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September 2005

Knowledge diffusion under patent with asymmetric firms

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Abstract: We show that if patent protection and trade secrecy generate asymmetric market structure, an innovator may prefer patent protection than trade secrecy even if the diffusion probability is higher under the former but it increases market concentration by preventing some imitators. So, whether an innovator prefers patent protection or trade secrecy depends on the trade-off between the diffusion probability and market concentration. Thus, our paper contrasts and complements Bessen (2005).

Key Words: Asymmetric firms; Innovation; Knowledge diffusion; Patents; Trade secrecy

JEL Classifications: K3; L5; O3

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Knowledge diffusion under patent with asymmetric firms

Abstract: We show that if patent protection and trade secrecy generate asymmetric market structure, an innovator may prefer patent protection than trade secrecy even if the diffusion probability is higher under the former but it increases market concentration by preventing some imitators. So, whether an innovator prefers patent protection or trade secrecy depends on the trade-off between the diffusion probability and market concentration. Thus, our paper contrasts and complements Bessen (2005).

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1. Introduction

There are two main roles of any patent system: (i) to provide stronger incentive for innovation and (ii) to promote diffusion of technical information. Though, the existing literature has largely concentrated on the former effect of patent system, the latter role of the patent system did not receive much attention.

The argument regarding knowledge diffusion under patent system presumes that all patentable inventions are patented.[1] Recently, Bessen (2005) shows that if the innovator has alternative ways, such as trade secrecy, to protect information about its technology, knowledge diffusion cannot be more under patent system than trade secrecy.[2] The intuition behind this result is easy to see. If the firm anticipates that knowledge diffusion will be more under patent system, it will not apply for patent,

[1] See Friedman et al. (1991) for a discussion on this issue.

rather it will prefer trade secrecy to protect the technical information. Hence, the argument that patent system facilitates knowledge diffusion may be misplaced.

Though the argument in Bessen (2005) is interesting, it ignores another side of the story, viz., the effect of market structure on the decision for patenting. We show that if the imitators differ according to their ability to imitate, patent system may increase market concentration, compared to trade secrecy, by preventing entry of some imitators. Hence, if there are asymmetric imitators, an innovator may prefer patent protection compared to trade secrecy even if the knowledge diffusion is higher under the former. So, the trade-off is between the relative strengths of the diffusion probability and market concentration.

The remainder of the paper is organized as follows. Section 2 describes the model and shows the results. Section 3 concludes.

2. The model and the results

We use a model similar to Bessen (2005) with the exception that there are two imitators, who differ according to their capability for imitation or 'inventing around'. Consider an industry consisting of three risk-neutral firms where firm I is an innovating firm and other two firms are firm A and firm B. We consider two regimes: one with patent and trade secrecy law and another with only trade secrecy. Firm I has an invention that gives it a temporary monopoly. However, firms A and B can compete for profits with firm I either through imitation or through 'inventing around'.

[2] One may refer to Gallini (1992) for the effect of patent and trade secrecy on the incentive for innovation.

Let us now define the product market profits (i.e., revenue minus total cost) of the firms by V_M, V_D and V_t respectively for the situations where only one firm produces in the market, two firms produce in the market and all three firms produce in the market. We consider symmetric product market profits for the firms under competition.

Now, we set out the game. At stage 1, firm I decides whether or not to patent, if patent protection is available. Though patenting typically costs more than trade secrecy alone, however, we assume that these costs are the same in order to focus on the effects of asymmetric product market competition under patent protection and trade secrecy only. At stage 2, firms A and B simultaneously decide whether to develop a substitute invention by 'inventing around' or imitation. We assume that the cost of imitation or 'inventing around' requires an investment c, and this is irrespective of firm I's choice about patent protection or trade secrecy.[3] These costs are the same for both firms A and B. However, A and B differs according to their success probability of inventing around. We assume that firm A (B) invents successfully with probability q_A^i (q_B^i), $i = S, P$, $0 \le q_A^i, q_B^i \le 1$. At stage 3, the firms take their production decisions simultaneously and the profits are realized. We solve the game through backward induction.

Following Bessen (2005), we call q_A^i and q_B^i as the diffusion probabilities to firms A and B. We do our analysis under the assumptions that (i) $q_A^i > q_B^i$, which implies that firm A is more capable in developing the substitute invention than firm

[3] In general, the cost of imitation or 'inventing around' may vary depending on the innovator's choice about patent protection and trade secrecy. However, it will be easy to understand from our analysis that if the cost of imitation is lower under trade secrecy, it will strengthen our result. The same cost of imitation or 'inventing around' irrespective of patent protection or trade secrecy can be justified if we view these costs as the opportunity costs of imitation or 'inventing around' and the symmetry helps us to show the effects of asymmetric market structure for our analysis.

B, and (ii) the diffusion probabilities for both firms A and B are higher under patent than trade secrecy alone, i.e.,

$$q_A^P > q_A^S \qquad \text{and} \qquad q_B^P > q_B^S. \tag{1}$$

Note that condition (1) also implies that $q_A^P + q_B^P - q_A^P q_B^P > q_A^S + q_B^S - q_A^S q_B^S$, i.e., total diffusion probability is higher under patent than trade secrecy only.

Though, firms A and B are capable of doing imitation or 'inventing around', whether both of them will imitate or 'invent around' will depend on the parametric configuration, which, in turn, will determine the innovator's preference for patent protection relative to trade secrecy alone. The following analysis will show that, if (1) is satisfied, the result of Bessen (2005) will always hold when the market structure is the same under patent protection and trade secrecy alone. But, the result of Bessen (2005) may not hold if the market structure differs between patent protection and trade secrecy alone, and therefore, both diffusion probability and market structure are important for the choice between patent and trade secrecy alone.

Proposition 1: *Even if (1) holds, firm I prefers patent rather than trade secrecy when $X^P < c < X^S$, where $X^P = q_B^P V_D - q_A^P q_B^P (V_D - V_t)$ and $X^S = q_B^S V_D - q_A^S q_B^S (V_D - V_t)$, and the total diffusion probability under patent protection is not very large compared to that of under trade secrecy.*

Proof: If there is patent protection, firm A does 'inventing around' but firm B does not if $q_A^P V_D > c > X^P$. Moreover, under trade secrecy only, both firms A and B imitate the technology of firm I provided $c < X^S$. Since $X^S < q_B^P V_D < q_A^P V_D$, we find that if $X^P < c < X^S$, both firms A and B imitate under trade secrecy only

whereas only firm A does 'inventing around' under patent protection. Thus, the net profits of firm I under patent protection and trade secrecy only are respectively

$$\pi_I^P = q_A^P V_D + (1 - q_A^P) V_M \tag{2}$$

and

$$\pi_I^S = q_A^S q_B^S V_t + (q_A^S + q_B^S - 2q_A^S q_B^S) V_D + (1 - q_A^S)(1 - q_B^S) V_M \,. \tag{3}$$

We find that (2) is greater than (3) provided

$$\left[(V_D - V_t) q_A^S q_B^S + (V_M - V_D) q_B^P (1 - q_A^P)\right] - (V_M - V_D)(q_A^P + q_B^P - q_A^P q_B^P - q_A^S - q_B^S + q_A^S q_B^S) > 0. \tag{4}$$

A sufficient condition for condition (4) to hold is that $(q_A^P + q_B^P - q_A^P q_B^P - q_A^S - q_B^S + q_A^S q_B^S) \to 0$. Q.E.D.

As an example, if $q_A^P = 1$, $q_A^S \to 1$ and $q_B^P \to q_B^S$, it satisfies both (1) and (4) along with $X^P < c < X^S$. Proposition 1 is in contrast to Bessen (2005) and shows that even if total diffusion probability is higher under patent protection, the innovator may still prefer the patent system compared to trade secrecy only. The reason for this result is easy to understand. Though, total diffusion probability is higher under patent system, given the parametric configuration of Proposition 1, patent system prevents imitation by the relatively less capable imitator (firm B). Hence, patent system increases market concentration, and increases product market profit of the innovator, firm I. So, if the effect of market concentration under patent protection is stronger than the effect of higher diffusion probability under patent system, the innovator is better off under patent system than trade secrecy.[4]

[4] It is clear that even if the patenting is marginally more costly than only trade secrecy, the above result holds good.

It should also be noted that the if the cost of imitation or 'inventing around' is lower under trade secrecy than patent protection, it makes it more likely that only firm A does 'inventing around' under patent protection while both firms A and B do imitation under trade secrecy, which strengthens our results by relaxing the condition that c needs to be between X^P and X^S.

Proposition 1 has considered the situation where asymmetric market structure evolves under patent protection and trade secrecy. However, it is easy to check that if $c < \min\{X^P, X^C\}$, both firms A and B do 'inventing around' or imitation under patent system and trade secrecy only. Hence, the net profits of firm I under patent protection and trade secrecy only are respectively

$$\pi_I^P = q_A^P q_B^P V_t + (q_A^P + q_B^P - 2q_A^P q_B^P)V_D + (1 - q_A^P)(1 - q_B^P)V_M . \tag{5}$$

and

$$\pi_I^S = q_A^S q_B^S V_t + (q_A^S + q_B^S - 2q_A^S q_B^S)V_D + (1 - q_A^S)(1 - q_B^S)V_M . \tag{6}$$

Straightforward comparison of (5) and (6) gives the following proposition immediately.

Proposition 2: *If the market structure is similar under patent protection and trade secrecy only, the innovator prefers trade secrecy when the total diffusion probability is higher under patent protection than trade secrecy only.*[5]

The above result extends the main result of Bessen (2005) for the case of multiple and asymmetric imitators.

[5] The other case where only firm A does imitation or 'inventing around' under patent protection and trade secrecy only follows immediately from Bessen (2005), and the innovator prefers trade secrecy in this situation if the diffusion probability is higher under patent protection than trade secrecy only.

3. Conclusion

Bessen (2005) shows that an innovator prefers trade secrecy when the probability of knowledge diffusion is higher under patent protection. Hence, patent protection cannot generate higher knowledge diffusion when the innovator has alternative strategy of trade secrecy.

The above argument ignores the effect of market structure. We show that if patent protection and trade secrecy generate asymmetric market structure, an innovator may prefer patent protection than trade secrecy if it prevents some imitators to invent around and compete under patent protection regime and thereby, increases market concentration, though the diffusion probability is higher under patent protection. So, whether an innovator prefers patent protection or trade secrecy depends on the trade-off between the diffusion probability and market concentration.

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