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Determinants of Demand for Technology in Relationships with Complementary Assets in Japanese Firms[1]

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Abstract

There is a growing trend of open innovation in the new product development process, while technology insourcing has not been investigated very well as compared to technology outsourcing in empirical literature. In this paper, we examine the factors that determine whether to acquire external knowledge and how to assimilate it in the process of new product development by using novel dataset at the product level, conducted by RIETI in 2011. We distinguish whether technology partners are also business partners such as suppliers or customers, and show their distinct patterns. In the case that technology partners are not business partners, patents play an important role in moderating transaction costs in the partnership, while co-specialization of technology and its complementary assets with partners is found for cases in which technology partners are also business partners.

JEL classification: D22, L22, O32

Keywords: Technology sourcing, Co-specialization, Complementary assets

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1. Introduction

Division of innovative labor is progressing in high-tech sectors such as software and pharmaceutical products, and an effective use of external knowledge source becomes one of important issues in technology management at firm. However, a process of new product development (NPD) is too complex to be decomposed into separate activities, so that knowledge generation process for NPD is mostly constrained within a firm or limited number of business partners (Arora et. al, 2001). In addition, a moderating factor of patent to high transaction cost associated with innovation partnership is empirically supported (Arora and Gambardella, 2010).

This paper empirically investigates such difficulty in division of innovative labor by using the dataset from the questionnaire survey on the source of knowledge for new product development by the Research Institute of Economy, Trade and Industry (RIETI), Japan in 2011. This survey reveals information of the balance between inside and outside of firm on the resources devoted to NPD and a type of collaboration, such as joint venture, collaborative R&D and licensing in case of using external resources. In addition, an information on investment in market introduction of new products is available, which allows us to investigate the division of labor not only for technology asset, but also for its complementary assets.

From this survey, we have found that substantial numbers of external partners in NPD process are business partners as well. Therefore, the innovative division of labor does not occur independently from business relationship (Arora et. al, 2001). In our sample, a substantial number of firms are operating B2B business, so that their customers are firms which use their material, parts and capital products. In this case, a NPD at B2B firms is organized jointly with their customers. A typical case is the relationship between an automobile assembler and parts company. In many cases, a parts supplier jointly develops new products with its customer (assembler), instead of producing the product which is completely specified by its customer. In this case, a long-term relationship between supplier and manufacturer facilitates co-specialization of relation specific investment more than those who are dealing with pure technology transactions in market base competition. This paper distinguishes two types of technology partnership, whether technology partner is business partner or not, to see understand more clearly the mechanism of technology sourcing in a whole process of NPD.

This paper is structured as follows. A next section is a literature survey in the field of technology transactions. We have reviewed theoretical arguments both in transaction cost theory and resource based view of firm. This section is followed by a description of

survey and some variables used for our empirical model. The section 4 shows the results of econometric analysis on the determinants of technology sourcing. Finally, a conclusion part summarizes our main findings and provides further research questions.

2. Literature Review

Based on the framework of transaction costs introduced by Coase (1937), the boundary of the firm, the make-or-buy, is determined by the relative costs of internal versus external exchange. The earliest literature on the make-or-buy decision addressed the choice between external sourcing and in house procurement, and then firms were modeled as choosing between markets and hierarchies, as expressed by the title of Williamson's book (Klein, 2005). Williamson set up the transaction cost theory, and proposed the perspective of vertical integration. In addition, Williamson (1991) distinguishes organization forms, market, hybrid, and hierarchy. A hybrid form is a non-standard vertical contractual arrangement, such as long-term contracts, partial ownership agreements, franchises, networks, alliances, and other combinations. Joskow (2005) reviews the causes and consequences of vertical integration, and additionally relationships between vertical integration and substitute non-standard vertical contractual arrangements. Thus, on empirical studies of firm's boundary decision which Klein (2005) and Lafontaine and Slade (2007) review the findings of, the organization form, which is defined as 'make,' 'buy,' or 'hybrid', is the dependent variable, and asset specificity, uncertainty, complexity, and frequency are independent variables.

Especially, asset specificity is an important factor on the decision of the firm's boundary, and higher asset specificity has the higher value under the condition of a specific utilization or relationship. Similarly, relationship-specific investment is to invest in the asset which supports a specific trading relationship, including both specialized physical and human capital, along with intangibles such as R&D and firm-specific knowledge or capabilities (Klein, 2005). The firms would not invest relation specific assets even if the investment was efficient because once relationship specific investments have been made owners of the assets could face on a hold-up problem. Vertical contracts mitigate a hold-up problem. Williamson (1991) expresses a governance cost of each forms, market, hybrid, and hierarchy, as a function of asset specificity, and denotes the organization form transits from market, hybrid, to hierarchy if asset specificity increases.

In addition, the property rights theory, based on more formal economics modeling, has developed and addressed the firm's boundary questions (Hart and Moore, 1990; Hart, 1995). The property rights theory focuses on the investment incentives of players in joint production system, and suggests that asset specificity in relation specific

investment leads to lower incentive for a player for fear of ex-post hold up problem by its counterpart. Therefore, more asset specificity makes vertical integration more efficient, as is the case in transaction cost theory. However, it should be noted that technology complexity and uncertainty of joint project does not always lead to vertical integration in this model. For example, in case that supplier and manufacturer are involved with joint production activity, technological complexity in upstream activity induces higher marginal return from supplier's investment. As a result, separation of supplier and manufacturer becomes more efficient, as compared to integration by manufacturer's ownership of supplier's asset (Lafontaine and Slade, 2007).

In contrast to transaction cost theory (as well as property right theory), focusing on the efficient governance structure of firm's assets, resource based view sees its assets as a source of competitiveness which differentiate from other firms. It is predicated that organizational capabilities and accumulated technology which have economic value are rare and highly difficult to imitate to create sustainable advantage vis-à-vis competitors, and that these resources cannot easily be transferred between firms (Barney, 1991). According to resource based view, inter-firm collaboration occurs in the process of accessing to complementary assets in other firms, instead of minimizing transaction cost associated with such partnership (Madhok, 2002).

Jacobides and Winter (2005) illustrate a dynamic view of co-evolution of transaction cost and capability. This mechanism starts with selection of partners in a space of different assets distributed among firms. Then, a firm starts figuring out institutional setting to lower transaction cost. Using market intermediary or consultancy service is one solution. In addition, repeated interactions with one partner reduce transaction cost of partnership substantially. In a world of decreasing transaction cost, co-specialization of firm's investment in its capability is progressed. This will lead to further development of intermediation services, and drive down transaction cost.

Lavie (2006) addresses the question of incentive to collaborate, focusing on firm's resource in dyadic partnership. There are overlapping part of firms' resources in two firms, and the rent arising from the alliance can be broken down into (1) rent based on the firm's technology resources, (2) relational rent appropriated from shared assets, (3) inbound spillover rent gained from the other side's technology resources and (4) outbound spillover rent flowing from the firm's technology resources to the other sides.

Empirically, the existence of share technology resources is supported by the fact that internal R&D activity and adopting external technology are often not mutually substitutionary, but complement each other; the R&D boundary decision is considered

as the make-and-buy but not the make-or-buy. Cassiman and Veugelers (2006) investigate the innovation strategy, 'NoMake&Buy,' 'MakeOnly,' 'BuyOnly,' and 'Make&Buy,' using a survey data on innovation in Belgian manufacturing industry, and suggest that internal R&D and external knowledge acquisition are complementary innovation activities; the 'Make&Buy' strategy increase the share of sales from new products. However, the degree of complementarity is sensitive to other elements of the firm's strategic environment; effective intellectual property protection industry, effectiveness strategic protection and basic R&D reliance increase the probability adopting the 'Make&Buy' strategy.

The portion of appropriated rent from the shared resources is called as an appropriated relational rent, and is determined by various factors including relative absorptive capacity and relative scope/scale of resources (Lavie, 2006). An absorptive capacity is a learning capability from alliance, such as acquisition of external technology and its exploitation to come up with economic rent (Cohen and Levinthal, 1990). The relative absorptive capacity reflects the efficiency of rent extraction from the shared resources. As for the size of appropriated relational rent, the size of potential shared resource does matter as well. In this sense, a relatively smaller firm may be able to gain from alliance with a larger firm with wider and greater resources (Lavie, 2006).

In addition, in the course of the interaction with partners, technology is exposed to other companies, making it difficult to appropriate the rent arising from that technology. R&D partnerships have both a spillover effect, broadening a firm's own technology base, and a heightened risk of technology leaking outside, which reduce appropriating rents from the technology. Methods to increase technology appropriability, in addition to intellectual property rights protection, include complexity of product design and speed of development (Levin et al, 1986). Some research findings indicate that firms which have a greater ability to control the outside spillover therefore pursue more partnerships (Cassiman and Veugelers, 2002).

3. Data and variables

3.1 Survey of New Product Development

We conducted the survey for 18,000 business units of Japanese firms in 2011, and 3705 responded (response rate=20.6%). In this survey, new product development is defined according to the Oslo Manual of OECD, and for 1,390 business units (38% of total responses) with some new product introduced in the period between 2008 and 2010, the sources of information for new product development are identified.

To consider innovation activity for a new product, we categorize our data by innovation strategy as shown by Figure 1. At first, we classify into two categories depending on whether mainly internal development or external development.

- Internal development, where firms mainly develop this new product or services by themselves.
- External development, where outside organizations mainly develop this new product or services.

The vast majority of samples (1199 samples; 86%) have undertaken internal development, and the remainders (168 samples; 12%) have undertaken external development. The group that undertook external development includes several kinds of business. One of them is that a firm introduces a product which another firm develops (and manufactures) and then sells it through their sales network without internal R&D expenditure. The other one is that a firm is subcontracted to produce to order using the design by a contractee. We consider that the structure of innovation is different between these businesses and those who develop by themselves, therefore in this paper we have analyzed the group of internal development. In the typology of Cassiman and Veugeles (2006), i.e, 'NoMake&Buy,' 'MakeOnly,' 'BuyOnly,' or 'Make&Buy',our study focus is 'MakeOnly' and 'Make&Buy'm involving internal development activity.

Regarding the sample of internal development, we identify that whether they have acquired external technology formally and how did they acquire it. I

n Figure 1, the number of 'Acquiring external technology' is that firms develop the prototype using at least one of the formal ways like making a contract with outside organizations; M&A or investment, joint venture or collaborative R&D, license in, R&D commission or consulting(436 samples).

(Figure 1)

Furthermore, we focus on the type of a technology partner. Figure 1 illustrates the new product development process incorporating external technologies. A discussion on firm's boundary of technological development is made whether there is an external collaborator for technological contents (technology partner). However, new product development process involves product conceptualization, taking into account market needs. In addition, we would expect that the determinants of external technology sourcing are different, whether a firm has a business partner for the new products, such as specific suppliers and customers, or not.

For example, automotive parts manufacturers often develop parts jointly with their customers, the automotive manufacturers. In such cases, the automotive manufacturers play the role of both the provider of external technologies and customers. The decision to incorporate external technologies is made in conjunction with the client, leaving the firm in question with no choice. Incorporating external technologies from a particular customer or supplier is not an isolated technology market issue, but rather calls for consideration within an analytical framework including the relationship with business partners.

Therefore, we divide the samples of 'Acquiring external technology' by the type of partners; 'Technology partner = Business partner (T = B)' or 'Technology partner ≠ Business partner (T ≠ B)'. Although there is no information about partners, we can use information about most important source at the prototyping stage[2]. Of samples 66% acquiring external technology conduct a transaction with a partner of a business relationship, suppliers (23%) or customers (43%), we define these samples as 'T = B'. The process of new product development is too complex to be decomposed into separate activities, so that knowledge generation process for new product development is mostly constrained within a firm or limited number of business partners (Arora et. al, 2001).

In this paper, we have empirically investigated determinants of two types of division of labor (asset), as is shown in Figure 2. One is a division of labor in technology assets, i.e., whether a firm use external technology sourcing in its innovation process. Another is a division of technology asset and its complementary assets for innovation such as marketing channels and personnel.

(Figure 2)

The second division of labor is identified by using the information whether (T = B) or (T ≠ B). Our survey has the following items inquiring whether new investments to complementary assets related to new products are made.

New channel: "Did you developed new sales and distribution channels to

[2] Question: In developing this product, did you utilize information from any of the following? Please reply and classify by "①Conceptualization stage" and "②Prototyping stage". (check the most important source)
A supplier, A customer, Another firm in your industry, A consultant, An engineering service provider or commercial lab, Universities, Government labs, Information on patents, The public domain, such as, publications or public meetings, A collaboration between your firm and others.

commercialize the product?"

New factor: "Did you buy new types of equipment or employee with skills different from those of existing employee?"

As shown in Figure 3, groups of acquiring external technology have higher proportions of requirement of new complementary resources, and 'acquiring from T ≠ B' is higher than 'acquiring from T = B,' in both items. Therefore, in case of T = B, it is more likely for a firm to use marketing channels and new employees which required to new products of business partner. In contrast, in case of T ≠ B, a firm invests in these complementary assets by itself. Therefore, we assume that division of technology and complementary assets are conducted more for T = B, as compared to T ≠ B.

(Figure 3)

3.2 Dependent Variables

We have conducted two regressions in as shown in section 4. In the first regression, where we analyze the factors that the firms which mainly develop this new product or services by themselves assimilate external knowledge by a probit model, the dependent variable is a dummy equal to one if acquiring external technology, ***Acquiring***. In the second regression, where we research how to assimilate external technology by a multinomial logit model, the dependent variable is the set of three discrete choices, ***acquiring from technology partner ≠ business partner (T≠B), acquiring from technology partner = business partner (T=B), or not acquiring.***

3.3 Explanatory Variables

We organize explanatory variables to acquiring external technology on NPD into three parts, i.e., moderating factors of transaction costs, the degree of co-specialization of technology and complementary assets, based on the resource based view and other control variables.

3.3.1 *Moderating factors of transaction costs*

As is described in the section 2, asset specificity and uncertainty plays an important role in determining firm's boundary. In terms of technology transactions, patent plays an important role to moderate transaction costs. First, intellectual property ownership mitigates risk of ex-post hold-up problem, because it can be more easily traded with other parties. A related argument as regards to patent is that patent information is

disclosed to public, which reduces information asymmetry between technology owner and its potential users.

Patent: The dummy variable takes the value 1 if the respondents own patents of the product.

In addition, the effect of IPR protection on transaction moderation is particularly large in science based industry, such as pharmaceuticals. More science base implies more codification of technological contents, which makes IPR protection stronger. In this sense, IPR protection and science based are inter-related each other. Arrora and Ceccagnoli (2006) shows the effect of IP protection on licensing can be found in R&D firms without manufacturing resources, while it is not the case for integrated firms with complementary assets. The degree of science base can be measured by R&D intensity as follows.

R&D*:** The propensity of R&D expenditure to sales in a business unit (the R&D intensity) is indicated by a categorical response, 0%, 0 to 1%, 1 to 3%, 3 to 5%, 5 to 10%, and more than 10%, on a scale of 0–5. ***R&D0, ***R&D1***, ***R&D2***, ***R&D3***, ***R&D4***, or ***R&D5*** take the value 1 if the survey respondent indicates that the propensity of R&D expenditure to sales in a business unit is 0%, 0 to 1%, 1 to 3%, 3 to 5%, 5 to 10%, or more than 10%, respectively.

3.3.2 *Degree of co-specialization of technology and complementary assets*

Resource based view literature suggests co-specialization pattern in technology partnership, since each of party has more incentive to invest in its core capability. Therefore, a firm will gain relatively more from the other side by entering into alliances in fields in which it has less expertise. In contrast, a firm with substantial assets has less incentive to collaboration with others in its competitive field (Lavie, 2006). Here, we investigate the possible co-specialization of technology and complementary assets. It is found that a firm with larger marketing assets has less incentive in technology in-sourcing for pharmaceutical firms (Ceccagnoli et. al, 2010). Therefore, we include the following two explanatory variables, reflecting the size of complementary assets.

***Different business*:** The dummy variable takes the value 1 if the business category of the respondent is different from the new product category, which consists of 90 categories.

Experience: The dummy variable takes the value 1 if respondent entered your business filed more than five years ago.

3.4 Control variables

Technology sourcing decision is complicated in nature, and there are substantial numbers of control variables which should be considered in our empirical model. First one is the speed of innovation process. In emergent markets alliances improve strategic position because alliances can provide financial resources that enable cost- and risk-sharing with other firms (Eisenhardt and Schoonhoven, 1996).

First mover: The dummy variable takes the value 1 if the product was released ahead of other firms.

As internal hampering factor, internal departments could be obstacle to acquire external technology as Allen and Katz (1982) points out “not-invented-here” (NIH) syndrome. It is also one of the hampering factors in the survey. The other variables are control variables.

NIH: The dummy variable takes the value 1 if the respondents checked the item; “Another department resists acquiring external information”.

In order to maximize the return from technology partnership, it is also important to control potential damage from unintentional information leakage to outsiders. Therefore, the following variable is also included.

Risk of divulging: The dummy variable takes the value 1 if the respondents checked the item; “The risk for divulging of internal information is too large”.

Finally, we control for the characteristics of a firm, its business relationship and industry as follows.

Employee: We use the logarithm of the number of employees in a firm.

Start-up: The dummy variable takes the value 1 if the firm is a start-up firm which is defined as being in business less than five years.

Single specific customer: The dummy variable takes the value 1 if the product is sold to one specific customer.

Multiple specific customers: The dummy variable takes the value 1 if the product is sold to multiple specific customers.

Affiliated supplier: The dummy variable takes the value 1 if the firm mainly receives supplies from affiliated companies.

Affiliated customer: The dummy variable takes the value 1 if the firm's main customers are affiliated companies.

Industry dummy variables: In order to control for industry characteristics, we included twenty seven industry dummy variables except for Others; Chemicals, Pharmaceuticals, Electronics, Machinery, Transportations, Instruments, IT service, and Others.

Table 1 presents summary statistics of variables by choices; 'acquiring from T≠B,' 'acquiring from T=B,' or 'not acquiring'. In both 'acquiring from T≠B' and 'acquiring from T=B,' the score of R&D intensity and the share of a product, which was non-core business field or was released ahead of other firms, are higher than 'not acquiring.' By contrast, in 'acquiring from T≠B' more than half own patents of the new product, and the proportion of product for specific customers is higher than other two groups in 'acquiring from T=B'. We can observe the different attributes by partners even external technology acquisition. Table 2 shows the correlation matrix.

(Table 1) (Table 2)

4. Econometric analysis

We analyze what factors the firms which mainly develop a new product or service by themselves determine assimilating external technology. At first, we estimate a probit model of whether the firms decide to acquire external technology or not, as reported in Table 3. The coefficients show the marginal effects of these factors on the probability of external technology acquisition.

(Table 3)

Patent protection for the new product, *Patent*, has a positive effect on the probability of external technology acquisition. This result suggests that a firm intend to adopt external technology if in-house technology is adequately protected by patents. Although *Patent* could indicate the evidence for high-tech, we consider that it would be possible to identify the effect to some extent by controlling for R&D intensity and industry dummy variable. Regarding R&D intensity, in regression (1) the effect of patent protection would be overestimated because the marginal effect of *Patent* largely decreases, 0.266

to 0.094, when we examine R&D intensity closely using the dummy variables in regression (2). Furthermore, regression (3) and (4) present the estimation results excluding the samples which have not been aware of external knowledge or technology acquisition. We can observe that the magnitudes of all marginal effects decrease to compare regression (1) and (3), although there is no change about statistically significance. Therefore, overestimation could be caused by the samples which have not been aware of external knowledge or technology acquisition rather than R&D intensity because of no difference between the results of regression (3) and (4).

R&D, which shows the category variable depending on the R&D intensity, has a positive and significant effect on assimilating external technology.. Furthermore, in regression (2) when we replace *R&D* with *R&D1*, *R&D2*, *R&D3*, *R&D4*, and *R&D5*, only the coefficient of the highest level of R&D intensity, *R&D5*, is positive and has a significant effect. This result implies that the group, which has on R&D intensity of more than 10%, increases the probability of external R&D acquisition rather than monotonically rising as a function of R&D intensity. Therefore, external collaboration is particularly found in high-tech firm. Together with the positive coefficient of *Patent,* the moderation effect of patent to transaction cost is particularly found for firms with less complementary assets.

We find the significantly positive effects of *Different business*, therefore the probability of utilizing external technology increase by about 10% when a firm is not familiar with the business field. In addition, negative and statistically significant coefficients are found to *Experience*. This is because a firm will gain relatively more from the other side by entering into alliances in fields in which it has less expertise.

Next, we divide acquiring external technology by the type of partners, and investigate the factors that influence the choice probability of 'acquiring from T≠B', 'acquiring from T=B', and 'not acquiring' using multinomial models. As is discussed in the section 3.2, those who acquire technology from its business partners (T=B) invests less in complementary assets, such as new marketing channels and personnel, as compared to firms acquiring from T≠B, which suggests the possibility of division of labor between technology and complementary assets with its business partner. Table 4 shows the estimation results using multinomial logit model where we use the following alternatives; 'acquiring from T≠B,' 'acquiring from T=B,' or 'not acquiring'[3]. Note that

[3] The base category is 'No acquiring'. We conducted a Hauseman test to check the independence from irrelevant alternatives, IIA assumption. We could not reject the equality of the common coefficients across original estimation and estimation without

our estimation model is not a sequential decision process; acquiring or not, and then 'acquiring from T≠B' or 'acquiring from T=B.'

(Table 4)

We find the significantly positive effects of *Patent* on the probability of 'acquiring from T ≠ B,' therefore the probability of acquiring external technology from other than suppliers and customers increase by about 10% when firms own patents of the product. Instead, the probability of internalization on new product development process decreases by owning patents. Although the estimation results of probit models in Table 3 show just the positive effects on external technology acquisition, we can identify the effect of patents depending on partners by dividing the type of partners. This result suggests that moderating effect of patents can be particularly found in the case of pure technology asset insourcing without interactions of complementary assets.

Positive coefficients to R&D intensity are found conversely in firms acquiring from T = B. This supports the hypothesis of co-specialization between technology assets (for technology acquirer) and complementary assets (for its business partner). Furthermore, *Different field* has a positive and significant effects on the probability of 'acquiring from T = B,' suggesting again this co-specialization story. When a firm develops a new product in which the field is not a main business, it has less incentive to invent in its less competitive resources such as marketing channels and personnel. Therefore, such firm tends to rely on the resources of its business partner by focusing on technological development activities.

As is shown in positive and statistically significant coefficients with Experience in not technology acquisition group, there is less incentive to collaborate with others for a firm which has substantial business experience in a field of new product development. This result can be explained also by resource based view, where a firm tends to invent in its relatively competitive assets by itself.

First mover positively affects the probability that a firm assimilates technology from business partners. It is implied that although the product which is released ahead of other firms involves large commercial risks, the alliance with business partners might mitigate the risks.

Single specific customer and *Multiple specific customers* positively affect the probability that the firm adopts external technology of business partner, while they have

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'acquiring from T≠B,' and also original estimation and estimation without 'acquiring from T=B.'

negative effects on the probability of acquiring external technology from other than suppliers and customers. For technology transaction with different types of partner, the factor of specific customers has a completely different effect on external technology sourcing. Moreover, the marginal effect of *Single specific customer*, about 20%, is larger than multiple customers because asset specificity could be higher. In addition, In addition, *Affiliated supplier* has positive and statistically significant coefficient. A potential hold-up problem associated with asset specificity will be mitigated by linages with partners by equity ownership.

5. Concluding Remarks

In this paper, we provided an empirical analysis of the division of innovative labor in the process of new product development by using a novel survey data covering not only technological development but also market introduction of the new product. A focus of our analysis is the division of innovative technology and its complementary resources with other firms. We have found that the determinants of external collaboration of technology are completely different by the type of its partner, i.e., whether technology partner is also its business partner, such as supplier and customer (T = B), or not (T ≠ B).

In case of T ≠ B, we can see a moderating effect of patent to cost of technology transaction as a determinant of external technology sourcing, However, there is no evidence of co-specialization of complementary asset with other firms. In addition, these firms invest in new marketing channels and personnel more than a firm sourcing technology from its business partner (T = B). Therefore, these firms are pursing own new business development strategy, and complement their technology resources with other firms. Such technology transaction requires patent protection which mitigate potential hold-up problem in relationship with technology partner.

In contrast, the determinants drawn from resource based view, works for the case of T = B, and patent is not a relevant factor here. We would expect co-specialization of managerial resources, particularly for complementary asset, with partner firm are well developed for this group. These firms are dealing more with specific customers and are likely to have equity linkage with its supplier. Therefore, we would expect that these firms have substantially invested in relational assets with partner. The existence of such relationship (or equity linkage) enables co-specialization of managerial resources related to new product development.

In this paper, we have investigated the complex nature of technology collaboration, A clear finding from our study is the importance of taking into account business relationship, instead of dealing with technology transaction only, to address the question of innovative division of labor. We have found two distinct patterns between the case of $T \neq B$ or $T = B$. The next question of our research is which pattern in more efficient on what condition. A co-specialization pattern should be more efficient for partnership, but transaction cost theory (as well as property right theory) suggests relation specific asset investments incurs hold-up problem, so that the amount of this cost (or reduced incentive for investment by property right theory) has to be deducted from the partnership's value added. Our study suggests that such potential loss can be controlled by relational assets with partners.

It is off course that the effectiveness of such relational assets is different by industry. In case of automobile industry, close communication between supplier and manufacturer is important to come up with a high quality car. In contrast, technology transaction by patents is progressed in pharmaceutical industry. However, we need clearer understanding the relational assets in order to answer to the question like, "how to make a good balance between relational asset investment and flexibility" and "how to achieve effective relationship with partner?, is partially equity ownership, for example, a good way?". These are some future directions of our work.

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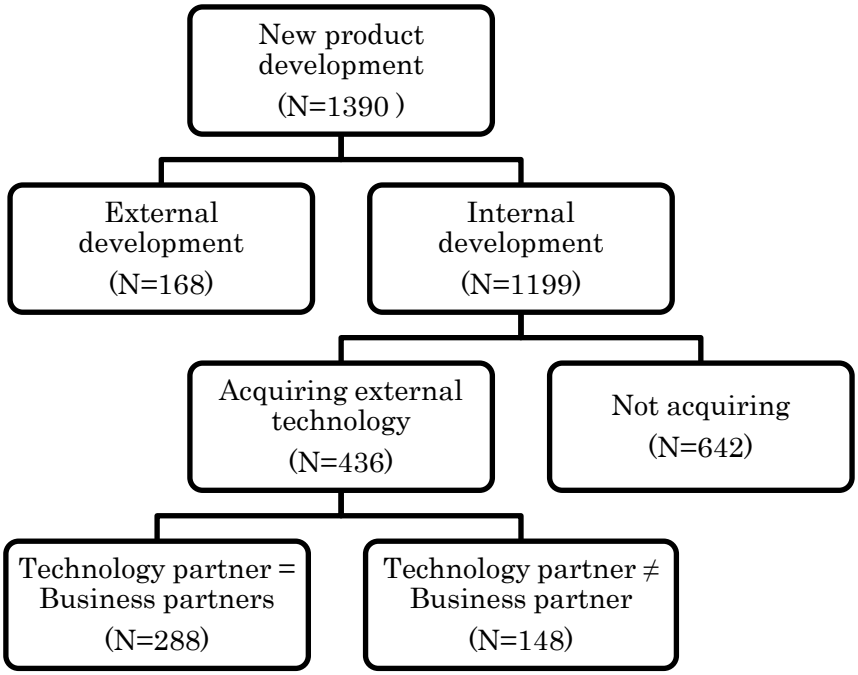
Figure 1 Innovation strategy on new product development process



Note: The number of samples does not fully match the number of upper level's samples because of using the available data.

Figure 2 External collaborations in technology and business

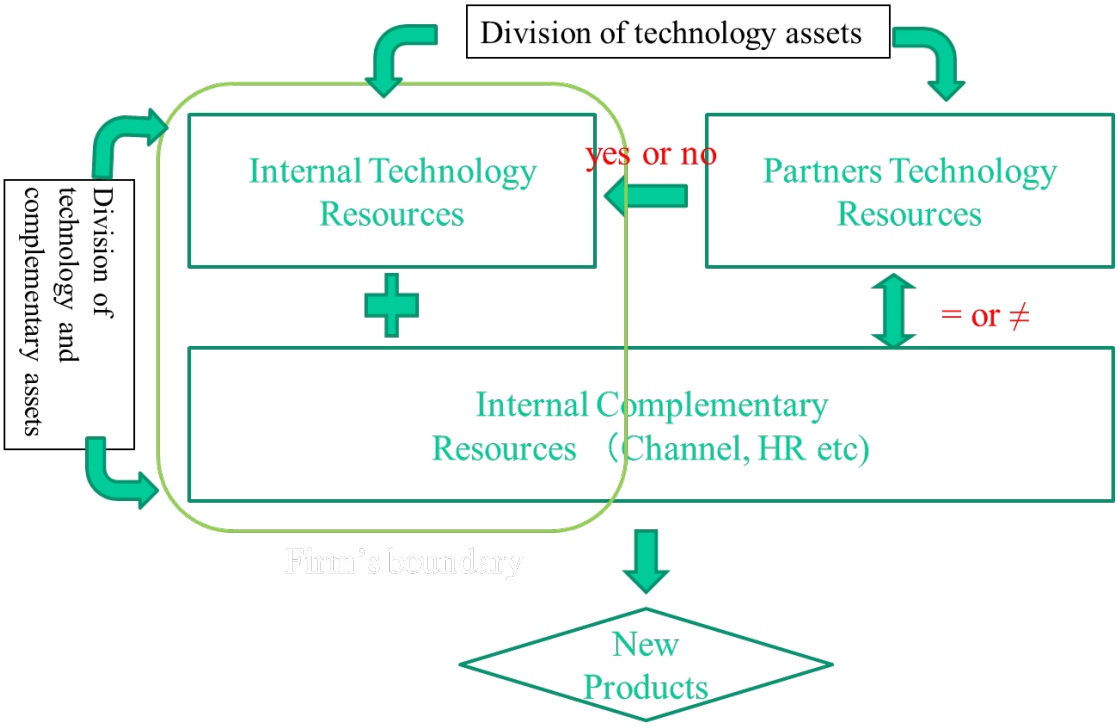
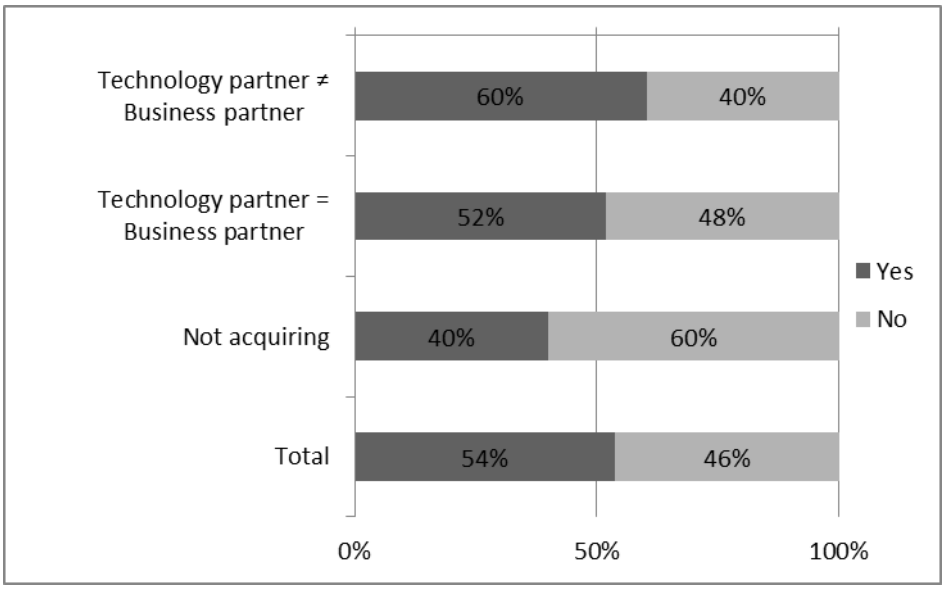


Figure 3　Requirement of new complementary resources

New channel: “Did you develope new sales and distribution channels to commercialize the product?”



New factor: “Did you buy new types of equipment or employee with skills different from those of existing employee?”

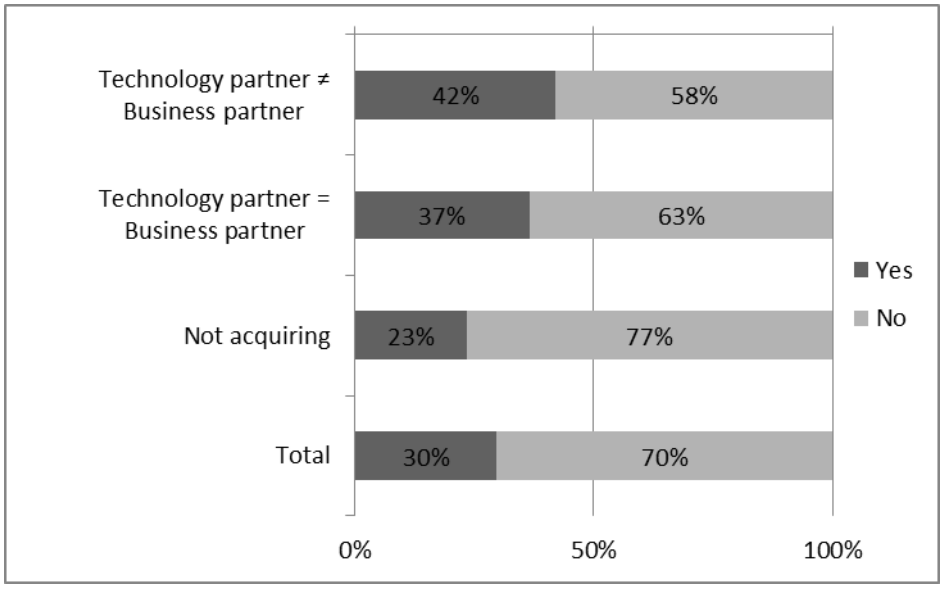


Table 1 Descriptive statistics

	Technology partner ≠ Business partner	Technology partner = Business partner	Not acquiring	Total
Risk of divulging	0.426 (0.497)	0.411 (0.493)	0.380 (0.486)	0.395 (0.489)
Patent	0.541 (0.5)	0.424 (0.495)	0.356 (0.479)	0.401 (0.49)
R&D	3.373 (3.284)	3.432 (3.014)	2.854 (2.748)	3.086 (2.913)
Experience	0.762 (0.427)	0.775 (0.418)	0.827 (0.379)	0.804 (0.397)
Different business	0.279 (0.45)	0.297 (0.458)	0.193 (0.395)	0.233 (0.423)
First mover	0.508 (0.502)	0.534 (0.5)	0.443 (0.497)	0.477 (0.5)
Single specific customer	0.057 (0.234)	0.174 (0.38)	0.082 (0.274)	0.103 (0.305)
Multiple specific customers	0.205 (0.405)	0.347 (0.477)	0.286 (0.452)	0.292 (0.455)
Not invented here	0.090 (0.288)	0.068 (0.252)	0.058 (0.233)	0.065 (0.247)
Employee	4.933 (1.551)	5.240 (1.567)	5.137 (1.392)	5.136 (1.466)
Start-up	0.033 (0.179)	0.025 (0.158)	0.038 (0.191)	0.034 (0.181)
Affiliated customer	0.213 (0.411)	0.225 (0.418)	0.203 (0.402)	0.210 (0.408)
Affiliated supplier	0.213 (0.411)	0.284 (0.452)	0.219 (0.414)	0.236 (0.425)
N	122	236	503	861

Note: Values are sample means. Standard deviations are in parentheses.

Table 2 Correlation matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Dep.ver.(Acquring)	1													
2	Risk of divulging	0.037	1												
3	Patent	0.108	0.135	1											
4	R&D	0.095	0.064	0.240	1										
5	Experience	−0.070	0.064	0.082	0.026	1									
6	Different business	0.114	0.004	−0.048	−0.028	−0.163	1								
7	First mover	0.081	0.065	0.348	0.160	−0.014	−0.005	1							
8	Single specific customer	0.085	−0.001	−0.106	0.030	−0.034	0.047	−0.057	1						
9	Multiple specific customers	0.014	0.083	0.164	0.073	0.034	0.009	0.068	−0.218	1					
10	Not invented here	0.036	0.009	0.034	−0.032	0.047	−0.045	−0.016	−0.028	−0.003	1				
11	Employee	0.000	0.099	0.358	0.102	0.140	−0.056	0.148	−0.047	0.119	0.092	1			
12	Start-up	−0.027	0.047	0.018	0.049	−0.054	−0.012	−0.037	0.064	−0.091	0.055	−0.075	1		
13	Affiliated customer	0.022	−0.038	−0.021	−0.059	0.068	−0.015	−0.088	0.068	0.002	0.095	−0.096	0.014	1	
14	Affiliated supplier	0.0477	0.0159	0.0148	−0.0427	0.0609	−0.009	−0.0433	0.0001	0.0471	0.0643	−0.0228	0.048	0.5662	1

N=861

Table 3　Results of probit model estimation for external technology acquisition

	(1)	(2)	(3)	(4)
	Acquiring	Acquiring	Acquiring	Acquiring
Risk of divulging	0.056	0.019	0.017	0.015
	(0.091)	(0.034)	(0.035)	(0.035)
Patent	0.266**	0.094**	0.094**	0.088**
	(0.108)	(0.041)	(0.042)	(0.043)
R&D	0.030*		0.015**	
	(0.016)		(0.006)	
R&D1		−0.004		−0.003
		(0.101)		(0.101)
R&D2		0.006		0.031
		(0.102)		(0.101)
R&D3		0.037		0.067
		(0.104)		(0.104)
R&D4		0.003		0.048
		(0.110)		(0.112)
R&D5		0.201*		0.218*
		(0.119)		(0.118)
Experience	−0.217*	−0.081*	−0.082*	−0.080*
	(0.116)	(0.044)	(0.046)	(0.046)
Different business	0.323***	0.124***	0.142***	0.145***
	(0.107)	(0.041)	(0.042)	(0.042)
First mover	0.118	0.044	0.057	0.057
	(0.095)	(0.036)	(0.037)	(0.037)
Single specific customer	0.338**	0.131**	0.140**	0.140**
	(0.153)	(0.058)	(0.061)	(0.061)
Multiple specific customers	−0.003	−0.005	−0.020	−0.027
	(0.103)	(0.038)	(0.040)	(0.040)
Not invented here	0.260	0.105	0.081	0.086
	(0.179)	(0.068)	(0.069)	(0.069)
Employee	−0.042	−0.011	−0.021	−0.017
	(0.034)	(0.013)	(0.013)	(0.013)
Start-up	−0.363	−0.147	−0.110	−0.123
	(0.243)	(0.091)	(0.094)	(0.095)
Affiliated customer	−0.028	−0.016	−0.020	−0.023
	(0.134)	(0.050)	(0.051)	(0.051)
Affiliated supplier	0.180	0.074	0.088*	0.093*
	(0.127)	(0.048)	(0.050)	(0.050)
Pseudo R2	0.043	0.047	0.050	0.053
Log Likelihood	−559.354	−557.183	−513.248	−511.915
N	861	861	792	792

Note: Values in parentheses are robust standard errors. The coefficients are the marginal effect of the independent variable on the probability of external technology acquisition. The marginal effect for factor levels is the discrete change from the base level. The Industry dummy variables and constant are dropped from the table. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 4　Results of multinomial logit model estimation for external technology acquisition

	(5)			(6)			(7)		
	Technology partner ≠ Business partner	Technology partner = Business partner	Not acquiring	Technology partner ≠ Business partner	Technology partner = Business partner	Not acquiring	Technology partner ≠ Business partner	Technology partner = Business partner	Not acquiring
Risk of divulging	0.021	−0.003	−0.018	0.026	−0.010	−0.016	0.027	−0.012	−0.015
	(0.024)	(0.030)	(0.034)	(0.025)	(0.032)	(0.035)	(0.025)	(0.032)	(0.035)
Patent	0.114***	−0.025	−0.089**	0.118***	−0.029	−0.088**	0.118***	−0.034	−0.084**
	(0.027)	(0.037)	(0.040)	(0.027)	(0.038)	(0.041)	(0.027)	(0.039)	(0.042)
R&D				0.004	0.011*	−0.014**			
				(0.004)	(0.006)	(0.006)			
R&D1	−0.029	0.029	−0.000				−0.039	0.042	−0.003
	(0.060)	(0.099)	(0.102)				(0.061)	(0.100)	(0.101)
R&D2	−0.091	0.099	−0.009				−0.081	0.117	−0.036
	(0.063)	(0.098)	(0.102)				(0.063)	(0.099)	(0.101)
R&D3	−0.056	0.100	−0.043				−0.045	0.119	−0.075
	(0.064)	(0.098)	(0.104)				(0.064)	(0.099)	(0.103)
R&D4	−0.047	0.054	−0.007				−0.034	0.090	−0.056
	(0.068)	(0.106)	(0.111)				(0.070)	(0.108)	(0.112)
R&D5	0.006	0.192*	−0.198*				−0.006	0.227**	−0.221*
	(0.070)	(0.110)	(0.119)				(0.071)	(0.112)	(0.120)
Experience	−0.037	−0.042	0.079*	−0.055**	−0.025	0.081*	−0.055**	−0.024	0.079*
	(0.028)	(0.039)	(0.043)	(0.028)	(0.041)	(0.045)	(0.028)	(0.041)	(0.045)
Different business	0.033	0.086**	−0.119***	0.047*	0.089**	−0.136***	0.044	0.095***	−0.139***
	(0.028)	(0.034)	(0.039)	(0.028)	(0.036)	(0.040)	(0.028)	(0.036)	(0.041)
First mover	−0.014	0.058*	−0.044	−0.023	0.079**	−0.056	−0.021	0.077**	−0.056
	(0.024)	(0.032)	(0.035)	(0.025)	(0.033)	(0.037)	(0.025)	(0.033)	(0.037)
Single specific customer	−0.094*	0.195***	−0.101*	−0.083*	0.199***	−0.116*	−0.085*	0.199***	−0.114*
	(0.050)	(0.045)	(0.059)	(0.050)	(0.048)	(0.061)	(0.051)	(0.048)	(0.061)
Multiple specific customers	−0.081***	0.072**	0.008	−0.101***	0.076**	0.025	−0.097***	0.066*	0.032
	(0.029)	(0.034)	(0.039)	(0.031)	(0.036)	(0.040)	(0.031)	(0.036)	(0.041)
Not invented here	0.061	0.041	−0.102	0.057	0.024	−0.081	0.056	0.028	−0.084
	(0.046)	(0.064)	(0.066)	(0.047)	(0.067)	(0.068)	(0.047)	(0.067)	(0.068)
Employee	−0.021**	0.010	0.011	−0.022**	0.001	0.021	−0.020**	0.003	0.017
	(0.009)	(0.011)	(0.013)	(0.010)	(0.012)	(0.013)	(0.010)	(0.012)	(0.013)
Start-up	−0.044	−0.098	0.143	−0.036	−0.076	0.112	−0.033	−0.089	0.123
	(0.061)	(0.086)	(0.090)	(0.064)	(0.086)	(0.091)	(0.062)	(0.089)	(0.093)
Affiliated customer	0.009	−0.025	0.016	−0.002	−0.016	0.018	−0.005	−0.016	0.021
	(0.035)	(0.046)	(0.050)	(0.037)	(0.047)	(0.051)	(0.037)	(0.048)	(0.052)
Affiliated supplier	−0.031	0.100**	−0.069	−0.024	0.108**	−0.084*	−0.025	0.112**	−0.087*
	(0.033)	(0.042)	(0.048)	(0.035)	(0.044)	(0.049)	(0.034)	(0.044)	(0.049)
Pseudo R2		0.069			0.068			0.073	
Log Likelihood		−758.386			−703.903			−700.390	
N		861			792			792	

Note: On multinomial logit model estimation a base category is ‘No acquiring’. Values in parentheses are robust standard errors. The coefficients are the marginal effect of the independent variable on the probability of external technology acquisition. The marginal effect for factor levels is the discrete change from the base level. The Industry dummy variables and constant are dropped from the table. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.