Optimal Timing of Collaborative Alliances in Technology Commercialization

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Abstract

As the need for time-to-market becomes an imperative in high-tech industries, more and more firms find that they can get to market quicker by collaborating with partners. However, more collaboration also engenders an environment where there will be intellectual property rights infringements and appropriation issues. In this paper, we show that in addition to patents and contracts, a firm can protect its innovation by finding the optimal time for releasing information to a potential partner. Our model, which derives the optimal timing function, balances the trade-off between the benefits of minimizing delay cost in commercialization with the risk of having the information appropriated by the potential partner. We show that firms should release information early when the cost of delay is high and when the salvage value of the idea after being rejected is high. We also show that the optimal timing approach mitigates the negative effects of increases in delay cost and exaggerates the positive effects of increases in the salvage value.

Keywords: Hi-tech marketing; strategic alliance; new product development

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Ⅰ. Introduction

Although investment in R&D is one of the drivers of growth, investment in R&D in and of itself does not guarantee that the maker of the investment will reap its rewards. Such a situation where the rewards from R&D are reaped by those that have not invested in it is called the *appropriation* problem. As collaboration between firms increases and the sharing of information increases, so does the possibility of appropriation. One example of appropriation is the case of Xerox's PARC (Palo Alto Research Center) where inventions such as the mouse, pull-down menus, postscript printing, and networking were concocted. However, instead of Xerox being the main beneficiary of these inventions, it seems that firms such as Microsoft, Apple and 3-Comm. were the main beneficiaries of the technology.

The problem of appropriation is especially acute in the case of small start-up firms. Start-up firms that need the help of industry *giants* to help commercialize their products often bear the risk of giving away the technology to the industry giant in the process of collaboration. How can innovative firms protect their intellectual property rights in such an environment? Firms have adopted two principal methods for achieving this goal: patenting and secrecy. One of the most commonly used methods is patenting. Although patenting is probably the best-known method for protecting property rights, it has some severe limitations. First, contrary to its intended purpose, patenting makes the underlying technology public knowledge. In many cases, patents are used as means, by local governments, to force companies entering the local market to share their technologies by making them public (Badaracco 1991). Second, the responsibility of detecting and prosecuting patent infringement lies with the holder of the patent. Thus the holder of the patent often needs to spend substantial effort if it is to make sure no infringements are taking place. Third, it is possible to *legally imitate* product patents by working around the patent. In fact, Mansfield (1984) showed that this was possible 60% of the time in chemical, drug, electronics and machinery industries.

The second method of protecting one's intellectual property rights is secrecy. However, efforts to maintain secrecy about innovations have very limited effects (Levin et al. 1987). Also, if one enters into a strategic alliance with a partner, the veil of secrecy will have to be lifted at some point. What else can firms do? In this paper, we argue that innovative firms need to consider the issue of timing in two ways: the timing of taking the technology to market, and the issue of disclosure of the technology to the partner.

Timing is important, as the firm that initiates contact with a potential partner will need to consider when to make contact and to disclose information. The benefits from early contact and disclosure are the possibility of being early to market. However, the drawback from early contact and disclosure is that the potential partner may refuse to be a partner, but can glean enough information from the contact to go ahead and develop and market the product on its own. Therefore, the firm that initiates the contact would like to know the optimal timing of information disclosure to a potential partner. The problem of optimal timing of information disclosure is the focus of this paper.

An Illustrative example The example is the case of a fictional high-tech start-up firm with a strong research orientation, which has developed new software that makes Internet commerce "safer" for consumers. The start-up has a working product that will make purchasing on the Internet safer for consumers, but has not yet carried out developmental work for a user-friendly customer interface. The start-up is also limited by its lack of knowledge about potential markets for the new product, and does not know how to effectively distribute the product and how to "educate" consumers about the benefits of using their software. The start-up needs financial and marketing support in order to succeed, and concludes that a major software company will be the best choice for a strategic partner.

After identifying an appropriate potential partner, the high-tech start-up must decide about the timing of the initial contact and information disclosure. In order to convince the software company about the efficacy and commercial benefits from participation in the partnership, the start-up company must provide the software giant enough information for the latter to make a decision about whether to become a partner or not. The benefit from immediate contact is that manufacturing strategies, marketing research, packaging and advertising approaches can be undertaken at the same time that the remainder of the development work is carried out, leading to an earlier market release of the product and a longer period of returns. It also implies that the software giant will perform some of the functions that will lead to the commercialization of the product.

However, early contact may decrease the probability of the software giant accepting the alliance because the software giant may feel that the idea is too primitive to be useful. Also, early contact raises the possibility that the software company will decide not to become a strategic partner, but develop a similar product on its own or with another partner, based on the information handed over by the start-up company during the negotiations. The degree to which the large software company can benefit from imitating the product based on the information provided by the start-up firm, and therefore reduce the returns (i.e., salvage value) to the start-up firm will be determined by a number of factors: -

1. The degree to which the software company is active in similar technologies. Rosenberg (1976) and Sahal (1985) referred to "focusing devices" and "technological signposts" respectively in their arguments that innovation is strongly selective, and an organization that is already dealing in similar innovations will clearly be better placed to use the information provided by the smaller firm.
2. The availability of alternative partners for the smaller firm, or alternative approaches to commercialization. While it is possible that an alternative

partner may be found, the start up firm still faces the prospect of reduced returns as the original software company will enter the market as a competitor with reduced lead times, and the possibility of further expropriation by the potential alternative still remains.

3. The time available to get the product to market to maximize revenue.

As the above discussion illustrates, the start-up firm faces a dilemma, as early disclosure increases both potential returns and the risk of expropriation and late disclosure has the effect of reducing the risk of expropriation and the potential returns. The dilemma raises the possibility that there is an optimal time at which innovators can disclose information to potential partners. The problem and an optimization solution under a range of conditions are presented in the next section.

II. The Model

The Software Giant is assumed to have a valuation for the start-up's innovation that is increasing over time. The reasons for this assumption are as follows: -

1. Innovation presented later will be more developed.
2. More development work put in by the start-up implies less development cost for the software giant.
3. *Ceteris Paribus*, an innovation presented later will be closer to commercialization. This implies that the software giant will have less chance of succeeding by expropriating the idea. This in turn will make the software giant value the innovation more.[1]

The software giant has a threshold level of valuation for the innovation at

1) Of course, it is possible that if the innovation is brought too late to the software giant, it may already be outdated. We do not consider this time region because a start-up will never wait this long and therefore this region does not affect the optimal timing of knowledge sharing.

which it will accept the strategic alliance. Let's assume that the threshold value is reached at $\tilde{t}$. Since the valuation is increasing in time, if the innovation is introduced to the software giant before (after)$\tilde{t}$ the software giant will reject (accept) the strategic alliance. The parameter $\tilde{t}$ is distributed according to cumulative distribution function F defined over a support of [a, b]. While F is common knowledge, $\tilde{t}$ is the private information of the software giant.

The Start-Up has an innovation that is partially developed. The innovation will need to go through several additional stages in the product development process before it is ready for commercialization. We assume the start-up will have the following value function for its innovation, depending on whether the strategic alliance proposal is accepted or not.

We may now define the profit function, $\Pi(t|\tilde{t})$, of the start-up company.

$$\Pi(t|\tilde{t}) = \begin{cases} \underline{u} & (if \quad t<\tilde{t}, \quad i.e., proposal \quad is \quad rejected) \\ R-C(t) & (if \quad t \geq \tilde{t}, \quad i.e., proposal \quad is \quad rejected) \end{cases}$$

The parameter is the salvage value of the product to the Start-up Company when the potential partner rejects the offer of an alliance. The parameter R is the maximum revenue possible if the product is available immediately. The delay cost, C(t), represents both the development cost as well as the opportunity cost of lost sales by being late to the market. We will assume that $C(t) = \gamma t^2$. We assume that R-C(t) $> \underline{u}$ for all t. We may then calculate the expected profits of the start-up.

$$E[\Pi(t)] = \int_a^t R-C(t)\, dF(\tilde{t}) + \int_t^b \underline{u}\, dF(\tilde{t}) = [R-C(t)-\underline{u}]F(t) + \underline{u}$$

To obtain the optimal timing of the release of information, t^*, we compute the first-order conditions.

$$\frac{dE[\Pi(t)]}{dt} = [R-C(t)-\underline{u}]f(t) - C'(t)F(t) = 0$$

Further, we will define H as follows

$$H=[R-C(t)-\underline{u}]f(t)-C'(t)F(t)=0$$

The second-order conditions are given by the following equation, and we will assume that they are satisfied

$$\frac{d^2E[\Pi(t)]}{dt^2}=[R-C(t)-\underline{u}]f'(t)-2C''(t)f(t)-C''(t)F(t)<0.$$

Let us also define G as follows,

$$G=[R-C(t)-\underline{u}]f'(t)-2C''(t)f(t)-C''(t)F(t)<0.$$

Below is a table of notation.

Table 1. Notation

t : time of releasing the information (i.e., time of contacting the potential partner)

$\tilde{t}$: time when the potential partner is indifferent between rejecting the offer and entering into a partnership.

E[Π(t)] : expected profit of the start-up firm

R : revenue from immediate commercialization

C(t) = γt^2 : development and opportunity cost of lost sales due to delay

γ : parameter of the cost function

F, f : Cumulative distribution and density distribution of $\tilde{t}$, respectively

$\underline{u}$: salvage value of the product after the potential partner rejects the offer

Ⅲ. Optimal Timing

We may now derive the following propositions regarding the optimal timing of collaborative alliances.

Proposition 1. If the cost of delay is high, then the start-up should share information with a potential partner early. (i.e., $\partial t^{*}/\partial \gamma < 0$)

If the risk of delay is high, the start-up should approach the software giant early even though there may be a risk of being rejected. In industries such as computers and telecommunications, the cost of delay is large, so a start-up with an innovation may approach a partner early. One example of this is Palm Computing, which was developing a personal digital assistant (PDA) with e-mail capability. In order to make the product commercially viable, it needed a mini-modem for its PDA, and decided to approach US-Robotics relatively early for the modem technology even though there was a risk of having its product design being exposed and expropriated by US-Robotics.

Proposition 2. If the salvage value after being rejected from the potential partner is high, then the start-up should share information with a potential partner early. (i.e., $\partial t^{*}/\partial \underline{u} < 0$)

The salvage value after being rejected will be higher in cases where there are many potential partners for the innovation. Also, the salvage value will be higher if the information revealed cannot be expropriated easily by the potential partner. In such a case it is advantageous to share information early. One example where salvage value is high is the case of a company that possesses a video compression technology for the Internet. The firm approached Microsoft to be its partner early because its technology was not easily discernable. On the other hand, Cnidaria Technologies, a biotech start-up, which invented a form of jellyfish repellent was rather slow in taking its product to the potential partner because it feared that its product could easily be deciphered by chemical analysis.

Proposition 3. If the potential partner has a shorter time frame for rejecting offers, the start-up company's profits will be higher. (Namely, letting F_1 and

F_2 be two cumulative density over $\tilde{t}$, if F_1 stochastically dominates F_2 (i.e., $F_1(\tilde{t}) < F_2(\tilde{t})$ for all $\tilde{t}$), then $E_1[\Pi(t)] < E_2[\Pi(t)]$).

There are cases where the potential partner may accept even crude ideas (i.e., have a small $\tilde{t}$ in our model) either because the product-life cycle is short or the potential payoff is high. In this case, the start-up will have greater profits. Publishers often accept books that capitalize on news events, even if they are crude and incomplete because the books only have a short window of opportunity during which it will sell. This could mean high profits for the writer. On the other hand, textbooks, which have a longer product-life cycle, often have to be complete before a publisher accepts it.

Special Case of Uniform Distribution So far, we have assumed that $\tilde{t}$ is distributed according to a general distribution function F. In this section we derive further results concerning the behavior of optimal profits by assuming that $\tilde{t}$ is distributed according to a uniform distribution with support [0, T].

Proposition 4. As the cost of delay parameter, γ, increases, optimal profit decreases in a convex way.

This result indicates that cost of delay parameter decreases optimal profits. However, it also states that the marginal effect of increases in the cost of delay parameter on decreased profits will be lower. The negative effect of marginal increases in the cost of delay parameter on profits is lessened by the mediating role of t^*. Thus, if a firm optimizes the timing of its collaboration, the marginal increases in delay cost will not be as damaging.

Proposition 5. As the salvage value after being rejected from the potential partner increases, the optimal profits increase in a convex way.

This proposition suggests that an increase in the salvage value will lead to increased profits. Also, the proposition shows that marginal increases in the salvage value will increase profits even more. That is, the effect of increases in the salvage value is multiplied by the optimal changes in t^*, leading to even greater profits.

Both propositions 4 and 5 show that fine-tuning of optimal timing, alleviates the negative effects of increases in delay cost, while exaggerating the positive effects of increases in the salvage value at the margin.

Ⅳ. Conclusion

The purpose of this paper was to identify optimal timing of information disclosure to maximize the profits accruing to the creator of a new technology. While any relationship requires some minimal level of cooperation in order to exist, the expectation that parties to a cooperative venture will seek to maximize their own gains is reasonable. We showed that one of the ways to minimize the loss from opportunistic behavior while maximizing the benefits from joint collaboration is to simply attempt to find the optimal timing of releasing information to a potential partner. After deriving the optimal timing function, we derive these further results.

- If the cost of delay in introducing the product is high, firms should release information to its potential partner early.
- If the salvage value after being rejected is high, firms should release information to its partners early.
- Fine-tuning of optimal timing alleviates the negative effects of delay cost increase while exaggerating the positive effects of an increase in the salvage value of the idea after rejection.

Optimal timing approach has the advantage that the efficacy of the mechanism is entirely in the hand of the owner of the innovation. By contrast, other forms of intellectual property rights protection (i.e., patents and contracts) are often expensive to draft and enforce. Indeed many product patents can be *legally imitated* and contracts to prevent opportunistic behavior is often takes months to write up. It should also be noted that contract arrangements are more likely to suit the more powerful partner. The parties to a relationship are by definition in asymmetric technical and economic conditions and will have asymmetric preferences over possible organizational arrangements so a contract will suit one party more than another (Grandori 1987). Indeed, both the anecdotal information provided by the patent attorneys, and previous research into firm size, has shown that large firms have resource advantages which assist them in the detection of contract breaches and in the enforcement of contracts (Deeds & Hill 1996, Hill & Snell 1989, Hoskisson et al. 1993).

The use of an optimal timing approach provides additional possibilities for protecting the revenue stream from innovation. It does not rely on court ordering in the way that patenting and formal contracts do, nor does it depend on the cooperation of the potential partner in putting contracts in place. In addition, the impact of the characteristics of the potential partner such as the size and variety of resources they have available, is reduced.

Finally, the management of innovation is an inherently untidy process (Sahal 1983), a problem that is compounded by the lack of adequate consideration given to alliance partners (Harrigan 1985). Our results highlight the importance of delay costs, the salvage value of the project, and the fine-tuning effect of the optimal timing approach in protecting one's innovation from undue appropriation by another party.

APPENDIX

Proof of Proposition 1: By the implicit function theorem, we have

$$\frac{\partial t^*}{\partial \gamma} = \frac{dH/d\gamma}{dH/Dt} = -\frac{-2tF(t)-f(t)t^2}{G} < 0$$

Proof of Proposition 2: By the implicit function theorem, we have

$$\frac{\partial t^*}{\partial \underline{u}} = \frac{dH/d\underline{u}}{dH/dt} = -\frac{-f(t)}{G} < 0$$

Proof of Proposition 3: $E_1[\Pi(t)] - E_2[\Pi(t)] = [R-C(t)-\underline{u}][F_1(t)-F_2(t)] < 0$

Proof of Proposition 4:

Given a uniform distribution with support [0, T], we have the following profit function.

$$E[\Pi(t)] = \underline{\mu} + \frac{t}{T}(R-\gamma t^2-\underline{\mu}).$$

Differentiating the above equation with respect to t, and solving for t gives,

$$t^* = \left[\frac{R-\mu}{3\gamma}\right]^{1/2}.$$

Substituting t^* into E[(t)] gives

$$E[\Pi(t^*)] = \mu + \frac{1}{T}\left[\frac{R-\mu}{3\gamma}\right]^{1/2}\left[R-\gamma\left[\frac{R-\mu}{3\gamma}\right]-\mu\right].$$

$$\frac{\partial E[\Pi(t^*)]}{\partial \gamma} = -\frac{1}{T}\left[\frac{R-\mu}{3\gamma}\right]^{3/2} < 0$$

$$\frac{\partial^2 E[\Pi(t^*)]}{\partial \gamma^2} = -\frac{1}{2T\gamma^2}\frac{(R-\mu)^{3/2}}{(3\gamma)^{1/2}} > 0$$

Proof of Proposition 5: As in the proof of proposition 4, we can derive the following inequalities.

$$\frac{\partial E[\Pi(t^*)]}{\partial \mu} = 1 - \frac{1}{T}\left[\frac{R-\mu}{3\gamma}\right]^{1/2}$$

Since $t^* < T$, we have $\frac{\partial E[\Pi(t^*)]}{\partial \mu} > 0$.

Also, $\frac{\partial^2 E[\Pi(t^*)]}{\partial \mu} = \frac{1}{6T\gamma}\left[\frac{3\mu}{R-\mu}\right] > 0$.

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