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# PATENTS AND R&D WITH IMITATION AND LICENSING

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# Patents and R&D with imitation and licensing

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**Abstract:** We show the effect of patent protection on R&D investment in presence of ‘inventing around’ (or imitation) and technology licensing. Though the ‘tournament effect’ under patent protection may reduce R&D investment, we show that the effect of either imitation or technology licensing can always dominate the tournament effect and create higher R&D investments under patent protection. The effect of higher R&D investment on welfare is ambiguous.

**JEL Classifications:** O31; O34; O38

**Key Words:** Inventing around; Knowledge spillover; Patent protection; R&D; Technology licensing

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## 1. Introduction

The main reason for patent protection is to enhance R&D investment by giving the innovator property right on its innovation, thus allowing recovery of R&D costs by increasing profit of the innovator. Roy Chowdhury (2005, EL) argues that if patent protection makes the R&D competition into tournament, it reduces R&D investment if the tournament effect[1] is negative. Though this is an interesting finding, we show that if there is either ‘inventing around’ (or imitation)[2] or technology licensing, patent protection can increase R&D investment *irrespective of the tournament effect*.

Though patent protection can eliminate knowledge spillover, which is the public good nature of R&D, it does not necessarily eliminate non-infringing imitation; rather, it increases the incentive for imitation (Gallini, 1992 and Mukherjee and Pennings, 2004). Section 2 shows that, if imitation is very likely, patent protection always increase R&D investment.

More interestingly, even if the patent system protects the innovation *perfectly* and eliminates imitation *completely*, there may still be *deliberate* knowledge sharing through technology licensing. Section 3 shows that patent protection always increase R&D investment in presence of technology licensing.[3] So, it may not be proper to attribute only the tournament effect to the result of Roy Chowdhury (2005); rather it is a combination of tournament effect and absence of other factors such as imitation or licensing.

The welfare effect of higher R&D investment is ambiguous.

Section 4 concludes the paper.

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[1] The tournament effect is the difference between the equilibrium payoffs of the firms in the presence and absence of patent protection when all firms do R&D.

[2] Patent protection allows non-infringing imitation of the original innovation (Gallini and Wright, 1990, Gallini, 1992 and Bessen, 2005).

[3] Using fixed-fee licensing, Roy Chowdhury (2005) shows the welfare effects of licensing under patent protection and no patent protection. However, he did not consider the effect of licensing on R&D investment. Further, as we show, the fixed-fee licensing is not optimal under patent protection.

## 2. Imitation and patent protection

Consider a market with two firms, 1 and 2, producing a homogeneous product. Let $q_i$ denotes the output of firm $i$, $i = 1,2$. The inverse market demand function is $f(q)$, where $q = q_1 + q_2$, and $f' < 0$ and $f'(q) + q_i f''(q) < 0, \forall q, q_i$.

Initially, the cost function of each firm is $cq$. However, by investing $F > 0$ in R&D, each firm can change its cost function to $c'q$, where $0 \le c' < c$. We denote the profit function of firm $i$ by $\pi_i(.,.)$, where the first (second) argument in the profit function is the marginal cost of firm 1 (firm 2). Profit of a firm is negatively (positively) related to its own (competitor's) marginal cost.

We consider a two-stage game. At stage 1, the firms simultaneously decide whether to do R&D or not. At stage 2, they compete like Cournot duopolists. After the R&D decisions, the subsequent outcome in stage 2 depends on whether there is patent protection or not. We solve the game through backward induction.

Let us now define the non-strategic and strategic incentives for R&D with and without patent protection. The *non-strategic (strategic) incentive* for R&D is firm $i$'s payoff from R&D net of its payoff from not doing R&D, when firm $j$ does not invest (invests) in R&D (Roy Chowdhury, 2005).

Now, consider no patent protection. Under bilateral R&D, each firm reduces its marginal cost to $c'q$, whereas, under unilateral R&D, the innovating firm reduces its cost to $c'q$, and knowledge spillover (caused, e.g., by the movement of personnel across firms) reduces the non-innovating firm's cost to $\tilde{c}q$, where $c' < \tilde{c} \le c$.

Table 1 shows the firms' payoffs at the R&D stage under no patent protection.

|  |  | Firm 2 |  |
| --- | --- | --- | --- |
|  |  | R&D | No R&D |
| Firm 1 | R&D | $\pi_1(c',c') - F$ , $\pi_2(c',c') - F$ | $\pi_1(c',\tilde{c}) - F$ , $\pi_2(c',\tilde{c})$ |
|  | No R&D | $\pi_1(\tilde{c},c')$ , $\pi_2(\tilde{c},c') - F$ | $\pi_1(c,c)$ , $\pi_2(c,c)$ |

**Table 1:** Payoffs under no patent protection.

The non-strategic and strategic incentives for R&D for each firm are respectively $N(NP) = \pi_2(\tilde{c},c') - \pi_2(c,c) - F = \pi_1(c',\tilde{c}) - \pi_1(c,c) - F$ and $S(NP) = \pi_2(c',c') - \pi_2(c',\tilde{c}) - F = \pi_1(c',c') - \pi_1(\tilde{c},c') - F$ .

Now, consider patent protection. Following Roy Chowdhury (2005), we assume that, under bilateral R&D, each firm gets the patent protection with probability $\frac{1}{2}$. However, by investing $I$ , the non-patent holder invents around the innovated technology with probability $z$ , and produces with marginal cost $c'$ .[4]

For unilateral R&D under patent protection, the marginal costs of the innovating and non-innovating firms are respectively $c'$ and $c$ without imitation. However, by investing $I$ , the non-innovating firm reduces its marginal cost to $\tilde{c}$ with probability $z$ , through imitation.[5] Hence, patent disclosure is not useful for knowledge diffusion, and it is consistent with Bessen (2005), which shows that patent protection does not increase knowledge diffusion. Evidences also suggest that firms do not place much value on the disclosed information (Macdonald, 1998 and Cohen et al., 2002).

[4] The technology for inventing around or imitation is similar to Bessen (2005).

[5] Like Roy Chowdhury (2005), we assume that R&D provides some critical knowledge about the innovated technology. Therefore, knowledge spillover or imitation does not give the non-innovating firm full benefit of the innovated technology.

Table 2 shows the firms' payoffs at the R&D stage under patent protection.[6]

| | | Firm 2: R&D | Firm 2: No R&D |
|---|---|---|---|
| Firm 1 | R&D | $z\pi_1(c',c') + \frac{(1-z)(\pi_1(c',c)+\pi_1(c,c'))}{2} - F - \frac{I}{2}$, $z\pi_2(c',c') + \frac{(1-z)(\pi_2(c,c')+\pi_2(c',c))}{2} - F - \frac{I}{2}$ | $z\pi_1(c',\widetilde{c}) + (1-z)\pi_1(c',c) - F$, $z\pi_2(c',\widetilde{c}) + (1-z)\pi_2(c',c) - I$ |
| | No R&D | $z\pi_1(\widetilde{c},c') + (1-z)\pi_1(c,c') - I$, $z\pi_2(\widetilde{c},c') + (1-z)\pi_2(c,c') - F$ | $\pi_1(c,c)$, $\pi_2(c,c)$ |

**Table 2:** Payoffs under patent protection.

The non-strategic and strategic incentives for R&D for each firm are respectively $N(P) = z\pi_2(\widetilde{c},c') + (1-z)\pi_2(c,c') - \pi_2(c,c) - F = z\pi_1(c',\widetilde{c}) + (1-z)\pi_1(c',c) - \pi_1(c,c) - F$ and

$$S(P) = \frac{2z(\pi_2(c',c') - \pi_2(c',\widetilde{c})) + (1-z)(\pi_2(c,c') - \pi_2(c',c))}{2} - F + \frac{I}{2}$$
$$= \frac{2z(\pi_1(c',c') - \pi_1(\widetilde{c},c')) + (1-z)(\pi_1(c',c) - \pi_1(c,c'))}{2} - F + \frac{I}{2}.$$

So, the non-strategic incentive for R&D is higher under patent protection for $z < 1$, and the strategic incentive for R&D is higher under patent protection provided

$$\begin{aligned}&(1-z)\big(2\pi_2(c',\widetilde{c}) - 2\pi_2(c',c) + (\pi_2(c',c) + \pi_2(c,c') - 2\pi_2(c',c'))\big) + I \\ &= (1-z)\big(2\pi_1(\widetilde{c},c') - 2\pi_1(c,c') + (\pi_1(c,c') + \pi_1(c',c) - 2\pi_1(c',c'))\big) + I > 0.\end{aligned} \quad (1)$$

Since $\pi_2(c',\widetilde{c}) > \pi_2(c',c)$, (1) may hold even if the tournament effect is negative, i.e., $\pi_2(c',c) + \pi_2(c,c') - 2\pi_2(c',c') = \pi_1(c,c') + \pi_1(c',c) - 2\pi_1(c',c') < 0$. If imitation is

[6] We consider that imitation is profitable under both unilateral and bilateral R&D. Our result can hold even if

very likely, i.e., $z \to 1$,[7] (1) always holds. If $S(P) > 0 \geq S(NP)$, both firms investing in R&D constitutes equilibrium under patent protection, but not in its absence.[8]

**Proposition 1:** *If non-infringing imitation is very likely under patent protection, R&D investment always increase with patent protection.*

Though imitation allows producing with the same marginal cost under patent protection and no patent protection, patent protection makes the marginal cost reduction relatively more costly under unilateral R&D, thus increases the incentive for R&D investment.

The welfare effect of higher R&D investment is ambiguous. While higher R&D investment along with imitation tends to increase welfare by making the new technology available to both firms, the cost of imitation and higher R&D investments tend to reduce welfare.

## 3. Technology licensing and patent protection

Now, assume that there is *no imitation*, but there is possibility of technology licensing. While high transaction cost might prevent technology licensing in the previous section, this section considers prohibitive cost of imitation. For simplicity, we concentrate on non-drastic R&D only.

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imitation is profitable only under bilateral R&D.

[7] If $I$ is sufficiently large, $z$ must be very high to make imitation feasible. Both these high values are consistent with Mansfield et al. (1981), which find that 60% of a sample of their patented innovations is imitated within four years and the average cost of imitation is two-thirds the original cost of innovation.

[8] Further conditions ensure pure strategy equilibria under no patent protection. However, both firms do R&D in neither of these equilibria.

We consider a game similar to section 2 along with the possibility of technology licensing between R&D and production. If there is technological difference after R&D, the technologically superior firm decides whether to license the technology to the other firm. Assume that the licenser offers a take-it-or-leave-it two-part tariff contract with up-front fixed-fee and per-unit output royalty. The license accepts the offer if it is not worse-off under licensing than no licensing.

The situation under no patent protection is similar to section 2 except the possibility of technology licensing. Here, licensing is an option under unilateral R&D. If there is no patent protection and licensing occurs, the non-innovating firm's *complete access* to the innovated technology can create *complete knowledge spillover*, thus prevents royalty payment by the licensee. Hence, the optimal licensing contract consists of up-front fixed-fee only. However, licensing occurs if it increases the industry profit. For example, if firm 1 is the licenser, licensing occurs provided $\pi_1(c',c') + \pi_2(c',c') > \pi_1(c',\widetilde{c}) + \pi_2(c',\widetilde{c})$, and the licensing fee will be $L(c',\widetilde{c}) = \pi_2(c',c') - \pi_2(c',\widetilde{c})$, which is increasing in $\widetilde{c}$.

Table 3 shows the firms' payoffs at the R&D stage under no patent protection with licensing.

| | | Firm 2 R&D | Firm 2 No R&D |
|---|---|---|---|
| Firm 1 | R&D | $\pi_1(c',c') - F$, $\pi_2(c',c') - F$ | $\pi_1(c',c') + L(c',\widetilde{c}) - F$, $\pi_2(c',\widetilde{c})$ |
| | No R&D | $\pi_1(\widetilde{c},c')$, $\pi_2(c',c') + L(\widetilde{c},c') - F$ | $\pi_1(c,c)$, $\pi_2(c,c)$ |

**Table 3:** Payoffs under no patent protection.

The non-strategic and strategic incentives for R&D for each firm are respectively $N(NP) = \pi_2(c',c') - \pi_2(c,c) + L(\widetilde{c},c') - F = \pi_1(c',c') - \pi_1(c,c) + L(c',\widetilde{c}) - F$ and

$S(NP)=\pi_2(c',c')-\pi_2(c',\tilde{c})-F=\pi_1(c',c')-\pi_1(\tilde{c},c')-F$. Hence, licensing increases the non-strategic incentive for R&D compared to no licensing.

Table 1 shows the firms' payoffs if licensing is unprofitable under no patent protection.

If there is patent protection, licensing may occur under both unilateral and bilateral R&D. Further, since patent protection eliminates imitation, following Rockett (1990), the optimal licensing contract will consist of zero fixed-fee and the per-unit output royalty $(c-c')$, where the marginal costs of the innovating and non-innovating firms are respectively $c'$ and $c$. Hence, licensing always occurs under patent protection. So, the incentive for licensing is higher under patent protection than no patent protection,[9] which is in contrast to Bessen (2005) and Roy Chowdhury (2005).

Table 4 shows the firms' payoffs at the R&D stage under patent protection with licensing, where $G(.,.)$ shows the royalty income.

| | | Firm 2: R&D | Firm 2: No R&D |
|---|---|---|---|
| Firm 1 | R&D | $\frac{\pi_1(c',c)+G(c',c)+\pi_1(c,c')}{2}-F$, $\frac{\pi_2(c',c)+\pi_2(c,c')+G(c,c')}{2}-F$ | $\pi_1(c',c)+G(c',c)-F$, $\pi_2(c',c)$ |
| | No R&D | $\pi_1(c,c')$, $\pi_2(c,c')+G(c,c')-F$ | $\pi_1(c,c)$, $\pi_2(c,c)$ |

**Table 4:** Payoffs under patent protection.

[9] The opposite happens if the innovation is drastic and knowledge spillover encourages licensing under no patent protection.

The non-strategic and strategic incentives for R&D for each firm are respectively $N(P)=\pi_2(c,c')+G(c,c')-\pi_2(c,c)-F=\pi_1(c',c)+G(c',c)-\pi_1(c,c)-F$ and $S(P)=\frac{\pi_2(c,c')+G(c,c')-\pi_2(c',c)}{2}-F=\frac{\pi_1(c',c)+G(c',c)-\pi_1(c,c')}{2}-F$. Hence, licensing increases the non-strategic and strategic incentives for R&D compared to no licensing.

Since, the licensing contract under patent protection involves only per-unit output royalty, $\pi_2(c,c')+G(c,c')>\pi_2(c',c')+L(c,c')>\pi_2(c',c')+L(\tilde{c},c')$ or $\pi_1(c',c)+G(c',c)>\pi_1(c',c')+L(c',c)>\pi_1(c',c')+L(c',\tilde{c})$. Further, $\pi_2(c,c')+G(c,c')=\pi_1(c',c)+G(c',c)>\pi_2(\tilde{c},c')=\pi_1(c',\tilde{c})$. Hence, patent protection increases the non-strategic incentive for R&D in presence of licensing.

Now consider the strategic incentives for R&D. Without loss of generality, consider the problem of firm 1. Patent protection increases the strategic incentive for R&D provided

$$[\pi_1(c',c)+G(c',c)]-[2\pi_1(c',c')-\pi_1(c,c')]+2[\pi_1(\tilde{c},c')-\pi_1(c,c')]>0. \qquad (2)$$

The optimal licensing contract under patent protection implies $[\pi_1(c',c)+G(c',c)]>[2\pi_1(c',c')-\pi_1(c,c')]$ (because $\pi_1(c,c')=\pi_2(c',c)$), and since $\pi_1(\tilde{c},c')>\pi_1(c,c')$, condition (2) holds always. If $S(P)>0\geq S(NP)$, both firms investing in R&D constitutes equilibrium under patent protection, but not in its absence.[10]

**Proposition 2:** *In presence of technology licensing, patent protection increases R&D investment irrespective of the tournament effect.*

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[10] Remark similar to footnote 8 is also valid for this situation.

The optimal licensing differs between the patent systems, and patent protection helps to extract higher surplus from licensing, thus increases the incentive for R&D investment. As a remark, the above proposition holds even if the licensee has some bargaining power.

Though licensing increases gross industry profit under patent protection compared to no patent protection, consumer surplus is not higher under patent protection. Higher R&D investment under patent protection imposes further cost on the society. Hence, the welfare effect of higher R&D investment is ambiguous.

## 3. Conclusion

We show that the effect of either imitation or licensing can always dominate the tournament effect and patent protection always increase R&D investments. However, the welfare effect of higher R&D investments is ambiguous.

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