since firm 1 can adjust the fixed fee that firm 2 pays. It must also be noted that licensing occurs if neither firm 1 nor firm 2 is worse off under licensing compared to no licensing.

It can be shown that the optimal royalty rate is $r^* = c$ and the optimal fixed fee is $F^* = 0$. The equilibrium net profits of the firms under licensing are $\pi_1^{w,l} = \frac{(1+c)^2 + 3c(1-2c)}{9} - I - K$ and $\pi_2^{w,l} = \frac{(1-2c)^2}{9}$.

The above discussion assumes that licensing is profitable, which occurs if it increases the industry profit compared with no licensing. Licensing is profitable if

$$\frac{c(1-2c)}{3} > K. \tag{4}$$

The left hand side of (4) is concave in c for $c \in [0, 0.5]$ and is maximized at $\frac{1}{24}$. Let c_1 and c_2 be the values of c that equate the two sides of (4). Hence, for $K \in [0, \frac{1}{24}]$, licensing is not profitable for $c \in [0, c_1)$ and $c \in (c_2, 0.5]$, while it is profitable for $c \in [c_1, c_2]$.

If licensing is profitable, i.e., if condition (4) holds, welfare is

$$W^{w,l} = \frac{2(1+c)^2 + 2(1-2c)^2 + 6c(1-2c) + (2-c)^2}{18} - I - K. \quad (5)$$

Now we analyze the change in the welfare function due to licensing. Note that $W^{w,l}$ is negatively sloped and concave in c for $c \in [0, 0.5]$, $W^{w,l} + K = W^{w,nl} = W^{s,nl}$ at $c = 0.5$ and $W^{w,l} + K = W^{w,nl} > W^{s,nl}$ at $c = 0$.

First, consider the case of $K = 0$. In this case, note from (4) that if licensing is an option, firm 1 licenses its technology for $c \in (0, 0.5)$. Further, if $K = 0$, $W^{w,l} > W^{w,nl}$ for $c \in (0, 0.5)$. Hence, if $K = 0$ and licensing is an option, a strong patent regime is never optimal. In contrast, it follows from Proposition 1(c) that without the option to license, a strong regime is optimal for $I \in (\frac{(1+c^*)^2}{9}, \frac{1}{4})$.

Next, consider the case of $K > 0$. For a given $K > 0$, Figure 2 shows the profits of firm 1 and welfare for different values of c.

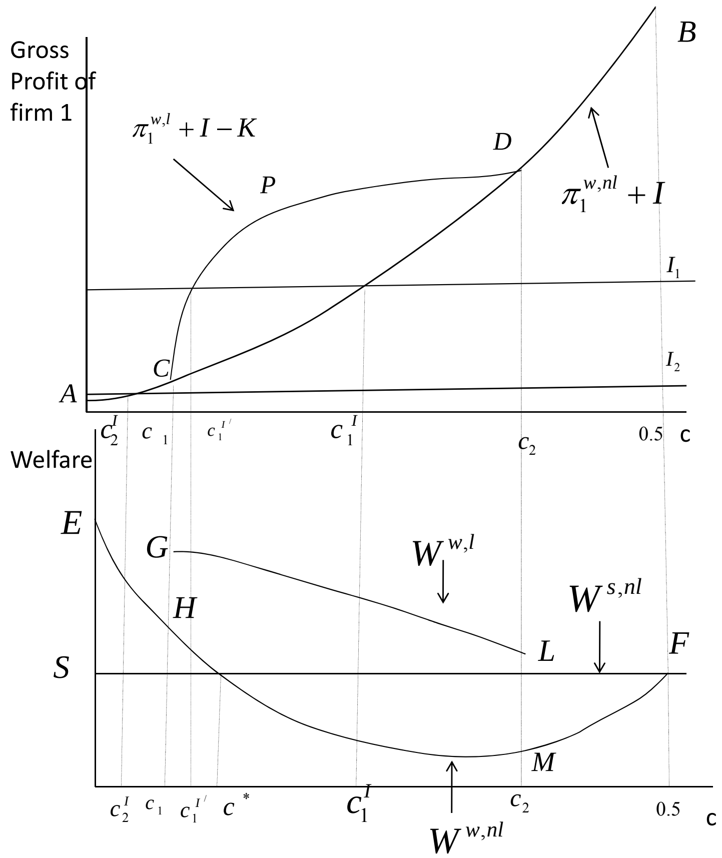

Figure 2: Profit of firm 1 and welfare with and without licensing

The upper panel of Figure 2 shows the gross profit of firm 1 (which includes the cost of innovation) and the lower panel of Figure 2 shows welfare for different values of c. The curve *AB* is the profit of firm 1 without licensing and the curve *ACPDB* is the profit of firm 1 with licensing. Notice that licensing occurs for $c \in [c_1, c_2]$.

In the lower panel of Figure 2, the curves *SF*, *EHMF* and *EHGLMF* depict $W^{s,nl}$, $W^{w,nl}$ and $W^{w,l}$ respectively. Since licensing does not occur under the weak patent regime for $c \in [0, c_1)$ and $c \in (c_2, 0.5]$, we obtain $W^{w,nl} = W^{w,l}$ in these situations.

Now consider I_1 as the cost of innovation in Figure 2. Under no licensing, the optimal regime must be strong (*c = 0.5*). However, under licensing, the equilibrium patent protection is $c_1^{I'}$, which implies that licensing reduces the strength of patent protection in this situation.

Next, consider the case where the cost of innovation is I_2. In this situation, the equilibrium patent protection under no licensing corresponds to c_2^I. However, in the presence of licensing, since licensing occurs for $c \in [c_1, c_2]$, the optimal patent protection is $c = c_1$, since such a policy maximizes welfare (given by point *G*) subject to the constraint that firm 1 innovates and licenses its technology. Therefore, licensing increases the strength of patent protection if the cost of innovation is I_2. This result is presented in the proposition below.

Proposition 2: *(a) If licensing is costless, strong patent protection is not the equilibrium outcome in the presence of licensing.*
(b) If there is a positive cost of licensing, licensing may increase or reduce the strength of patent protection, depending on the cost of innovation. For a given positive cost of licensing, licensing increases the strength of patent protection if the cost of innovation is such that the optimal level of patent protection under no licensing is less than c^* and licensing does not occur at the optimal level of patent protection under no licensing. However, if the cost of innovation is such that licensing occurs at the level of patent protection that is optimal under no licensing, licensing reduces the strength of patent protection.

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