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Abstract

This note gives a short proof that both fixed-fee and royalty licensing under patent protection can always create higher R&D investment.

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In Mukherjee (2006) (Henceforth MU), royalty licensing is introduced as a regime under patent protection to always increase R&D investment irrespective of the tournament effect, which is considered in Chowdhury (2005). Then we have the following result for both fixed-fee and royalty licensing schemes

Proposition 1. *Both fixed-fee and royalty licensing under patent protection can always create higher R&D investment.*

Proof. According to Wang (1998), fixed-fee licensing for the patent-holding firm is inferior to royalty licensing when the cost-reducing innovation is non-drastic. This result is implicitly implied in Rockett (1990), which considers both fixed-fee

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and royalty licensing and concludes that in equilibrium, fixed-fee is zero and only output royalty is positive. MU already proves that royalty licensing under patent protection may always induce higher R&D investment. Now, we need to show that fixed-fee licensing also has this effect.

Fixed-fee licensing has a net profit transferred from the licensee (firm 2) to the licensor (firm 1). The optimal level of fixed-fee charged by firm 1 should be the amount that makes firm 2 indifferent between licensing and no licensing, which is

$$G(c', c) = \pi_2(c', c') - \pi_2(c', c) = \pi_1(c', c') - \pi_1(c, c'). \quad (1)$$

As a result, the net profit transfer from the licensee to the licensor when license is sold, yields the following payoff of firm 1 as

$$\begin{aligned} & \frac{1}{2} [(p_{(c', c')} - c')q_1(c', c') + G(c', c)] + \frac{1}{2} [(p_{(c', c')} - c')q_1(c', c') - G(c', c)] - F \\ & = \frac{1}{2}\pi_1(c', c') + \frac{1}{2}\pi_1(c', c') - F = \pi_1(c', c') - F. \quad (2) \end{aligned}$$

The fixed-fee $G(c', \tilde{c})$ under no patent protection with licensing is calculated using the same logic as Eq.(1), implying $G(c', \tilde{c}) = \pi_2(c', c') - \pi_2(c', \tilde{c}) = \pi_1(c', \tilde{c}) - \pi_1(c', c')$. Consequently, the game matrices can be written as

Table 3.1 payoffs under no patent protection

| | R&D | No R&D |
|--------|--------------------------------------------------------------|--------------------------------------------------------------|
| R&D | $\pi_1(c', c') - F, \pi_2(c', c') - F$ | $\pi_1(c', c') + G(c', \tilde{c}) - F, \pi_2(c', \tilde{c})$ |
| No R&D | $\pi_1(\tilde{c}, c'), \pi_2(c', c') + G(\tilde{c}, c') - F$ | $\pi(c, c), \pi(c, c)$ |

Table 4.1 payoffs under patent protection

| | R&D | No R&D |
|--------|----------------------------------------------------------|----------------------------------------------------------|
| R&D | $\pi_1(c', c') - F, \pi_2(c', c') - F$ | $\pi_1(c', c') + G(c', c) - F, \pi_2(c', c') - G(c', c)$ |
| No R&D | $\pi_1(c', c') - G(c, c'), \pi_2(c', c') + G(c, c') - F$ | $\pi(c, c), \pi(c, c)$ |

where in both tables, the strategies of firm 1 and firm 2 are labeled vertically and horizontally. For every payoff vector, the first and second expressions represent the net equilibrium payoff of firm 1 and firm 2, respectively.

Thus, from Table 3.1, we know that the non-strategic and strategic incentives for R&D under no patent protection with licensing for each firm are $N(NP) = \pi(c', c') - \pi(c, c) + G(c', \tilde{c}) - F$ and $S(NP) = \pi(c', c') - \pi(\tilde{c}, c') - F$. Meanwhile,

Table 4.1 yields the non-strategic and strategic incentives for R&D under patent protection with licensing for each firm as $N(L) = \pi(c', c') - \pi(c, c) + G(c', c) - F$ and $S(L) = G(c', c) - F$. A direct comparison between $S(L)$ and $S(NP)$, and the optimal licensing fixed-fee give:

$$S(L) - S(NP) = \pi_1(\tilde{c}, c') - \pi_1(c, c') > 0. \quad (3)$$

Similarly, the comparison between $N(L)$ and $N(NP)$ gives:

$$N(L) - N(NP) = G(c', c) - G(c', \tilde{c}) = \pi_1(c', \tilde{c}) - \pi_1(c, c') > 0 \quad (4)$$

This result implies that fixed-fee licensing also generates higher R&D investment, and it then completes the proof with the effect of royalty licensing in MU. \square

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