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Free licensing to boost aggregate odds for success

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Revised Highlights For

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We provide a novel explanation for free technology-licensing to potential rivals.

Incumbent innovator works to improve her patented technology.

The incumbent licenses entrant to also improve this technology through different R&D line.

Gains from rivalry rise as demand increases with *aggregate* probability for success.

The positive effect of higher demand on expected profit should outweigh competition risk.

Free Licensing to Boost Aggregate Odds for Success

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Abstract

We show how technological leader gains from inviting entrant into R&D competition to improve over existing patented technology, as the entrant takes complementary R&D effort and demand for both current and improved technologies is increasing with aggregate probability for successful quality improvement.

Key words: Invited competition, Technology Licensing, Complementary R&D.
JEL Classification: L15, L24.

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1. Introduction

A main thread of the current literature on innovation aims to explain pro-competitive actions taken by technological leaders to attract rivals[1]. In a recent influential paper Bessen and Maskin (2009) show that mutual imitation spurs technological progress and prospect profits in a dynamic framework, where innovators repeatedly engaged in R&D competition through complementary R&D efforts[2]. This is because imitation enables innovators to repeatedly learn how to improve upon each other's successful innovations, and thereby increasing the likelihood for sequential technological breakthroughs.

Previous studies on technology-licensing advanced two main rationales to explain a firm acting to weaken its own market power. The first addresses the holdup problems induced when optimal pricing or quality set by monopolist are subject to dynamic inconsistency (Shepard 1987, Farrell and Gallini 1988). In this context, inviting competition serves as a commitment to a future low price or high quality[3]. The second implies that the licensee may gain from giving up some of its current market power when doing so deters potential rivals from intensifying competition in the future (Gallini 1984 and Rockett 1990).

The present study explores a novel source of gains from rivalry through complementary R&D effort, which does not involve knowledge spillover or strategic considerations of commitment and deterrence. Where the aforementioned studies focus on inviting competition by giving up lagging-breadth patent protection—that is, allowing imitation—we focus on giving up leading-breadth patent protection (see O'Donoghue et al., 1998), that is allowing rivals to capitalize patented technological improvements. Here, the gains from the invited competition are due to demand externalities which prevail where demand for both old and new technology increases with the overall likelihood for future quality improvements. These positive demand externalities should outweigh the risk of intense competition in case the entrant succeeds in innovating. We demonstrate the mechanism under study with two simple examples of different economic environments.

[1] Bessen and Maskin (2009, p. 612 footnote 4) provide some interesting examples of incumbents sharing patented technological knowledge with potential competitors.

[2] R&D efforts are complementary if their joint probability for success is greater than that of the private venture. A common example is the case of independent probabilities for success.

[3] Commitment should increase demand enough to compensate for the loss of market share or decrease in markup, caused by competition between the licensed and the licensee.

2. Complementary Markets

The setup

Two complementary technologies, such as software and hardware, are provided by two risk-neutral and non-cooperative monopolistic innovators, denoted A and B. Both innovators face symmetric linear demand

(1) $d_i = q_i\left(1+\alpha q_j\right) - p_i - \beta p_j$

where $i, j = \{A, B\}$ and $i \neq j$, q_i stands for product quality in market i, and the parameters $\alpha > 0$ and $0 \leq \beta < 1$ resemble products' complementarities in the conventional fashion. After normalizing the marginal production-cost to zero, the first-order condition for profit maximization implies the following best response function for optimal price in each market, denoted p_i*

(2) $$p_i* = \frac{q_i\left(1+\alpha q_j\right) - \beta p_j}{2}$$

Substituting the optimal price for innovator j into the best response function of innovator i, we obtain the Nash-Equilibrium prices, denoted p_i^e, which depend solely on technological qualities

(3) $$p_i^e = \frac{q_i\left(2+\alpha q_j\left(2-\beta\right)\right) - \beta q_j}{4-\beta^2}$$

Substitution of (2) into (1) implies $p_i^e = d_i^e$, and thus producer's surplus in each market, denoted by PS_i, is given by

(4) $$PS_i = p_i^e \cdot d_i^e = \left[\frac{q_i\left(2+\alpha q_j\left(2-\beta\right)\right) - \beta q_j}{4-\beta^2}\right]^2$$

Assuming $q_i > \dfrac{1}{\alpha}$ we ensure the existence of unique equilibrium and markets complementarities, that is: $\dfrac{\partial \pi_i}{\partial q_j} > 0$. Current product quality - denoted q_i^o - can be improved to $q_i^n > q_i^o$, through R&D investment R_i which takes one period, with probability of success ρ_i. To facilitate tractability we assume certain innovation outcomes for innovator B; that is

$\rho_B = 1$. Also, information is complete. The strategic interaction between innovators is defined along a two-period timeline, to be solved as a sub-game perfect equilibrium. In period 1 both innovators simultaneously decide whether or not to invest in R&D. In period 2, R&D outcomes are revealed and prices are simultaneously set according to the equilibrium equation (3). Solving this sequential interaction backward, we apply (4) to derive the expected profit for innovator A when investing in R&D

$$(5)\quad E\{\pi_A\} = \rho_A \left[\frac{q_A^n\left(2+\alpha q_B\left(2-\beta\right)\right)-\beta q_B}{4-\beta^2}\right]^2 + \left(1-\rho_A\right)\left[\frac{q_A^o\left(2+\alpha q_B\left(2-\beta\right)\right)-\beta q_B}{4-\beta^2}\right]^2 - R_A$$

where $q_B = q_B^n$ if B innovates and $q_B = q_B^o$ if not. Comparing (5) with the expected profit in case of no R&D investment, one finds that innovator A invests in R&D only if

$$(6)\quad \left[q_A^n\left(2+\alpha q_B\left(2-\beta\right)\right)-\beta q_B\right]^2 - \left[q_A^o\left(2+\alpha q_B\left(2-\beta\right)\right)-\beta q_B\right]^2 > \left(4-\beta^2\right)^2 \frac{R_A}{\rho_A}$$

For highly efficient (inefficient) innovation technology (defined by ρ_A, R_A, q_A^n), A does (does not) invest in R&D regardless of the R&D decision of B; that is, regardless of q_B. Similarly, if A invests in R&D, innovator B invests in R&D as well only if

$$(7)\quad \begin{aligned} &\rho_A\left\{\left[q_B^n\left(2+\alpha q_A^n\left(2-\beta\right)\right)-\beta q_A^n\right]^2 - \left[q_B^o\left(2+\alpha q_A^n\left(2-\beta\right)\right)-\beta q_A^n\right]^2\right\}+ \\ &+\left(1-\rho_A\right)\left\{\left[q_B^n\left(2+\alpha q_A^o\left(2-\beta\right)\right)-\beta q_A^o\right]^2 - \left[q_B^o\left(2+\alpha q_A^o\left(2-\beta\right)\right)-\beta q_A^o\right]^2\right\} > \left(4-\beta^2\right)^2 R_B \end{aligned}$$

However, in case innovator A does not invest in R&D, innovator B may still find it beneficial to innovate if

$$(7a)\quad \left[q_B^n\left(2+\alpha q_A^o\left(2-\beta\right)\right)-\beta q_A^o\right]^2 - \left[q_B^o\left(2+\alpha q_A^o\left(2-\beta\right)\right)-\beta q_A^o\right]^2 > \left(4-\beta^2\right)^2 R_B$$

Conditions (6)-(7a) give rise to two symmetric Nash-equilibria with both innovators either investing or not, and two asymmetric equilibria with only one innovator investing.

Gains from complementary R&D

Suppose now that there is a third innovator, denoted $\hat{A}$, who has an idea about how to improve the quality of product A to $\hat{q}_A^n > q_A^o$ with probability $\hat{\rho}_A$ subject to R&D investment

$\hat{R}_A$, where $\hat{\rho}_A$ is independent of ρ_A.[4] However, due to overlapping property rights, innovator $\hat{A}$ must be licensed by innovator A to capitalize the quality improvement $\hat{q}_A^n$. If $\hat{A}$ is licensed, the three innovators A, B, and $\hat{A}$ are involved in the same interaction described before. For tractability we assume that in case of joint success it is the entrant who granted a patent that excludes the incumbent from the market. Thus, the expected profit for innovator A under free licensing becomes

$$(8)\quad E\{\pi_A\} = (1-\hat{\rho}_A)\left\{\rho_A\left[\frac{q_A^n\left(2+\alpha q_B(2-\beta)\right)-\beta q_B}{4-\beta^2}\right]^2 + (1-\rho_A)\left[\frac{q_A^o\left(2+\alpha q_B(2-\beta)\right)-\beta q_B}{4-\beta^2}\right]^2\right\} - R_A$$

The incumbent may gain from entry only if it spurs R&D investment by innovator B. turning q_B form q_B^o into q_B^n. By comparing (8) with (5), one finds that such the incumbent gains from entry occur only if

$$(9)\quad (1-\hat{\rho}_A) > \frac{\rho_A\left[\dfrac{q_A^n\left(2+\alpha q_B^o(2-\beta)\right)-\beta q_B^o}{4-\beta^2}\right]^2 + (1-\rho_A)\left[\dfrac{q_A^o\left(2+\alpha q_B^o(2-\beta)\right)-\beta q_B^o}{4-\beta^2}\right]^2}{\rho_A\left[\dfrac{q_A^n\left(2+\alpha q_B^n(2-\beta)\right)-\beta q_B^n}{4-\beta^2}\right]^2 + (1-\rho_A)\left[\dfrac{q_A^o\left(2+\alpha q_B^n(2-\beta)\right)-\beta q_B^n}{4-\beta^2}\right]^2}$$

The greater the potential for quality improvement in the complementary market $\frac{q_B^n}{q_B^o}$, the higher the competition risk $\hat{\rho}_A$ the incumbent is willing to bear in order to encourage innovator B investing in R&D. In the presence of the entrant $\hat{A}$, the expected profit for innovator B becomes

$$(10)\quad \begin{aligned} E\{\pi_B\} &= (1-\hat{\rho}_A)\left\{\rho_A\left[\frac{q_B\left(2+\alpha q_A^n(2-\beta)\right)-\beta q_A^n}{4-\beta^2}\right]^2 + (1-\rho_A)\left[\frac{q_B\left(2+\alpha q_A^o(2-\beta)\right)-\beta q_A^o}{4-\beta^2}\right]^2\right\} + \\ &+\hat{\rho}_A\left[\frac{q_B\left(2+\alpha \hat{q}_A^n(2-\beta)\right)-\beta \hat{q}_A^n}{4-\beta^2}\right]^2 - R_B \end{aligned}$$

And the expected profit for innovator $\hat{A}$ is

[4]Hence, the incumbent's and entrant's R&D efforts are complementary as their joint probability for success, given by $1-(1-\rho_A)(1-\hat{\rho}_A) = \rho_A + \hat{\rho}_A - \rho_A\hat{\rho}_A$, is greater than the private ones.

(11) $E\{\hat{\pi}_A\} = \hat{\rho}_A \left[\frac{\hat{q}_A^n \left(1+\alpha q_B (2-\beta)\right) - \beta q_B}{4-\beta^2} \right]^2 - \hat{R}_A$

Proposition 1: If, initially, innovator B does not invest in R&D and A does, there are sufficiently low values for $\hat{\rho}_A$ and $\hat{R}_A$ and sufficiently high values for $\hat{q}_A$ for which R&D investment by B becomes profitable; thereby, the expected profit for innovator A increases.

Proof:

For sufficiently low values of $\hat{R}_A$ condition (11) is satisfied, ensuring entry. If initially B does not innovate, (10) is negative for $\hat{\rho}_A = 0$. However, for any $\hat{\rho}_A > 0$ there is a sufficiently high value of $\hat{q}_A^n$ that turns (10) to positive. Then, $\hat{\rho}_A$ can be set sufficiently low to satisfy (9) as well; Q.E.D.

Note that if initially innovators A and B do not invest in R&D, the entrant may encourage both to invest. Nevertheless, even if the incumbent is not pushed to make R&D investment, she still gains from entry that encourages B to innovate if the quality improvement made by B is big enough relative to the competition risk. Finally, note that the analysis applies also for licensing an interim non-commercialized invention to a developer of a subsequent invention that can be commercialized. In this case, the incentive to license is even stronger because there is no first market for the licensee to lose.

3. Utilization Setup Cost

Here again, a current technology granted with leading-breadth patent protection is to be improved. However, the first utilization of this technology (e.g., adoption) entails a fixed setup cost, denoted by F, that is paid by the user. After bearing this cost, the buyer uses the new technology for two periods: in the first period the quality of the technology is given, and it can be improved in the second period to possess better quality[5]. If the existing and expected qualities of the technology are not sufficiently high compared with the setup cost, users delay the decision to step into the market, and the capitalization of the technology is also delayed. To facilitate tractability here, we assume that both innovators have the same

[5] A concrete example would be buying a Smartphone or Laptop to utilize online services on per-period basis. In this example the online services are to be improved.

innovation function and that in case of joint success each innovator has equal chances of granting an exclusive patent. We assume that first the incumbent decides whether to license or not, and based on that consumers decide whether or not to enter the market. The prices of the old and new technologies are denoted p^o and p^n respectively. The market for the technology is populated by a unit mass of identical consumers with linear per-period demand that increases with quality

(12) $d_i = q_i - p_i$

Facing market demand (12), the provider of the old technology sets a monopolistic price in the first period by equalizing the marginal revenue to the (zero) marginal cost: $p_1^o = \frac{q^o}{2}$. At this price demand is $d_1 = \frac{q^o}{2}$ and the consumers' surplus is $CS_1 = \frac{\left(q^o\right)^2}{8}$. Accordingly, if the improved technology is sold in the second period, its monopolistic price would be $p^n = \frac{q^n}{2}$ and the consumer surplus would be $CS_2 = \frac{\left(q^n\right)^2}{8}$. Thus, the expected consumer surplus over two periods in the cases of one and two innovators, respectively, is given by

(13a) $E_{n=1}\{CS\} = \frac{1}{8}\left[(2-\rho)\left(q^o\right)^2 + \rho \cdot \left(q^n\right)^2\right]$

(13b) $E_{n=2}\{CS\} = \frac{1}{8}\left\{\left[1+(1-\rho)^2\right] \cdot \left(q^o\right)^2 + \left[1-(1-\rho)^2\right] \cdot \left(q^n\right)^2\right\}$

If the setup cost F is lower than the expected surplus given in (13a) and (13b) consumers enter the market and the demand functions are valid. Otherwise, consumers stay out of the market, and the demand for technologies is zero. The expected profit for an innovator in the absence and presence of a potential rival, respectively, is given by

(14a) $E_{n=1}\{\pi\} = \frac{1}{4}\left[(2-\rho)\left(q^0\right)^2 + \rho \cdot \left(q^n\right)^2\right] - R$

(14b) $E_{n=2}\{\pi\} = \frac{1}{4}\left\{\left[1+(1-\rho)^2\right]\left(q^0\right)^2 + 0.5\left[1-(1-\rho)^2\right] \cdot \left(q^n\right)^2\right\} - R$

<u>Assumption 1</u>: R&D investment is low enough to make R&D investment profitable in (14a) and (14b) for both innovators, as long as consumers are in the market.

Proposition 2: *If the setup cost is large enough relative to the private probability of success and quality improvement, the incumbent gains from freely licensing the entrant.*

Proof:

Suppose that $E_{n=1}\{CS\}=F$ and thus consumers do not enter the market. Then, comparing (13) with (13a), we obtain $E_{n=2}\{CS\}>E_{n=1}\{CS\}=F$ for any success probability $\rho\in(0,1)$. Hence, free licensing the entrant pushes consumers into the market and by assumption 1 this turns the expected profit for the incumbent from zero to positive; *Q.E.D.*

4. Conclusion

We have shown how an entrant innovator raises the expected profitability of the incumbent's R&D effort by increasing demand through the boost in the aggregate probability of success. The incumbent weighs this positive effect against the risk of losing the market if the rival succeeds to innovating. The incumbent is more likely to gain from freely licensing overlapping property rights to a risky rival who works on great quality improvements with low probabilities of success. As free licensing here is Pareto improving, it maybe the outcome of a Nash- bargaining, or it may be optimal in face of significant contractual costs of charging royalties.

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