# A Symbiosis Model for New Product Development through Open Innovation Process

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***Abstract*—This research aims to propose a symbiosis model for new product development based on the open innovation concept. Particularly, a dynamical model of Lotka-Volterra approach is used to analyze the cooperative R&D relationship between the innovation intermediaries and R&D firms, the patent seekers, to share their patent portfolio or resources in the open innovation process. The study will develop a symbiosis model to assume the growth rate, growth limitation, and positive interaction effect of both R&D firms and innovation intermediaries, for best discussing the market situation in four different empirical cases. Simple numerical examples will also be adopted to demonstrate the utility of market research in this model and propose the strategic suggestion of different mutualism relationship between a R&D firm and an innovation intermediary.**

***Keywords-Symbiosis Model, Open Innovation, Innovation Intermediary, New Product Development***

## I. INTRODUCTION

Globalization and proliferation of product knowledge in knowledge-based economy demands a new open innovation approach, where integration of systems knowledge is pivotal in controlling information trafficking and management, for using the purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. Yet the evidence supporting the phenomenon of open innovation remains underdeveloped. There also has been little examination of open innovation in the context of symbiosis R&D model between the innovation intermediaries and R&D firms, especially in the discussion of their market share change after the collaborative R&D of new product development.

This research will develop a symbiosis model to assume the growth rate, growth limitation, and positive interaction effect of both R&D firms and innovation intermediaries, for best discussing the market situation in four different empirical cases. Simple numerical examples will be adopted to demonstrate the utility of market research in this model and explain the managerial explanation of different mutualism relationship between a R&D firm and an innovation intermediary.

## II. CONCEPTUAL DEVELOPMENT OF INNOVATION MODEL

The research of innovation theory has increasingly been the object of studies since Schumpeter (1934) provided a concept of innovation in the economic growth. Recently the concept of innovation was widely investigated to establish some analytical model based on the characteristic of innovation activities. These theoretical bases of model have been sufficiently supported by defining the role of innovation both in static and dynamic views. For static innovation models, Abernathy and Clark (1985) offer one explanation why incumbents may outperform new entrants in the face of some radical innovations by the segmentation of both technological and market knowledge underpinning an innovation, to define innovation as regular, niche, revolutionary, and architectural types. Meanwhile, Henderson and Clark (1990) examine why firms had problems with what appeared to be incremental innovation. This model offers that an innovation can impact either component knowledge or architectural knowledge, or both, with different consequences for the firm adopting it, to define four kinds of innovations, including incremental, radical, architectural, and modular ones.

There have been a number of studies that have investigated what the role of innovation is in the dynamic model. Abernathy and Utterback (1978) detail the dynamic processes that take place within a firm during the evolution of a technology from the fluid phase through a transitional phase to the specific phase. Tushman and Rosenkopf (1992) argue that the innovative strategy depends on the amount of technological uncertainty which in turn, depends on the complexity of the technology and the stage of evolution. This technological life cycle model starts with a technological discontinuity that can be either competence enhancing or competence destroying. Following the discontinuity is the era of ferment, when there is a significant amount of technological and market uncertainty. Finally, the emergence of a dominant design substantially reduces technological uncertainty, and ushers in the beginning of the era of incremental change.

## III. TREND OF OPEN INNOVATION

The concept of open innovation has been discussed noticeably, for creating the value in the R&D process instead of traditional closed innovation activities, comparing with the traditional closed innovation models. A growing number of studies are also now available to shed some light on open innovation (Chesbrough, 2003, 2006, Chesbrough, Vanhaverbeke and West, 2008), wisdom of crowds (Surowiecki, 2004, Libert and Spector, 2008), and collaborative R&D (Gloor, 2006, Sawyer, 2007) to analyze the

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new trend of open business model. An early discussion in the history of open innovation and customer involvement was the concept of "lead users" that are users whose present strong needs will become general in a marketplace in the future (Urban and von Hippel, 1988, von Hippel, 2005). Since lead users are familiar with conditions which lie in the future for most others, they can serve as a need-forecasting laboratory for marketing research. Moreover, since lead users often attempt to fill the need they experience, they can provide new product concept and design data as well.

In addition, the concept of open innovation has also been discussed noticeably, for creating the value in the knowledge diffusion process. An early discussion of trans-organizational innovation was the claim of Millar et al. (1997), and then Teece (2000) revealed the organizational implications of knowledge developing separately from the firms that use the knowledge. Meanwhile, collaborative R&D appears to be a useful means by which strategic flexibility can be increased and access to new knowledge can be realized (Pisano, 1990, Quinn, 2000; Fritsch and Lukas, 2001). A growing number of studies are also now available to shed some light on the new trend of external knowledge sourcing (Porter and Stern, 2001) and the division of innovation labor (Rigby and Zook, 2002), to sell the idea from one party to another party, and carry the idea to market by the latter party. This new mode of innovation and value creation is called "peer production" or "open innovation", instead of the traditional closed innovation paradigm, that makes idea flow into the firm and out to the market by the same firm (Chesbrough, 2003). Figure 1 shows the open innovation paradigm for managing industrial R&D. Ideas can originate from inside the firm's R&D process, but some of those ideas may seep out of the firm in this stage.

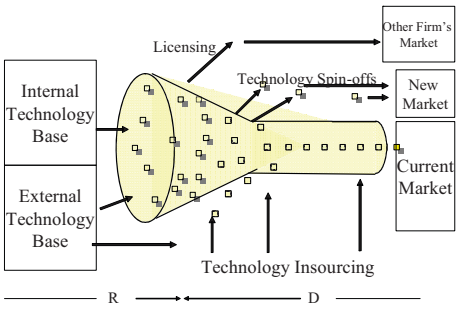


Figure 1 Open innovation paradigm (source: Chesbrough, 2003)

## IV. Innovation Intermediaries and R&D Firms in Open Innovation Process

### *a) A role of innovation intermediary*

In practice, several new service models have been developed in the intermediate market based on the concepts of open innovation. These service enterprises adopts four basic ideas of "wikinomics" (Tapscott and Williams, 2006), including openness, peering, sharing, and acting globally, to elaborate an open business model in the intermediate market, for leveraging the resources, suppliers, customers, and externalities in the industrial chain. Chesbrough (2006) depicts that the intermediate markets are markets in which an upstream supplier licenses its know-how and intellectual property to downstream developers and producers. In other word, open innovation system exploits the new division of innovation labor. This division shows up in intermediate markets for innovation and intellectual property, where ideas and patents can be bought or sold by the platform such as the electronic exchange market (Bakos, 1991, Benjamin, 1995). These markets will dramatically change the overall innovation environment (Nambisan and Sawhney, 2007a).

A lot of recent researches have been done to describe the role of innovation intermediaries as a knowledge broker (Hargadon and Sutton, 1997, Hoppe and Ozdenoren, 2005, Pollard, 2006)or a collaborative R&D entity (Powell, Koput and Smith-Doerr, 1996, Howells, 1999, Miozzo and Dewick, 2004). Several studies also suggested the category of innovation intermediaries in terms of operational role or business function. Hargadon (1998) claimed that the knowledge brokers engage in several strategic roles involving access, learning, linking, and implementation activities. Other typology (Sawhney, Prandelli and Verona, 2003) tried to identify the intermediary type based on their mechanisms that helping companies exploit customer knowledge as customer network operator, customer community operator, and innovation marketplace operator. Besides, Chesbrough (2006) offers a typology in intermediation market including agent, broker, and market maker. Howells (2006) claims that the role of intermediaries covered ten functions in all including foresignt and diagnostics, scanning and information processing, knowledge processing and combination/recombination, gate-keeping and brokering, testing and validation, accreditation, validation and regulation, protecting the results, commercialization, and evaluation of outcomes. In addition, Evans and Schmalensee (2007) define innovation intermediaries as a catalyst operating in three roles such as matchmaker, audience builder, and cost minimizer. In a view of organization, Winch and Courtney (2007) indicate two modes of innovation broking like broadcast and consultancy modes. Finally, in Nambisan and Sawhney's research (2007b), they introduced three new kinds of innovation intermediary that can help companies improve the effectiveness of their innovation sourcing efforts, including sales of raw ideas, sales of market-ready products, and sales of market-ready ideas. The findings reveals that the operational model of innovation intermediary includes idea scouts, which seek and screen ideas in the inventor community on behalf of large firms that then review them for commercial potential; patent brokers, which bring together inventors and firms that are interested in commercializing their patents, without representing either side; licensing agents, which broker the licensing of patented technologies; and invention capitalists, which buy patents from inventors and then sell them to companies, sometimes bundling patents related to a particular market opportunity; and electronic R&D marketplaces, can help match companies with promising ideas or patents.

### *b) Mutualism Relationship between Innovation Intermediary and R&D Firm*

A graphic model is constructed in Figure 2, to explain the operational mechanism of innovation intermediary discussed in this research. Platform operators, technology providers, and

technology searchers would play three major roles in this model operation, to receive the input of technology or patent, and produce the output of patent portfolio, technology licensing, technology solution, or product ideas by the active interaction of operators, providers, and searchers. In this business model, particularly, the boundary between technology providers and searchers would be vague, and the operational procedure of platform operators would be the cycle of knowledge (technology) search, sorting, reconfiguration, and delivery by the practical activities such as technology seek, screen, valuation, recombination, or connect providers and searchers together.

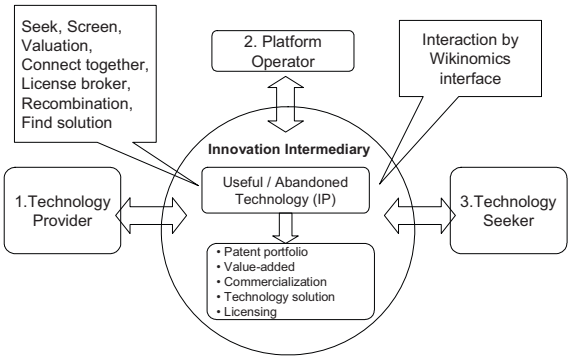


Figure 2 Business model of innovation intermediary

The business model of innovation intermediary can be applied in collaborative R&D process through open innovation concept. Figure 3 describe the mutualism relationship between innovation intermediaries and their clients, R&D firms or technology seekers, in the process of new product development in open innovation case. In this R&D collaborative model, the role of innovation intermediary will be to provide the patent portfolio B for the demand of R&D firms by technology consulting, licensing, technology transfer, or sale, although the source of patent portfolio B may be not developed by this innovation intermediary itself. As shown in Figure 3, this collaborative relationship will formulate a symbiosis model between R&D firms and innovation intermediaries for new product development, which the innovation intermediaries provide necessary technology solutions to the R&D firms for solving their technological barrier and survive in the intermediation markets by the financial support of R&D firms depending on their licensing and collaboration agreements.

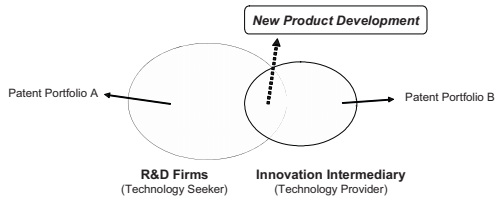


Figure 3 Mutualism relationships between innovation intermediary and R&D firm in new product development

## V. Analysis of Symbiosis Modeling

Now we build a symbiosis model to mathematically simulate the market situation between R&D firms and innovation intermediaries, further introducing a simple numerical example explaining the change of market share in a R&D firm and an innovation intermediary through open innovation process.

### *a) Scenario Writing*

This research constructs the business scenario between R&D firms and innovation intermediaries according to the empirical situation. Firstly, the model assumes that both R&D firms and innovation intermediary can exist solely in their own competition market by the individual business models. For the role of innovation intermediary, the business model that can exist solely means it may have its own new products for sales or other profit models in addition to licensing the patent portfolios to the R&D firms.

As shown in Table 1, this study assumes that the interaction effects between R&D firms X and innovation intermediary Y are the same, which represents the business supports with each other including patents, technologies, information or revenues have the same positive effects. Furthermore, the growth limitation of R&D firms and innovation intermediaries are both assumed the same due to the similar limitation of industrial and market resources. Table 1 also presents that the growth rate of R&D firms are assumed higher than the one of innovation intermediaries due to their different business model. Profits of R&D firms should be much higher after selling their own new products comparing with a purely technology licensing model of innovation intermediaries, resulting in a higher growth rate of market share for R&D firms.

Table 1 Scenario assumption of symbiosis model between R&D firm X and innovation intermediary Y

| | Growth rate | Growth limitation | Positive interaction effect | Initial market share | Industrial situation |
|---|---|---|---|---|---|
| Scenario 1 | X>Y | X=Y | X=Y | Both low, and X=Y | ◆ Emergent industry<br>◆ Industrial structure is amorphous<br>◆ Potential market growth is high |
| Scenario 2 | X>Y | X=Y | X=Y | X>Y | ◆ Closed industrial supply chain<br>◆ Industrial structure is oligopoly<br>◆ Potential market for innovation intermediaries |

| | | | | | |
|---|---|---|---|---|---|
| Scenario 3 | X>Y | X=Y | X=Y | Both high, and X=Y | ◆ Mature industry<br>◆ Industrial structure is oligopoly<br>◆ Potential market growth is low |
| Scenario 4 | X>Y | X=Y | X=Y | X<Y | ◆ Open industrial supply chain<br>◆ Active technology transfer<br>◆ Industrial structure is amorphous<br>◆ Potential market for R&D firms |

As a result, four empirical scenarios will be discussed in this research depending on the different initial market share of a R&D firm and an innovation intermediary as observed in Table 1. The low initial market share or less entries of R&D firms in an industry often reveal that the industry is emergent and potential market growth is high. The industrial structure in this stage is also amorphous due to the undefined industrial network. On the other hand, for the growth of innovation intermediaries, the high initial market share or more entries of intermediation firms in an industry may mean that the industrial supply chain is open for technological innovation and the operational mechanism of technology transfer in the industry cluster is active. Table 1 describes the industrial situation and managerial explanation of these four scenarios in this simulation model.

*b) Symbiosis Model between Innovation Intermediary and R&D Firm*

This section will construct a symbiosis model to describe the mutualism scenarios between innovation intermediaries and R&D firms mentioned as above, by employing an alternative model of dynamic competition based on the Lotka-Volterra model (Lotka, 1925, Voltera, 1928). In this formulation, we use X(t) and Y(t) represent the market share of a R&D firm and a innovation intermediary respectively. On the other hand, the function of X(t) and Y(t) can also be explained as the entry numbers of R&D firms and intermediation firms in their markets respectively. The symbiosis equations can be formulated as:

$$\frac{dX}{dt} = g_x X - l_x X^2 + k_{xy} XY \quad (1)$$

$$\frac{dY}{dt} = g_y Y - l_y Y^2 + k_{yx} YX \quad (2)$$

where all coefficients are positive. The coefficients $g_x$ and $g_y$ are the natural growth rate for the one in the absence of another one and under the assumption of unlimited resources. Meanwhile, the coefficients $k_{xy}$ and $k_{yx}$ account for positive interaction effect between the two firms X and Y. Their values represent the positive support and exchange with each other including patents, technologies, information or revenues. Finally, the coefficients $l_x$ and $l_y$ account for the intra-specific interference where growth resources are limited, as discussed in the traditional logistic growth.

The solution of Eqs (1) and (2) can be solved and described as time domain and phase diagram. The coordinates for the equilibrium point are given by:

$$X^* = \frac{g_x l_y + g_y k_{xy}}{l_x l_y - k_{xy} k_{yx}} \quad (3)$$

$$Y^* = \frac{g_y l_x + g_x k_{yx}}{l_y l_x - k_{yx} k_{xy}} \quad (4)$$

From the viewpoint of phase diagram, there are again two cases, viz. $l_x l_y > k_{xy} k_{yx}$ and $l_x l_y < k_{xy} k_{yx}$. Note that in the former case there is an equilibrium point in the region X,Y>0 and in the latter case there is not. This study will only discuss the first case $l_x l_y > k_{xy} k_{yx}$ with equilibrium point to explain the managerial explanation in the mathematical simulation.

*c) Results of Numerical Example*

This section will use numerical examples to describe four industrial scenarios noticed as above, to further solve this symbiosis model between R&D firms and innovation intermediaries. Referring to the assumption in Table 1, the coefficients of model will be assumed as follow:

$$\frac{dX}{dt} = 0.15X - 0.01X^2 + 0.005XY \quad (5)$$

$$\frac{dY}{dt} = 0.10Y - 0.01Y^2 + 0.005YX \quad (6)$$

As a result, the solution of Eqs (5) and (6) can be solved depending on the initial values of X(0) and Y(0) by the MATLAB software. Figure 4, 5, 6 and 7 show the trajectories as well as time domain plots for the same symbiosis model but with different initial values in the four scenarios in Table 1 (the initial values are shown in the Figures). We can find the path of the trajectory depends strongly on the initial market status/share of the R&D firm and innovation intermediary.

In the result of numerical example, the time domain plots reveal that both firms have benefited from the symbiotic open innovation process in all scenarios except the scenario 3. To be elaborate, both R&D firm and innovation intermediary attain a higher final market share when there is a symbiotic collaboration and both grow towards these final values faster except the scenario 3.

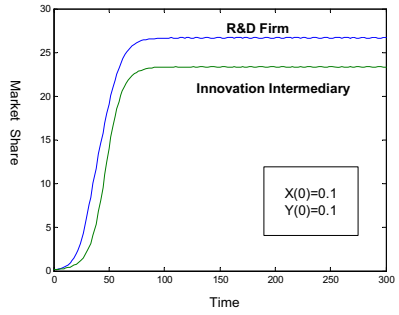


Figure 4 Time domain plot of scenario 1

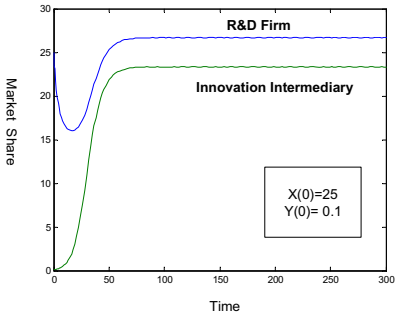


Figure 5 Time domain plot of scenario 2

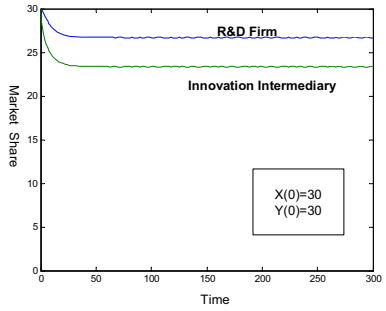


Figure 6 Time domain plot of scenario 3

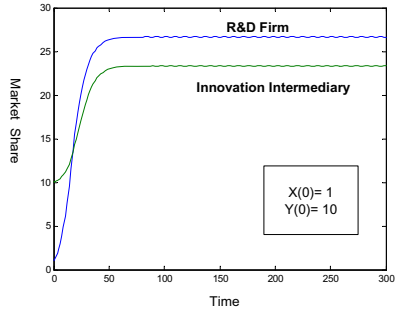


Figure 7 Time domain plot of scenario 4

## VI. DISCUSSION

The result of numerical examples in this symbiosis model can be further analyzed to discuss the managerial and industrial explanation. The future works about the minor revisions of symbiosis model between R&D firms and innovation intermediaries will also be discussed in this section.

### *a) Managerial Explanation*

The results of time domain plots in these four scenarios can be analyzed separating the perspectives of R&D firms and innovation intermediaries respectively. From the viewpoint of R&D firms, they can surely benefit from the technology licensing of innovation intermediary while the initial market share is low no matter the development status of intermediation market (scenario 1 and 4). The only difference is that the R&D firm can grow toward the final market share faster while the support and mechanism of technology intermediation is well-established (the initial value of innovation intermediary is high) such as the scenario 4.

On the other hand, if the initial market share of the R&D firm is high in a oligopoly and mature industry, the firm may benefit a bit from the symbiotic interaction (scenario 2) or gradually drop in market due to the mature industrial structure (scenario 3). The reason may be that the market share of the R&D firm will firstly decrease and then increase toward the final value due to the fast growth of potential intermediation market in scenario 2. On the contrary, the scenario 3 means that the industrial structures of both new product and intermediation markets are mature and occupied by specific companies, resulting in the technological support of innovation intermediaries to the R&D firms is limited for new product development and market promotion.

From the viewpoint of innovation intermediaries, they can attain a higher final market share and grow fast with the interactive support of R&D firms except the scenario 3. The mutualism relationship is particularly critical for innovation intermediaries due to their lower natural growth rate. For the case of scenario 3, the higher initial market share of innovation intermediary represents it has a stable business model and profit source in the industry, and the potential growth of intermediation market may be low due to the limited market growth and mature technological capabilities of their clients, the R&D firms.

### *b) Future Works*

The future works of research can focus on several minor revision of symbiosis model to simulate other empirical cases. For the role of innovation intermediaries, this research assumes that the intermediation firms can exist solely by their other profit models. However, the business model of innovation intermediaries can also be assumed as a purely technology provider according to the literature reviews of intermediation category. The operation of this intermediation model will not exist solely due to the only profit source of symbiotic interaction with the R&D firms. In this scenario, the symbiosis equation can be formulated as follow with the minor revision about the first term of the right sides in Eq (8):

$$\frac{dX}{dt} = g_x X - l_x X^2 + k_{xy} XY \tag{7}$$

$$\frac{dY}{dt} = -g_y Y - l_y Y^2 + k_{yx} YX \quad (8)$$

Furthermore, this model assumes that the interaction effects (k) between R&D firms and innovation intermediary and the growth limitation (l) of both R&D firms and innovation intermediary are the same. These assumptions can be probably adjusted to discuss the different case of real example. For instance, the positive support of interaction (k) may be more for the research of R&D firms than the operation of innovation intermediaries actually. On the other hand, the growth limitation (l) for intermediation market may also be higher due to the limitation of technology licensing in different fields and industries.

## VII. CONCLUSION

This research proposes a symbiosis model to simulate the market situation of mutualism relationship between R&D firms and innovation intermediaries, by assuming the growth rate, growth limitation, and positive interaction effect of both R&D firms and innovation intermediaries in four different empirical scenarios. Simple numerical examples are also adopted to demonstrate the utility of market research in this model and explain the managerial explanation of different mutualism relationship between a R&D firm and an innovation intermediary.

The results reveal that the R&D firms can benefit from the technology licensing of innovation intermediary while the initial market share is low no matter the development status of intermediation market. The only difference is that the R&D firm can grow toward the final market share faster while the support and mechanism of technology intermediation is well-established. Meanwhile, while the initial market share of the R&D firm is high in a oligopoly and mature industry, the firm may benefit a bit from the symbiotic interaction or gradually drop in market due to the mature industrial structure. This finding also shows the innovation intermediaries can attain a higher final market share and grow fast with the interactive support of R&D firms except the initial market shares of the R&D firm and the innovation intermediary are both high.

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