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Technology Transfer and Innovative Startups' Decision Criterion

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Abstract. When a startup develops a new innovation, it can market for its own sake affording initial sunk costs. If the innovation can create distinctive values for the startup, this is a valid option. However, creative destruction interrupts and creates another new innovation, which will deteriorate the values. So, the startup becomes to have a strong motivation to license it. When it comes to licensing, there exists an underlying fundamental conflict between a licensor and a licensee. In that, the startup refrains from selling its best technology as boomerang effect can occur. Further, a licensee may not pay royalties. Main findings are summarized into the followings. First, the entrepreneurial startup asks for a lump-sum payment only when boomerang effect is unavoidable. Second, the startup with new innovation will not transfer its best technology but sell an inferior one in a simultaneous move game. Third, in a finitely repeated game, the length of product life cycle is positively associated with the likelihood of a best technology transfer and a patient entrepreneur would be less likely to transfer a high technology.

Keywords: Technology transfer, payment, startup, innovation, and numerical test

1 Introduction

Entrepreneurial startups develop powerful ubiquitous technologies targeting multimedia convergence, which creates fragmented markets. Acknowledging this feature, the paper tackles IT startups' strategic decision on its newest innovation between own marketing and licensing. This paper attempts to tackle the following four issues. First, I demonstrate how a licensing compensation scheme is determined in equilibrium. Second, it is examined if an entrepreneurial firm's best technology can be transferred when an alternative option is available. Third, a best technology transfer in a finitely repeated game structure is analyzed when the best technology cannot be transferred in a simultaneous move game. A numerical experiment supports the theoretic predictions of the paper; the startup can sell it best technology when it is patient enough and when product life cycle is long. The paper is organized as follows.

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In section 2, the chance for a best technology transfer is examined in a simultaneous-move framework. In section 3 the best technology transfer in a finitely repeated game structure is scrutinized. Experiment results are discussed in section 4 and section 5 summarizes main findings.

2 Model

2.1. Cost Structure

The inverse demand is $p = \theta - q$ where θ determines market size.[1] Initially, firm 1 monopolizes the θ market with its marginal production cost c where $c \leq 1$ and the product generation is named to be A where $\theta \leq 1$ with $0 \leq \theta - c \leq 1$. A startup develops new knowledge-based innovation through information science; for instance, any new consumer interface, innovative platform, multiple objects extraction system, networking management system, and customized ubiquitous technology can be considered [1], [2], [3]. Assuming cost function is additive, the startup's newest innovation can decrease its marginal cost as such $c^e = c - w^e$ where $c^e < c$. In fact, w^e creates a differentiated market segment *B* for the startup in the θ market. As a result, the startup's innovation segregates the θ market into two segments, *i.e.* *A* and *B*. The startup is assumed to stay at *B* only.

The startup's monopoly quantity in *B* is determined at *MR*=*MC*, which yields $q_B^{s,m*}(c^m) = (\theta - c^m)/2$ and monopoly profit is $\pi_B^{s,m*}(c^m) = (\theta - c^m)^2/4$ where and the superscript s and m indicates the startup's monopoly and the subscript *B* represents market *B*. The monopoly price of c^e is defined to be $c^m = (\theta + c^e)/2$ where the superscript m indicates monopoly. A startup can market c^m for his own sake in *B*. Throughout the paper, c^e is denoted as the 'best' technology and c^m is denoted by the 'less-than-best' technology where $c^e \leq c^m \leq c$.[2]

2.2. Equilibrium Profits

The payoff of the licensor is (1) and the payoff of a licensee is (2) where the superscripts s and 1 indicate the startup and firm 1 and the subscripts *A* and *B* indicate market *A* and market *B* respectively.[3] In both equations, L is a lump-sum payment and r is a royalty per unit.[4]

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[1] A product generation is characterized by θ that measures the qualities of market participants. For instance, θ represents the product generation of high definition TV like PDP TV, LCD TV, and LED TV. By the design of Cournot-type competition, any quality improvement in θ is represented by marginal production cost

[2] The interval of c^e can be determined by $c^m \leq c$, which yields $c^e \leq 2c - \theta$. Rewriting this, it is $c \geq \theta/2$, and thus $\theta - c \leq 1$ is always satisfied.

[3] If $\hat{c} = c^e$ is transferred, $c - w^s = c - w^1 = c - w^e$. w^1 is determined by the level of a transferred technology and w^s is the licensor's choice variable between c^e and c^m.

[4] $\pi_B^s(c - w^s, c - w^1 + r)$ represents the licensor's *ex post* licensing duopoly profit in *B* and

$$\hat{\pi}^s(c-w^s, c-w^1) = L + rq_B^1(c-w^s, c-w^1+r) + \pi_B^s(c-w^s, c-w^1+r) \quad (1)$$

$$\hat{\pi}^1(c-w^s, c-w^1) = \pi_A^1(c) + \pi_B^1(c-w^s, c-w^1+r) - L - rq_B^1(c-w^s, c-w^1+r) \quad (2)$$

Let $\hat{c}$ be a transferred technology. If $\hat{c} = c^m$, firm 1 cannot penetrate into B because the startup can counterattack firm 1 by producing at c^e. Hence, $\pi_B^s(c-w^s, c-w^1+r) = \pi_B^s(c-w^s)$ in this case and $\pi_B^1(c-w^s, c-w^1+r) = 0$. If $\hat{c} = c^e$ is transferred, both firms can share B equally. Denote the technology transfer of $\hat{c} = c^e$ by the best technology transfer and denote $\hat{c} = c^m$ by the less-than-best technology transfer. The licensor solves (3).

$$\text{Max}_{r,L}\ \hat{\pi}^s(c-w^s, c-w^1)\ s.t.\ L \leq \pi_B^1(c-w^s, c-w^1+r) - \pi_A^1(c) \quad (3)$$

Solving (3), one can earn the equilibrium values of $L^* = \pi_B^1(c-w^s, c-w^1) - \pi_A^1(c)$ and $r^* = 0$. Plugging L^* into (1) and (2), the equilibrium profits are redefined to be (4) and (5).

$$\hat{\pi}^{s*}(c-w^s, c-w^1) = \pi_B^1(c-w^s, c-w^1) - \pi_A^1(c) + \pi_B^s(c-w^s, c-w^1) \quad (4)$$

$$\hat{\pi}^{1*}(c-w^s, c-w^1) = 2\pi_A^1(c) \quad (5)$$

3 Licensing vs. Own-Marketing

Note that it is $\hat{\pi}_B^{s*}(c^e, c^m) - \hat{\pi}_B^{s*}(c^e, c^e) > 0$; hence, the startup would license the non-best technology only because it is always better off. In one-shot equilibrium, the startup can transfer $\hat{c} = c^m$ at $t = 0$. Now, c^e innovation has a PLC; the new innovation is valid up to $t = n-1$ period from $t = 0$. Thus, a trigger strategy is used; the startups opens c^e to firm 1 at $t = 1$ if firm 1 pays L^*. Otherwise, the startups does not release c^e. Denote the startup's discounted payoff to transfer $\hat{c} = c^e$ at $t = 1$ by $V_e = \pi_B^{s,m*}(c^m) + \frac{\delta-\delta^n}{1-\delta}\hat{\pi}_B^{s*}(c^e, c^e)$ and denote the startup's discounted payoff for own marketing by $V_m = \frac{1-\delta^n}{1-\delta}\pi_B^{s,m*}(c^m)$. Note that δ is a discount factor that is defined as $\delta = 1/(1+r)$ where r is a discount rate ($r > 0$). Note that $v_m^e = V_e - V_m$.

Three important predictions are available. First, the best technology is more likely to be transferred as the more it is advanced because of $\frac{\partial V_{e-m}}{\partial c^e} < 0$. Second, if the startup pays higher future value, then it can license the best technology because of

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$\pi_B^1(c-w^s, c-w^1+r)$ means the licensee's duopoly profit in the same market. $\pi_A^1(c)$ is the licensee's monopoly profit in A.

$\partial V_{e-m}/\partial\delta > 0$.

4 Numerical Example

4.1. Demand Condition

The probability that consumers in A purchases from incumbent i is given as (6). α_B^A is a preference parameter that measure es the degree of consumers in A shifting from A to B where $\alpha_B^A > 0$ and $\alpha_A^B = -\infty$. The probability that consumers in B purchase from the startup is given to (7). λ_A^j, λ_B^j are similarly defined.[5]

$$\lambda_A^i = \frac{e^{\alpha_A^A\theta_A^i - p_A^i}}{1+e^{\alpha_A^A\theta_A^i - p_A^i}++e^{\alpha_A^A\theta_A^j - p_A^j}+e^{\alpha_B^A\theta_B^i - p_B^i}+e^{\alpha_B^A\theta_B^s - p_B^s}}$$

(6)

$$\lambda_B^s = \frac{e^{\alpha_B^B\theta_B^s - p_B^s}}{1+e^{\alpha_B^B\theta_B^i - p_B^i}+e^{\alpha_B^B\theta_B^s - p_B^s}}$$

(7)

A licensee i's profit is given to $\pi_i = \max_{p^i}(p^i - c^i)\{n_A\lambda_A^i + n_B\lambda_B^i\}$ where n_A and n_B are the number of consumers in A and B. In the finitely repeated game structure, the startup will license if the payoff from licensing is greater than the payoff from own marketing. For simulation, parameters are set to be the followings. The θ of all firms are set to be one. The level of two incumbents' marginal costs are given to c_A^1=0.8 and c_A^2=0.9 and the best technology of the startup is set to be $c^e = c - w^e$ where w^e determines c^e. The number of consumers in A and B are given to one $(n_A = n_B = 0.9)$ where α_B^A=0.45.

4.2. Results

Table 1 contains important implications on the game theoretic predictions. First, under δ=0.5, the startup is willing to sell c^e to both incumbents if w^e=0.9 while it does not if w^e=0.5. This suggests that the lower the c^e is, the transfer of $\hat{c} = c^e$ is more likely to occur. One can infer this result from [4]. Second, the startup is more likely to sell c^e as δ increases. Third, the gains from licensing when n=100 always outweigh the gains from licensing when n=10.

Table 1. Simulation Results by Scenarios in the Finitely Repeated Game

[5] The consumer's discrete choice follows the prototype of logit distribution and it is modified from [6] based on [7].

w^e	δ	Licensing	The Startup's Decision	A:Gains from licensing$^{(n=10)}$ vs. B:Gains from licensing$^{(n=100)}$
w^e=0.5	δ=0.2	Will the startup license c^e to firm 1?	No	-
		Will the startup license c^e to firm 2?	Yes	A = B
	δ=0.5	Will the startup license c^e to firm 1?	No	-
		Will the startup license c^e to firm 2?	Yes	A < B
	δ=0.8	Will the startup license c^e to firm 1?	Yes	A < B
		Will the startup license c^e to firm 2?	Yes	A < B
w^e=0.9	δ=0.2	Will the startup license c^e to firm 1?	No	-
		Will the startup license c^e to firm 2?	Yes	A < B
	δ=0.5	Will the startup license c^e to firm 1?	Yes	A < B
		Will the startup license c^e to firm 2?	Yes	A < B
	δ=0.8	Will the startup license c^e to firm 1?	Yes	A < B
		Will the startup license c^e to firm 2?	Yes	A < B

5 Conclusion

New innovations are frequently derived by entrepreneurial firms and such firms might be able to create fragmented markets. To large conglomerates, quality is a key success factor for successful market segregation and superior quality supported by sizable production system is the shortcut to their sustainable growth. Outsourcing marketable technology is substitutive to time-consuming and costly in-bound research and development. Actually, licensing is more attractive as the product lifecycle becomes shorter because startups can circumvent huge initial fixed investments. Therefore, licensing is a win-win strategy to both budget limited small startups and large incumbents. However, boomerang effect is unavoidable when imitation cost is considerably low. Thus, incomplete information on the quality of target technology creates a tension between a licensor and a licensee.

Acknowledging this aspect, we scrutinized some critical questions concerning on technology transfer. According to main results, an entrepreneurial startup's dominant strategy is to transfer a less-than-best technology. In a repeated framework, a trigger strategy can be set to enable a best technology transfer and its chance of best technology is disproportional to the duration of product life cycle. Numerical example supports these arguments.

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