RIETI Discussion Paper Series 18-E-042

Technology Sourcing in New Product Development Projects: When and how to use external resources?

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The Research Institute of Economy, Trade and Industry
https://www.rieti.go.jp/en/

RIETI Discussion Paper Series 18-E-042

June 2018

Technology Sourcing in New Product Development Projects: When and how to use external resources?[i]

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Abstract

This paper provides empirical analyses to understand the management of external technology sourcing using a novel dataset of new product development (NPD) projects in Japanese firms, focusing on the difference between bilateral and unilateral contract-based alliances. External technology sourcing takes on various forms that can be divided into two categories: bilateral alliances, such as joint research and development (R&D), and unilateral alliances, such as licensing and commissioned R&D. The former style involves the cooperation process of joint R&D with a partner, whereas the latter involves the straightforward process of technology acquisition from a partner. In this paper, the determinants of the sourcing strategy for each contract type are investigated, and we find that a firm is likely to use external technology sourcing in exploratory projects, and that the type of sourcing will differ between large and small firms. Furthermore, a bilateral alliance is likely found to be used for market pull-type projects, while technology push-type ones are more often managed by unilateral alliances.

Keywords: External technology sourcing, Exploration-exploitation, Transaction costs economics, Knowledge-based view

JEL classification: O32; L24; O33

[i] This study is conducted as a part of the project "Empirical Analysis of Innovation Ecosystems in Advancement of the Internet of Things (IoT) " undertaken at the Research Institute of Economy, Trade and Industry (RIETI).

1. Introduction

Knowledge is, more than ever, widely distributed in the world. Therefore, it is often more efficient to tap into external technological resources than to stick to in-house development in the innovation process (Chesbrough, 2003). The open innovation model becomes more and more relevant in today's business environment of increasing division of innovative labor, particularly in science-based industries (Arora et al., 2001), and there has been a growing number of papers on open innovation (Dahlander and Gann, 2010). However, external technology sourcing cannot be achieved simply by market transactions between buyers and sellers but rather involves a complex process of interactions with technology providers. A firm is confronted with difficulty in explicitly describing the task requirements, relation-specific assets, and risk of information leakage to competitors while engaging in external technology sourcing (Teece, 1988). Therefore, disentangling the complexity of it in the internal innovation process is important when attempting to manage open innovation effectively.

External technology sourcing has been studied from several perspectives. One of them is in terms of firms' boundaries, called the make-buy decision. The "make or buy" decision regarding governance structure has been discussed based on transaction cost economics, which shows that the relative transaction costs between "make" and "buy" determine the governance form (Williamson, 1985; Klein, 2005). However, the reality is more complicated. Cassiman and Veugelers (2006) empirically show contextual variables that affect the choice of innovation strategies—"No Make & Buy," "Make Only," "Buy Only," and "Make & Buy"—and that the latter generally dominates the other modes. It is consistent with an open innovation model of combining external ideas into internal ones for creating new value that the firm chooses both to "make" and "buy," rather than either of them separately. Thus, in order to innovate by using externally sourced technology, complementary technology assets (i.e., absorptive capacity, Cohen and Leventhal, 1990) are required and, besides them, complementary non-technological assets, such as manufacturing facilities and marketing channels, play crucial roles (Arora et al., 2001).

Another venue for previous empirical studies is focusing on the "buy" aspect of the make-buy decision, and examining the choice between non-equity alliances (or contract-based alliances) and equity ones (Oxley, 1997; Kale and Singh, 2009). Dividing non-equity alliances into simple contracts and more complex ones, Mowery, et al. (1996), who examined the effect of inter-firm knowledge transfers, proposed a typology of alliances—unilateral contract-based ones such as licensing, bilateral contract-based ones such as joint development, plus equity joint ventures. Oxley (1997) and Colombo (2003) employ the typology of alliances in the empirical studies on the choice of alliance formation, using a database on alliance agreements. Das and Teng (2000) analyzed a firm's preferences for structural forms of alliance, unilateral or bilateral contracts by knowledge type, and firm's resource profiles.

These two strains of past literature, i.e., investigating (1) the make-buy decision (or when to buy) and (2) what type to buy (i.e., a unilateral or bilateral contract) are separate—and they are rarely jointly investigated. This paper fills that gap, by comparing three options of technology sourcing for firms: (1) internal sourcing (or developing it in-house only), (2) external unilateral contract usage or (3) external bilateral contract implementation. Specifically, we take the situation of a firm, when it starts a new product development project, and investigate the relationship between the type of the new product development and the appropriate style of technology sourcing. We assume that a firm picks its technology sourcing decisions from one of the three aforementioned options, rather than sequential decisions, such as make-buy first, then what type to buy.

We use a novel dataset at the product development project level, based on a large-scale survey conducted by RIETI (Research Institute of Economy, Trade and Industry) for Japanese firms. A project-level data allows us to investigate the factors behind the choice of alliance type in more detail, compared with firm-level data, such as the data coming from the *Community Innovation Survey*. Specifically, we focus on the type of new product development project, such as "exploration" vs. "exploitation" and "technology push" vs. "market pull." Furthermore, these project-specific variables interact with firm-level characteristics, such as firm size, reflecting the size of absorptive capacity and (non-technological) complementary assets of the whole firm.

This remainder of this paper is structured as follows. Section 2 provides a typology of alliance strategies and theoretical hypotheses. Section 3 presents a description of the study's survey and variables used for our empirical model. Section 4 shows the results of econometric analysis and section 5 concludes.

2. Hypotheses on the determinants of type of technology sourcing

2-1. Type of technology sourcing

The types of alliance formed for external technology sourcing can be classified into non-equity alliances (or contract-based alliances), such as joint R&D, manufacturing, marketing contracts, or equity based alliances, such as joint ventures and minority equity investments (Oxley, 1997, Kale and Singh, 2009). Furthermore, a contract-based alliance can be further broken down into unilateral contract or bilateral contract, according to the direction of knowledge flow (Mowery et al., 1996, Das and Teng, 2000). Here we focus on the typology of contract-based alliance for external technology sourcing.

Unilateral contract-based alliances are used for the firms' own activities with technology or services provided in accordance to the contract without much coordination or collaboration, e.g., licensing and R&D contracts. The unilateral contracts are exchange technologies for cash payments and arm's-length contracts used to acquire the focal technology. The aim to the unilateral contract-based alliances is to increase the speed and the flexibility of technology development in association with shortened in-product lifecycles. Since they are more tightly packaged, inter-firm knowledge transfers are limited in the contract, compared with the bilateral contract-based alliances that lead to learning opportunities (Mowery et al., 1996).

On the one hand, with unilateral contract-based alliances, firms are required to accumulate knowledge and technology for their business horizon to recognize what they need and accurately assess external technology provided by potential partners based on their complete and specific technology. Reduction of search costs depends on conditions within the technology market. Besides, it is possible to decrease transaction costs by capabilities that allow them to access technology markets, to find the technology, and to integrate it well into internal knowledge.

On the other hand, bilateral contract-based alliances are used to share resources each other and work together, e.g., collaborative R&D. The bilateral contracts are beneficial not only to develop new products but also to provide more opportunities for learning than unilateral contract-based alliances (Das and Teng, 2000). In the organizational learning as a part of the broad resource-based view, firms are motivated to make bilateral contract-based alliances because they allow them to obtain resources/expertise from other firms, as well as to retain and develop their own resources or expertise by combining them with the resources or expertise of their counterparts (Kogut, 1988). The firms that intend to accumulate knowledge and technology through new product development for future business opportunities would prefer bilateral alliances to unilateral ones. The advantage that the bilateral contract-based alliances provide include learning opportunities that are appropriate for the exploration and pursuit of knowledge development that facilitate changing scope.

Grant and Baden-Fuller (2004) proposes two insights for alliances—the knowledge acquisition approach and the knowledge accessing one, based on the concept of the knowledge-based view. The knowledge acquisition approach, which is primarily studied in organization learning, argues that firms make alliances to learn and acquire their partners' knowledge. The knowledge-accessing approach emphasizes alliances as a means accessing partners' knowledge rather than acquiring knowledge "in order to exploit complementarities, but with the intention of maintaining its distinctive base of specialized knowledge." Since knowledge provides both economies of scale and scope, it is more efficient to utilize knowledge with a greater array of products. If the firm intends to develop all products in-house, it causes a problem of underutilized knowledge arising from incongruent product and knowledge domains (Grant and Baden-Fuller, 2004). Alliances can address underutilized knowledge to access partners' knowledge. Thus, we argue that the bilateral contract-based alliance is consistent with the idea of the knowledge-acquisition approach, whereas the unilateral contract-based alliance is more relevant for a knowledge-accessing one.

2-2. Exploration or exploitation

First, we examine exploration and exploitation as a potential determinants of the type of technology sourcing (i.e., internal, unilateral or bilateral). The notion of exploration-exploitation is derived from March's (1991) framework in organizational learning. March (1991) addresses the essences of these types; exploration is "experimentation with new alternatives," and exploitation is "refinement and extension of existing competences." When considering knowledge management through the lens of exploration-exploitation, exploration is knowledge development for changing scope from an organization's existing knowledge base and skills, whereas exploitation is knowledge utilization on the path of the organization's existing knowledge base (Leivinthal and March, 1993). Lavie, et al. (2010) indicates that there is an exploration-exploitation continuum, though some studies offer the dichotomy between exploration and exploitation, and the relativity of exploration-exploitation is manifest in that knowledge exists that is new to one firm but familiar to another, i.e., exploration by one and exploitation by another.

Whether a new product development project (called NPD project, hereafter) is an explorative or exploitative one is concerned with the choice of the technology sourcing. Since the knowledge (particularly in case of tacit knowledge) is not easily transferred between firms (Kogut and Zander, 1992), a firm is supposed to use its internal technological assets as much as possible for NPD projects. Grant and Baden-Fuller (2004) extend the idea on knowledge management, by defining knowledge domains and product domains separately. These two layers should overlap within a firm, in terms of efficient knowledge utilization. However, new product development projects may require new knowledge that does not exist inside it. A firm must choose whether to develop it internally or source it from outside. A make or buy decision based on the required knowledge is determined by whether the knowledge can be utilized for (potential) product domains. For new product development beyond the scope of a firm's core business field (or exploration project), the incongruity between knowledge domains and product domains is relatively large—compared to a project within its core business field (or exploitation project), wherein outside sourcing is likely to be more efficient than internal development. This logic brings us to the following hypothesis.

H1: A firm uses external sources more for a non-core NPD projects compared to core ones.

When the incongruity between knowledge domains and product domains is large, a firm prefers sourcing external knowledge from the view point of efficient knowledge utilization (Grant and Baden-Fuller, 2004). Since a large firm has combinative capabilities that come with experience from having done multiple business projects, it accesses external knowledge rather than acquiring it. Considering the problem of underutilized knowledge, accessing a partner's knowledge is more efficient than acquiring it, though both are measures of external technology sourcing, because accessing external knowledge prevents firms from holding excess knowledge capacity (Grant and Baden-Fuller, 2004). On the other hand, for a small firm, external sourcing involves interaction with a partner that enables combining external knowledge into internal knowledge, especially when the firm is inferior in its combinative capabilities in terms of accessing and integrating the knowledge into internal resources.

There are two types of technology sourcing, unilateral contracts such as licensing and contracted R&D, where knowledge flows occurs only from a partner to the firm, and bilateral contracts such as joint venture and collaborative R&D, where knowledge flows occurs in both directions between the firm and its partner (Oxley, 1997). With unilateral contracts, explicit knowledge, such as patents are traded in exchange for money, while tacit knowledge or knowhow can be communicated both ways via bilateral contracts (Das and Teng, 2000). It is presumed that a large firm with substantial internal tacit knowledge inclines itself more toward unilateral contracts for its technology sourcing, since explicit knowledge is easier to integrate for non-core business NPD. In contrast, a small firm seeks tacit knowledge, as well as explicit knowledge via bilateral contracts, in order to fulfill the gap between its internal knowledge portfolio and required knowledge for non-core business NPD. In addition, in bilateral contracts, a firm not only acquires partner's knowledge, but it needs to share its knowledge with its partner, too (Lavie et al., 2010). Therefore, a large firm with substantial knowledge sources would be reluctant to get involved such a process, compared to a small firm that would suffer less potential damage by giving away its knowledge. Therefore,

H2: In non-core NPD projects, a large firm is more likely to conduct external technology sourcing by means of unilateral contracts, while a small firm is more likely to use bilateral contracts.

2-3. Technology push or market pull

Second, we examine whether technology push or demand pull, according to the type of NPD project, relates to the technology sourcing style. Here, we focus on the factor whether an idea for the new product concept comes from a university or a customer. A great heterogeneity in NPD project comes whether it is exploitative or explorative one, or if it can be captured by a NPD project in its core business. At the same time, whether an original idea comes from universities (i.e., a technology push) or from its customer (i.e., market pull) makes significant impact on firm's decision to make or buy, as well as for unilateral or bilateral contract choice in case of "buy."

Von Hippel (1986) argues that the predominance of innovation is inherited from customers' ideas. The reason is that the relative expected value of an innovation project is driven by a customer's idea is high since the idea enhances the probability of commercial success. The national innovation survey in various countries reveals that customer is the most important source of innovation (Thether, 2002, Berderbos et al., 2004). If acquiring customer's knowledge makes the probability of commercial success high in a NPD project driven by the idea from a customer, a firm is likely to use external sourcing via bilateral contracts that involve more intense cooperation with a customer. In addition, any new product developed will be mutually beneficial to the firm as well as its customer. Therefore, both parties have substantial incentives to share their knowledge, with less risk associated with helping potential competitors (Lavie et al., 2010).

H3a: In cases of technology sourcing, a NPD project based on customers' ideas tend to favor using bilateral contracts.

A NPD project based on ideas from universities can apply cutting-edge research and technological opportunities. Such science-based knowledge is sufficiently codified and explicit to transfer across organization (Arora et al., 2001). It is found that unilateral contract is relatively efficient in the transaction of codified knowledge, while tacit and uncodified knowledge interactions would be expected more in bilateral contracts (Das and Teng, 2000).

H3b: In cases of technology sourcing, a NPD project based on universities' ideas tends to favor unilateral contracts.

2-4. Interaction of "exploitation or exploration" and "technology push or market pull"

A new product development process entails matching firm's knowledge domains to the technology specifications required for a new target product (Grant and Fuller, 2004). Hypotheses 1 and 2 discusses the relative abundance of internal knowledge compared to the required knowledge domain for the new product, comparing exploitation and exploration types. In addition, hypothesis 3 is focuses on the difference in information sources (customer or university) to determine the appropriate type of external technology sourcing.

These two dimensions of the NPD types are related to each other. When a concept of product development comes from a customer, a new product is more demand-driven and requires more market knowledge. If the project will be developed in a non-core business field, a firm lacks business knowledge in the required field, so it would be expected to search for such knowledge from without. Therefore, a process of new product development involves substantial interactions between a firm and its partner in order to combine both parties' knowledge. In such cases, a firm seeks for knowledge acquisition type collaboration (i.e., exchange of mutual knowledge), instead of simple knowledge access—i.e., incorporating specific knowledge without providing its own knowledge to a partner (Grant and Barden Fuller, 2004). In addition, agency costs associated with bilateral contracts are lower, since the project partner is also a firm's potential business partner (Eisenhardt, 1989). In contrast, when the core business project is involved, a firm has less incentive to undertake mutual processes for knowledge acquisition type collaboration, since its potential loss from giving away its own knowledge is relatively large. Instead, the firm uses its internal technology resource (internal sourcing), or a unilateral contract that does not obligate it to give away its own knowledge to a partner, in cases where external technology sources are required.

H4a: In cases when the information source of an NPD project is a customer, a firm facilitates the use of bilateral contracts for non-core business projects, as compared to core business ones.

H4b: In cases when the information source of an NPD project is a customer, a firm facilitates the use internal sourcing or unilateral contracts for core business projects, as compared to non-core business ones.

In cases where technology pushes a project, when a new product idea comes from a university, a firm must make substantial efforts to achieve some technological breakthrough that may be converted to a marketable product. If the project relates to its core business, the product development project will involve activities that adjust source technology to the existing and well-known market for the firm. Therefore, this process tends to be managed better by a bilateral contract between the firm with market knowledge and its counterpart with technology knowledge. Since the new technology required is greater, using internal knowledge (rather than external sourcing) is not a choice, and a firm is likely to use bilateral contract type technology sourcing. If the NPD project is a non-core business one, technology adjustments to accommodate a specific business domain is not largely required. The type of external technology sourcing utilized is likely to be a buy-in type (i.e., a unilateral contract) to come up with the new product, since it is closely related to the acquired technology. Of course, internal sourcing is not an option, since the required knowledge is far from a firm's business domain on both the technology and market sides.

H5a: In cases when an information source of an NPD project is a university, a firm facilitates the use of bilateral contracts for a core business project, compared to a non-core business one.

H5b: In cases when an information source of an NPD project is a university, a firm facilitates the use of unilateral contracts for a non-core business project, compared to a core business one.

3. Empirical strategy

3-1. Dataset

In this study, we used the data of the Survey of New Product Development, gathered by the Research Institute of Economy, Trade and Industry (RIETI) in 2011, targeting 17,997 business units of Japanese firms, of which 3,705 responded (response rate = 20.6%). Further, for 1,390 business units (38% of total responses), which had introduced new products between 2008 and 2010, information was collected on the product with the most sales among new products. Therefore, the information collected in this survey pertains to the project level, instead of the general level of the firm. This survey, designed based on the survey of Arora, et al. (2016), included various survey items on external technology sources being used in new product development process.[1]

To examine the NPD process incorporating internal development with external technology, we classify the 1,390 respondents into two groups depending on whether they used mainly internal development or external development (Figure 1). The group using internal development was the majority (1,199 respondents; 86%), whereas the group using external development represented the minority (168 respondents; 12%), with 23 non-respondents. The group that undertook external development included several kinds of businesses. One type was a firm that introduced a product it developed (and manufactured) by another firm and then sold it through their sales network without internal R&D expenditure. The other type was a firm that subcontracted another firm to custom produce it using the contractual counterpart's design, such as original equipment manufacturing (OEM). Since this paper focuses on the NPD process combining external technology with internal development efforts, we dropped the respondents that were mainly using external development. After excluding those ones (168 respondents), we used 1,199 respondents that utilized (mainly) internal development.

(Figure1)

3-2. Dependent variables

Focusing on mainly internal development (Figure 1), we divided the respondents into two groups based on whether or not external technology sourcing was used. The alliance strategy variable is based on the question: "How did you engage in developing a prototype for the focal new product?" Respondents selected responses from six items: M&A or investment, collaborative R&D or joint venture, licensing, research commissioned or consulting, informal sourcing such as reverse engineering, and otherwise. Our primary variable is a discrete dependent variable that takes on three outcomes: bilateral contract-based alliances (*bilateral*;

[1] The details of this survey are described in Kani and Motohashi (2017).

answering collaborative R&D or joint venture; 179 observations), unilateral contract-based alliances (*unilateral*; answering license-in or research commissioned; 196 observations), and internal sourcing, which means completely developed in-house without external technology sourcing (*internal sourcing*; 608 obs.).[2] The binary variable combining unilateral contract-based alliances and bilateral contract-based alliances is referred to as *external sourcing*, which means utilizing external technology sourcing on NPD.

3-3. Independent variables

Exploitation or exploration (i.e., based on a core or a non-core field): The variable *non-core field* indicates whether a NPD project is in a non-core business field, given that there is a large incongruity between knowledge domains and product domains in projects stemming from non-core fields. This binary variable takes a value of 1 of the main business category of the respondent's business unit that is different from the new product's category, which consisted of 90 categories. Lavie et al. (2010) refers to exploration as "a shift away from an organization's current knowledge base and skills" and exploitation as "building on the organization's existing knowledge base." This variable is used for testing hypotheses 1 and 2, wherein NPD projects within the core business field falls into the exploitation type category, while the non-core ones fall under exploration.

Technology push or market pull (i.e., where the concept comes from a university or a customer): We argued that where the idea for a concept for a new product comes from is relevant for decisions pertaining to external sourcing, especially when focusing on customers and universities. This variable is used as a proxy for the NPD type—technology push or market demand—used in testing hypothesis 3. In the survey we asked questions about information sources at two stages of conceptualization and making prototypes: "Which outside organization do you utilize information from?" Respondents selected the most important source from eleven types of organizations.[3] We used data on information sources at the conceptualization stage, instead of the prototype one since during the earlier stage information is supposed to be a predetermined factor before technology sourcing choices are made. We divided the eleven types of organizations into four categories. We focused on the following two variables of information sources at conceptualization. The binary variable *concept from customer* takes a value of 1 if the most important information source at conceptualization is a customer. The binary variable *concept from university* takes a value of 1 if the most important information source at conceptualization is universities or government labs. We also add the binary variable *concept from supplier*, which takes a value of 1 if a respondent asks that a supplier be the most important information source, serving as another type of information source from a business partner aside from a customer. In the questionnaire, we included an alternative for jointly forming of its concept with any type of external partner, instead of solely relying on external one for the new product conceptualization. We made another dummy variable, *joint conceptualization*, in order to control for such a choice. Please note that both *concept from customer* and *concept from university* reflect the idea coming solely from those correspondent which were different from *joint conceptualization*, which represented that the concept of new products is developed jointly between the firm and its counterpart.

Additionally, we controlled for several other variables of product and organization factors that may influence a decision for external sourcing on NPD: patented product, specific customer (2 variables), high R&D intensity, new business unit, affiliated transaction (2 variables), firm employee, firm age, and category of new products (20 variables).

First, we included variables for characteristics of the product. There are two types of technology utilized in NPD, which are property-based and knowledge-based technologies. Although property-based technology is protected by intellectual property rights, knowledge-based technology is faced with concerns regarding appropriability (Das and Teng, 2000). The appropriability concern in contractual hazards is that proprietary

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2 This question allowed multiple answers. We drop observations choosing M&A or investment and choosing both collaborative R&D and licensing. Observations choosing both collaborative R&D and research commission are defined as collaboration. Thus, after dropping observations with missing data in addition to the above, the valid number of mainly internal development observations is 946, not 1,199.

3 The alternatives are included as follow: supplier, customer, another firm in your industry, consultant, engineering/research service provider, university, government lab, patent research information, open information source, collaboration between your firm and others, and other.

information and technology are at risk of misappropriation in a given project (Mayer and Salomon, 2006). Thus, we control for whether the new product uses patent technology or not to capture the impact on the choice of external sourcing. The binary variable *patented product* takes a value of 1 if the new product is covered by one or more patents (or patents pending).

Whether the firm is selling to specific customers or not would influence the decision of the NPD process. The binary variable *single specific customer* takes a value of 1 if the product is sold to one specific customer, and the binary variable *multiple specific customers* takes a value of 1 if the product is sold to multiple specific customers.

Second, we consider other factors of the organization. R&D intensity, is defined as R&D expense divided by sales, is used as a proxy for technological capability. For firms with high R&D intensity, external technology sourcing, such as bilateral and unilateral contract-based alliances, is beneficial for NPD because the firm can effectively absorb the external organization's expertise. In the survey, the R&D intensity in a business unit is indicated by a categorical response: 0%, 0% to 1%, 1% to 3%, 3% to 5%, 5% to 10%, and more than 10%. Since according to the report of the Survey of Research and Development in FY2010, R&D intensity in Japanese firms implementing R&D activities is 3.22%. We define the binary variable *R&D intensity ≥ 5%* that takes a value of 1 if the proportion of R&D expenditure to sales is more than 5% as a measurement of higher R&D intensity.

Whether the business unit has business experience or not is relevant to hypothesis 2. To control for it at the level of a business unit, we include the binary variable *new business unit* that takes a value of 1 if the firm started the business unit less than five years ago. Furthermore, we control for the factor whether business transaction is an affiliated business or not. The variable *supplier in group* takes a value of 1 if the respondent mainly receives supplies from affiliated companies, and the binary variable *customer in group* takes a value of 1 if the respondent's main customers are affiliated companies.

As for other organizational factors, we controlled for several features of the firm: its size and age.[4] The variable *firm employee* is the logarithm of the number of employees in a firm, and the variable *Firm age* represents the logarithm of the firm age.

In addition to the control variables, we include twenty dummy variables representing new product categories. Table 1 shows the descriptive statistics and a matrix of correlation. Aside from the descriptive statistics for a whole sample (ALL), we present ones for large- and small-firm subsamples (LARGE and SMALL) dividing by the median value of the number of employees of a firm, i.e., 136 employees.

(Table 1)

3-4. Hypothesis testing methodology

Our hypotheses predict relationships between a choice of external technology sourcing and types of NPD projects. To analyze the choice problem, we employ two econometric models: a probit model using a binary variable that indicates whether the firm is sourcing external technology or not and a multinomial logit model, using a discrete dependent variable that takes on one of three alternatives: which are bilateral contract-based alliances (i.e., collaborative R&D or joint venture), unilateral contract-based alliances (i.e., license-in or research commissioned), and internal sourcing (i.e., in-house development not using external sources).[5]

With respect to model specification of a multinomial logit model, we conducted a specification test for IIA (the independence of irrelevant alternatives) based on a seemingly unrelated estimation model, since the Hausman test did not work. The results of all models shown below did not statistically reject the null

[4] The data source for firm age and the number of employees is Teikoku Databank, COSMOS2.

[5] Since we conducted the survey by business units, out of 994 responses, there are 115 responses that reflect multiple business units from one company. We carry out a robustness check for the sample excluding responses from multiple business units from the same company. Although the size of the estimated coefficients changes slightly, we confirm essentially similar results.

hypothesis of IIA.[6] Thus, they suggest the absence of a nested choice such that bilateral and unilateral are chosen at a stage of external technology sourcing after deciding whether or not to use such sourcing. In addition, as a robustness check, we employ the model using a whole samples including mainly external development (Figure 1), and we confirm the similar results.

Since the parameter estimates of a probit model and a multinomial logit model do not directly show choice probability, we reported the average marginal effects (AME hereinafter) by post-estimation computation. The AME for a binary variable shows the change in the probability of choosing the alternative when the variable goes from 0 to 1. For example, the AME of a non-core business project is calculated as follows. We calculate the predicted probability of choosing the alternative when assuming a project falls within the core business even though it is a project in the non-core one. Similarly, we calculate the predicted probability assuming a project falls within a non-core business. Then, we take the difference of the probabilities between the core project and the non-core project, which means the marginal effect of non-core business projects for the respondent. The AME takes the average of the differences for all respondents.

4. Results

Table 2 shows the values of the AME on the choice probabilities of external technology sourcing using parameter estimates of a probit model using a binary variable *external sourcing* as a dependent variable. The probability of external sourcing on the NPD projects in non-core business fields is 0.09 higher than the projects in the core field, shown in the model (1) using data from all firms. The result thus supports H1 that firms use external sources more for NPD in non-core fields. We find that a firm conducts external technology sourcing when there will be the incongruity between knowledge domains and product domains in the NPD project. Efficient knowledge utilization proposed by Grant and Baden-Fuller (2004) is one promising approach for understanding external technology sourcing. We also provide the results for large and small firm subsamples dividing by the median value of the number of employees of a firm, i.e., 136 employees. In model (2), a large firm has a higher probability of external sourcing in its non-core business as compared to in the core business, whereas there is statistically no difference in non-core and core business for a small firm in model (3).

(Table 2)

Since external technology sourcing includes two different types of sourcing, i.e., unilateral contract-based alliances and bilateral contract-based alliances, we examine the decision among three alternatives: *internal sourcing*, *bilateral*, and *unilateral*. Table 3 reports the values of the AMEs on the probabilities of choosing the alternative, based on parameter estimates of a multinomial logit model. Models (5) and (6) show the results for large and small firm subsamples, respectively. For the large firms in model (5), we find that there is a statistically significant difference regarding the probability of choosing unilateral contract-based alliances between in the core business and the non-core one. When the firm develops the product in the non-core business, the probability of choosing a unilateral contract-based alliance increases by 0.10 compared to developing products in the core business, whereas the probability of choosing internal sourcing (i.e., in-house development) decreases by 0.16. The result supports H2, that large firms have a greater incentive to access required knowledge for the NPD by unilateral contract alliances for non-core projects because it is efficient to access external technology—unless holding excess knowledge that can be underutilized. By contrast, the results pertaining to small firms in model (6) shows that the probability of bilateral contract-based alliances increases by 0.08, and the probability of unilateral contract-based alliances decreases by 0.07, when developing new products within a non-core field. Although it is difficult for small firms to access and

[6] As for Table 3, in the model for all firms we cannot reject the hypotheses that the coefficients of the full model and the restricted model without *Bilateral* are the same ($\chi^2(35)$ = 14.23, p = 0.99) and the coefficients of the full model and the restricted model without *Unilateral* are the same ($\chi^2(35)$ = 25.62, p = 0.88). Similarly, according to the test of the full model against the restricted model without *Bilateral* in the model for large firms we cannon reject the hypothesis ($\chi^2(32)$ = 13.35, p = 0.99), and the test of the full model against the restricted model without *Unilateral* shows that the hypothesis is not rejected ($\chi^2(32)$ = 15.38, p = 0.99). For small firms, we also cannot reject the hypotheses; ($\chi^2(34)$ = 12.68, p = 0.99) and ($\chi^2(34)$ = 15.78, p = 0.99). We also conducted the tests of models in Table 4 and 5. We use the Stata "suest" command for the tests.

integrate external knowledge, external sourcing involved interaction with a partner enables firms to combine external knowledge into internal resources. We find that the result supports H2, that small firms are likely to make bilateral contract-based alliances in NPD projects for non-core projects.

(Table 3)

As for the relationship between information sources for ideas regarding a new product and the choice of external technology sourcing, we examine the effect of *concept from customer* and *concept from university* in model (4) of Table 3. When a firm incorporates information from a customer into the new product during the conceptualization of a new product, the result shows the probability of bilateral contract-based alliance increases by 0.07, whereas there is no statistical difference in the probability of a unilateral contract, as compared to the reference category. The result supports H3a. If more knowledge on a customer would make a success in a NPD project driven by the idea from the customer, a firm is encouraged to make a bilateral contract involving interaction with a partner to get the more knowledge. Utilizing universities and government labs as an information source for the idea of a new product has a significantly positive effect on unilateral contract. The probabilities of choosing a unilateral contract are about 0.18 higher than for the reference category, whereas the probability of internal sourcing decreases by 0.37. In NPD projects introducing cutting-edge knowledge based on scientific innovation, firms facilitate external technology sourcing with unilateral contracts because it is easier to package its technology as more explicit knowledge. It supports H3b that projects based on universities' ideas use unilateral contract more often.

It should be noted that the coefficient of *concept from university* for the bilateral form is also positive and statistically significant. Therefore, not only unilateral contracts, but also bilateral ones are relevant styles for external technology sourcing in technology push types of NPD projects. When the concept for new products comes from a university, the firm is likely to have collaborative activities with it afterwards, and joint R&D (i.e., bilateral contracts) is a typical style of university and industry collaboration (UIC). It is found that greater heterogeneity exists in UIC according to firm size (Motohashi, 2005). Hence, we estimate the same model for large and small subsamples as is the case in Table 2. A positive and statistically significant coefficient in bilateral contract is found in larger firm subsamples (0.37 in model (5), while a unilateral contract is used more by small firms (0.22 in model (6)). This finding is consistent the findings in the prior literature, that is, substantial collaboration is found in UIC for large firms, while small firms tend to access specific technology from universities for short term NPD projects (Motohashi, 2005).

Furthermore, we list some results for other variables of product and organization factors in Table3. As for product factors, patented products in small firms, according to the model (6) of Table 3, has a statistically significant positive effect on the probability of unilateral contracts, whereas the effect on the probability of internal sourcing is significantly negative. The projects using patented technology have a 0.10 higher probability of choosing unilateral contracts compared to projects without it, and small firms do not prefer to develop completely in-house. For large firms, by contrast, choosing none of the alternatives is significantly influenced by whether or not the new product uses patent technology. The result suggests that alliances with small firms is more related to the patent system.

In terms of the types of customer, which is another product factor, the single, specific customer of small firms has a significantly positive effect on bilateral contract and a negative effect on internal sourcing. The results show a 0.11 higher probability of choosing bilateral contract and 0.15 lower probability of in-house development in the NPD for the single, specific customer. For small firms, a project of NPD for the single customer requires tighter communication with the customer, so a bilateral contract is chosen.

With regard to organizational factors, we find that higher R&D intensities of large firms have a significant effect on none of the alternatives, whereas in small firms with higher R&D intensities the probability of unilateral contracting increases by 0.19, and the probability of internal sourcing decreases by 0.19, compared with the case of those with less than 5 percent R&D intensity. The result implies that the only firms accessing external knowledge well are technology-intensive ones nested in small firms, denoting a difference in the capabilities between large and small firms when conducting external technology sourcing in a project pertaining to a non-core field.

Next, we estimated a model adding an interaction term *core* or *noncore* × *information source.*[7] Table 4 shows the AMEs of noncore field projects for all firms as well as the results estimated by large- and small-firm subsamples, when evaluating the four types of the most important information sources during the conceptualization stage.[8] As for the results generated by market pull project (i.e., using the customer as an information source), the probability of employing a bilateral contract increases by 0.09 for non-core business projects, compared to core business ones. This results supports H4a. The coefficient of internal sourcing is negative, indicating that internal sourcing is more likely to be used for core business projects (compared to non-core business ones), as proposed in H4b. However, a negative sign in the unilateral contract could not be found.

When we split a whole sample into large and small subsamples, results consistent with H4a were found in small firm samples. As for the AME on bilateral contracts in SMALL, in the case of the project based on customer's information, the AME for non-core projects using bilateral contract, 0.14, is larger than that for the AME of *non-core field* under a bilateral contract, which is 0.08 and significant, in model (6) of Table3. For NPD projects of a small firm, market knowledge provided by a customer is important in the case of a product concept relied upon the customer, such that the firm facilitates bilateral contracting for projects related to non-core business fields. It should be noted that the coefficients for both internal sourcing and unilateral contract are negative although they are statistically insignificant in SMALL. As for LARGE, all coefficients are statistically insignificant. As is discussed in H2, for a resource-rich firm, the difference between core- and non-core business is not very great, since some projects are non-core to some particular group, but it may not be the case for the entire firm.[9] Therefore, H4a and H4b are partially supported, depending on firm size.

We found different results with respect to projects based on customer's information and supplier's information, even though both counterparts are related to a business transaction. For the project based on supplier's information, a firm is likely to choose a unilateral contract in a core business field compared to a non-core one, as shown by the negative AME in ALL. In a core business field, where the firm has enough market knowledge, it is more efficient to source external knowledge using a unilateral contract when the firm implements an NPD project that entails process innovation by supplier technology. The reason is that technology knowledge is embedded in a part of it, or that machinery provided by the supplier includes it, and thus the knowledge transfer is easier.

As for the results of technology push projects (i.e., using a university as an information source) for ALL samples, the probability of using a bilateral contract decreases by 0.24 for non-core business projects (meaning that it increases by 0.24 for core ones). Therefore, H5a is supported. The probability of unilateral contract increased by 0.23 for non-core businesses, so that the sign of coefficient is consistent with H5b, but it is statistically insignificant. This outcome us due to the standard error being very high (0.20), which might be explained by the greater heterogeneity found in technology push projects. When we split the whole sample into LARGE and SMALL, results supporting both H5a and H5b for large firm subsamples are obtained. Considering that an NPD project is based on university information, a large firm facilitates unilateral contracting in projects related to non-core business fields compared with the projects core fields because science-based knowledge required on the project for technology push type ones is easier to transfer across organizations. However, this estimate of university source in LARGE is too large, and hence not a valid result because there are too few observations respecting technology push and non-core business projects.

(Table 4)

5. Concluding Remarks

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7 *Information source* consists of three binary variables, *Concept from customer*, *Concept from supplier*, *Concept from university*, and *Joint conceptualization*.

8 We do not report the average marginal effects of the other variables when adding an interaction term because the model with the interaction term works for decomposing the effect of a non-core project and then the other variables are almost same as the values in Table 3.

9 It should be noted that the survey was conducted at division level, instead of a whole firm in case of multidivisional firm.

In this study, we provided empirical analyses that help understand how firms source external technology and combine it with their own development in NPD by using a novel dataset about NPD projects among Japanese firms. We consider the choice between three alternatives: bilateral contract-based alliances (i.e., joint venture, joint R&D), unilateral contract-based alliances (i.e., licensing, commissioned R&D), and internal sourcing (i.e., completely in-house development). The former style involves the cooperation process of joint R&D with a partner, whereas the latter involves the straightforward process of technology acquisition from a partner.

In the analysis, the determinants of the sourcing strategy by contract type are investigated, and we show that the relationship between efficient knowledge management in NPD and the choice of technology sourcing. First, a large firm is more likely to undertake unilateral contracting in the NPD project of non-core business field (or exploration) compared to projects pertaining to the core field (or exploitation) because the firm resolves the incongruity between knowledge domains and product domains efficiently. By contrast, a small firm chooses bilateral contracts more in the NPD projects of non-core business fields (or exploitation), compared to the project core ones, in order to acquire explicit and tacit knowledge through an alliance.

Second, a firm with a NPD project based on a customer's idea (i.e., demand pull) prefers a bilateral contract that involves more intense cooperation with a customer, whereas a firm with an NPD project based on a universities' idea (i.e., technology push) facilitates unilateral contracting because it is easier to package its technology as more explicit knowledge. Third, we find that the relationship between technology sourcing type and projects in non-core business circumstances differs depending on the source of the new product concept.

This study does not only test the make-buy decision of technology. It also tests the impact on the choice of the type of alliance, bilateral or unilateral, in the case of the buy decision, in order to confirm some regularities regarding the type of project, such as "exploration" vs. "exploitation" and "technology push" vs. "market pull," predicted by efficient knowledge management. We have stipulated the complex process of external technology sourcing by using the concept of a knowledge-based view, focusing on new product development processes by combining internal and external knowledge (Grant and Baden Fuller, 2004). We extended that theory by treating market and technological knowledge separately, and empirically tested the regularities on technology sourcing mechanisms according to different types of new products being developed. In addition, these findings may serve as useful inputs to managers when they make decisions regarding external technology sourcing for a product development project.

One of the outstanding empirical findings from our analysis is that the differences of such regularities is correlated with the size of the firm. We even had some contrasting results between large and small firm samples in some specifications. In this paper, we used a crude measure, the size of employment, for firm-size variables. Therefore, further detailed analysis with finer granularity data would be recommended. For example, theories of the knowledge-based view are built upon the distinction between, within, and across firm-knowledge flows. However, the reality is more complex. What about the intra-firm case without inter-department knowledge flows? In this paper, we argue that one business department (i.e., an observation unit of our survey) within a large firm might be benefited more easily from other departments, compared to small firms that are less likely to be multi-divisional. Our dataset is too crude to investigate the efficacy of knowledge flows in such intermediate cases, between internal and external elements.

Another venue of further study of this paper is to make more explicit link between technology and market knowledge. Danneels (2002) presents a framework of the matrix of exploitation-exploration and technology-market domain, and explains the evolution of a firm's new product development process by using partial exploration (e.g., market exploration with existing technology exploitation or vice versa) to expand (explore) both market and technology resources. However, Danneels (2002) did not treat the possibility of external resources explicitly. In our survey samples, there are some NPD cases of technology push and non-core business, suggesting the possibility of jumping into a "pure exploration strategy" (by the Danneels quadrant) from using external technology sourcing. Therefore, new theoretical developments with empirical studies (either by means of case or quantitative studies with new survey), provide some promise in an era of open innovation.

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Acknowledgements

This paper is based on an international comparison of open innovation, a project supported by the Research Institute of Economy, Trade and Industry (RIETI). This is a drastically revised version of Kani and Motohashi (2016). The authors acknowledge helpful comments on earlier drafts from the seminar participants at the IIPR workshop, APIC2015, INFORMS international meeting 2016, and 2017 AOM annual meeting.

Figure 1. Strategy for the new product development process

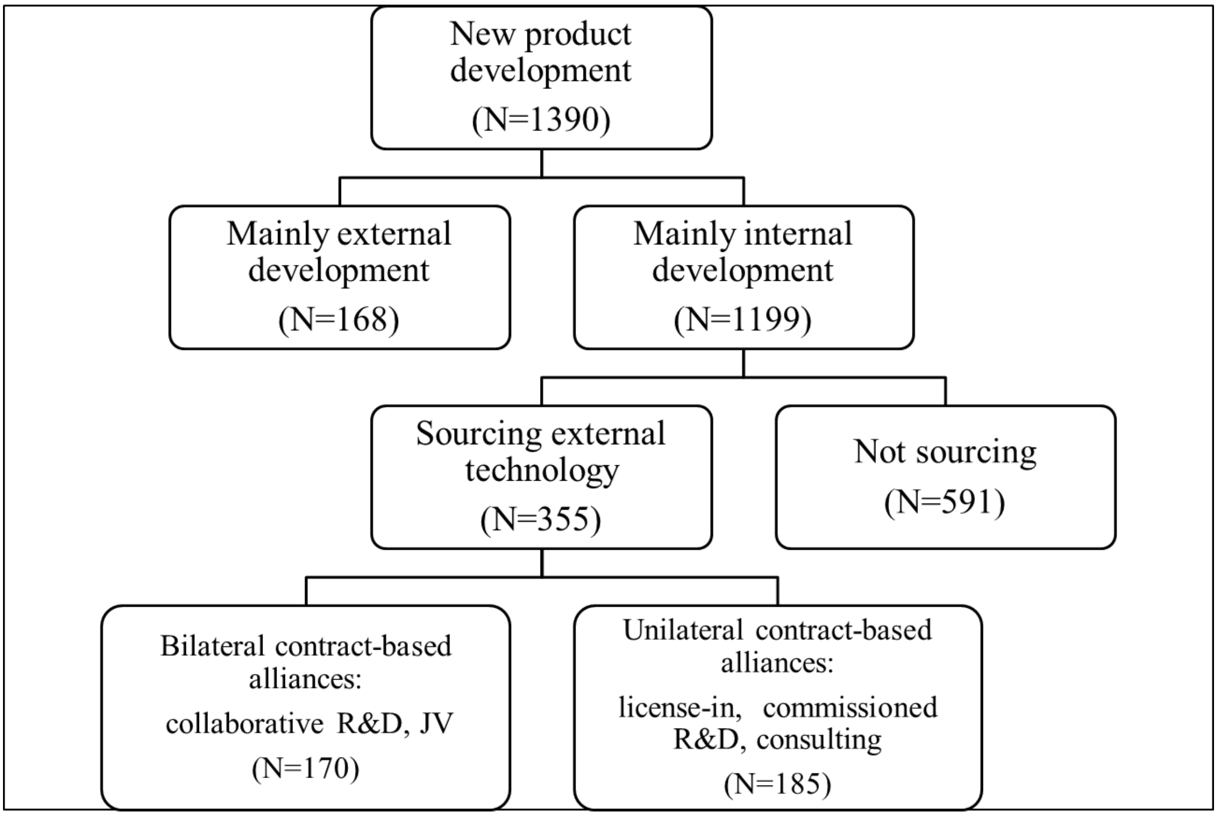
New product development
(N=1390)
Mainly external development
(N=168)
Mainly internal development
(N=1199)
Sourcing external technology
(N=355)
Not sourcing
(N=591)
Bilateral contract-based alliances:
collaborative R&D, JV
(N=170)
Unilateral contract-based alliances:
license-in, commissioned R&D, consulting
(N=185)

Table 1. Descriptive statistics and correlation matrix

	ALL		LARGE		SMALL	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Internal sourcing	0.62	0.49	0.63	0.48	0.62	0.49
Bilateral	0.18	0.39	0.19	0.39	0.17	0.38
Unilateral	0.20	0.40	0.18	0.39	0.21	0.41
Non-core field	0.22	0.42	0.20	0.40	0.25	0.43
Concept from customer	0.54	0.50	0.58	0.49	0.50	0.50
Concept from supplier	0.12	0.33	0.11	0.31	0.14	0.35
Concept from university	0.03	0.18	0.03	0.16	0.04	0.20
Joint conceptualization	0.18	0.38	0.16	0.37	0.20	0.40
Patented product	0.45	0.50	0.59	0.49	0.32	0.47
Single specific customer	0.10	0.30	0.08	0.28	0.11	0.32
Multi specific customer	0.29	0.45	0.33	0.47	0.25	0.43
R&D intensity ≥ 5%	0.17	0.38	0.21	0.40	0.14	0.34
New bus. unit	0.19	0.39	0.14	0.34	0.24	0.42
Supplier in group	0.23	0.42	0.23	0.42	0.23	0.42
Customer in group	0.21	0.40	0.18	0.38	0.23	0.42
Firm employee	5.17	1.49	6.28	1.21	4.07	0.71
Firm age	3.55	0.89	3.69	0.90	3.40	0.85
N	994		492		492	

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.	Internal sourcing	1.00																
2.	Bilateral	-0.60	1.00															
3.	Unilateral	-0.63	-0.23	1.00														
4.	Non-core field	-0.11	0.08	0.05	1.00													
5.	Concept from customer	0.05	0.01	-0.07	-0.04	1.00												
6.	Concept from supplier	-0.01	-0.04	0.05	0.04	-0.41	1.00											
7.	Concept from university	-0.13	0.06	0.11	0.01	-0.20	-0.07	1.00										
8.	Joint conceptualization	-0.09	0.09	0.02	0.05	-0.51	0.81	-0.09	1.00									
9.	Patented product	-0.10	0.08	0.05	-0.03	0.08	-0.11	0.08	-0.05	1.00								
10.	Single specific customer	-0.11	0.10	0.04	0.04	0.11	-0.04	-0.02	-0.08	-0.05	1.00							
11.	Multi specific customer	-0.02	0.04	-0.02	0.02	0.07	0.01	-0.04	0.00	0.15	-0.21	1.00						
12.	R&D intensity ≥ 5%	-0.07	0.03	0.06	0.01	0.03	-0.05	0.05	0.03	0.19	0.00	0.02	1.00					
13.	New bus. unit	-0.06	0.02	0.06	0.14	-0.06	0.00	0.06	0.01	-0.07	0.02	-0.01	0.00	1.00				
14.	Supplier in group	-0.03	-0.04	0.07	0.02	-0.05	0.05	0.01	0.04	-0.01	-0.01	0.02	-0.02	-0.06	1.00			
15.	Customer in group	-0.03	-0.05	0.09	0.02	-0.04	0.02	-0.02	0.04	-0.06	0.06	-0.01	-0.03	-0.06	0.53	1.00		
16.	Firm employee	0.01	0.01	-0.02	-0.04	0.12	-0.05	-0.02	-0.04	0.34	-0.04	0.12	0.09	-0.15	-0.02	-0.09	1.00	
17.	Firm age	-0.01	0.05	-0.04	0.01	0.08	0.02	0.00	0.03	0.06	0.00	0.03	0.00	-0.07	-0.10	-0.08	0.29	1.00

Note: N=994

Table 2. Average marginal effects from a probit model of external technology sourcing

	(1) All	(2) LARGE	(3) SMALL
	External sourcing	External sourcing	External sourcing
Non-core field	0.09**	0.16***	0.01
	(0.04)	(0.06)	(0.05)
Concept from customer	0.03	-0.02	0.11**
	(0.04)	(0.05)	(0.05)
Concept from supplier	0.07	0.06	0.12*
	(0.05)	(0.08)	(0.07)
Concept from university	0.37***	0.50***	0.30***
	(0.08)	(0.10)	(0.11)
Joint conceptualization	0.33***	0.27***	0.36***
	(0.07)	(0.10)	(0.10)
Patented product	0.09***	0.04	0.13***
	(0.03)	(0.05)	(0.05)
Single specific customer	0.16***	0.19**	0.15**
	(0.05)	(0.08)	(0.07)
Multi specific customer	0.03	0.04	-0.00
	(0.03)	(0.05)	(0.05)
R&D intensity ≥ 5%	0.04	-0.04	0.18***
	(0.04)	(0.05)	(0.07)
New business unit	0.05	-0.04	0.13**
	(0.04)	(0.06)	(0.05)
Supplier in group	0.04	0.05	0.02
	(0.04)	(0.06)	(0.06)
Customer in group	0.01	0.05	-0.03
	(0.04)	(0.07)	(0.06)
Firm employee	-0.01	-0.00	-0.02
	(0.01)	(0.02)	(0.03)
Firm age	0.02	0.03	0.01
	(0.02)	(0.03)	(0.03)
Industry dummy	YES	YES	YES
Log pseudo likelihood	-598.34	-288.11	-290.19
Pseudo R-squared	0.09	0.12	0.12
Wald Chi-square	119.32***	70.76***	82.01***
N	994	497	497

Note: The average marginal effect of factor levels is the discrete change from the base level/ the reference group. Values in parentheses are robust standard errors. The dummy variables of new product categories and a constant are dropped from the table. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively. LARGE refers to the group consisting of the respondents with more than 136 employees of the median value, SMALL is the group of the respondents with less than 136 employees.

Table 3. Average marginal effects from a multinomial logit model of external technology sourcing

	(4) ALL			(5) LARGE			(6) SMALL		
	Internal sourcing	Bilateral	Unilateral	Internal sourcing	Bilateral	Unilateral	Internal sourcing	Bilateral	Unilateral
Non-core field	-0.09**	0.07**	0.02	-0.16***	0.06	0.10**	-0.01	0.08*	-0.07*
	(0.04)	(0.03)	(0.03)	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)
Concept from customer	-0.03	0.07**	-0.03	0.02	0.02	-0.04	-0.11**	0.12***	-0.02
	(0.04)	(0.03)	(0.03)	(0.05)	(0.04)	(0.04)	(0.05)	(0.03)	(0.04)
Concept from supplier	-0.07	0.03	0.04	-0.06	0.05	0.02	-0.11	0.05	0.07
	(0.05)	(0.04)	(0.05)	(0.08)	(0.06)	(0.07)	(0.07)	(0.04)	(0.07)
Concept from university	-0.37***	0.19**	0.18**	-0.51***	0.37***	0.13	-0.29**	0.07	0.22*
	(0.09)	(0.09)	(0.09)	(0.10)	(0.14)	(0.13)	(0.12)	(0.08)	(0.12)
Joint conceptualization	-0.34***	0.44***	-0.10**	-0.29***	0.38***	-0.10	-0.38***	0.50***	-0.12*
	(0.07)	(0.07)	(0.05)	(0.09)	(0.09)	(0.06)	(0.09)	(0.09)	(0.06)
Patented product	-0.09***	0.03	0.07**	-0.04	-0.00	0.04	-0.13***	0.03	0.10**
	(0.04)	(0.03)	(0.03)	(0.05)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
Single specific customer	-0.16***	0.11**	0.05	-0.19**	0.10	0.09	-0.15**	0.11*	0.04
	(0.05)	(0.05)	(0.05)	(0.08)	(0.07)	(0.08)	(0.07)	(0.06)	(0.06)
Multi specific customer	-0.03	0.04	-0.00	-0.04	0.06	-0.02	0.01	-0.01	0.00
	(0.03)	(0.03)	(0.03)	(0.05)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
R&D intensity ≥ 5%	-0.04	-0.03	0.07*	0.04	-0.06	0.01	-0.19***	0.00	0.19***
	(0.04)	(0.03)	(0.04)	(0.05)	(0.04)	(0.04)	(0.07)	(0.05)	(0.07)
New business unit	-0.05	0.00	0.05	0.04	-0.04	0.00	-0.13**	0.05	0.08*
	(0.04)	(0.03)	(0.03)	(0.06)	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)
Supplier in group	-0.04	0.00	0.04	-0.04	-0.01	0.05	-0.01	0.01	-0.00
	(0.04)	(0.03)	(0.03)	(0.06)	(0.05)	(0.05)	(0.06)	(0.04)	(0.05)
Customer in group	-0.01	-0.05*	0.07*	-0.04	-0.10**	0.14**	0.03	-0.01	-0.02
	(0.04)	(0.03)	(0.04)	(0.07)	(0.04)	(0.06)	(0.06)	(0.04)	(0.05)
Firm employee	0.01	-0.01	0.00	0.01	-0.03*	0.02	0.02	-0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
Firm age	-0.02	0.02	-0.00	-0.04	0.05*	-0.01	-0.01	0.01	0.00
	(0.02)	(0.01)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Industry dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES
Log pseudo likelihood		-827.24			-383.47			-399.77	
Pseudo R-squared		0.10			0.16			0.14	
Wald Chi-square		193.62***			130.62***			136.43***	
N		994			497			497	

Note: The base category is *Internal sourcing*. Values are the average marginal effects of the independent variables on the probability choosing the alternative. The average marginal effect of factor levels is the discrete change from the base level/ the reference group. Values in parentheses are robust standard errors. The dummy variables of new product categories and a constant are dropped from the table. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 4. Average marginal effects of non-core filed (vs. core field) at information source

	ALL		
	Internal sourcing	Bilateral	Unilateral
Customer	-0.11**	0.09**	0.02
	(0.05)	(0.04)	(0.04)
Supplier	0.16*	0.03	-0.20***
	(0.09)	(0.07)	(0.07)
University	0.01	-0.24*	0.23
	(0.18)	(0.14)	(0.20)
Joint conceptualization	-0.12	0.00	0.12
	(0.13)	(0.15)	(0.09)
Others	-0.19**	0.13**	0.06
	(0.07)	(0.06)	(0.06)
N	994	994	994

	LARGE			SMALL		
	Internal sourcing	Bilateral	Unilateral	Internal sourcing	Bilateral	Unilateral
Customer	-0.11	0.01	0.10	-0.07	0.14**	-0.06
	(0.07)	(0.05)	(0.06)	(0.07)	(0.07)	(0.06)
Supplier	0.01	0.06	-0.08	0.26**	0.06	-0.32***
	(0.15)	(0.12)	(0.11)	(0.11)	(0.09)	(0.08)
University	-0.17	-0.55***	0.72***	-0.07	-0.02	0.09
	(0.11)	(0.15)	(0.13)	(0.21)	(0.16)	(0.22)
Joint conceptualization	-0.01	-0.07	0.08	-0.12	0.02	0.11
	(0.20)	(0.21)	(0.11)	(0.18)	(0.19)	(0.11)
Others	-0.41***	0.27**	0.14	0.01	0.03	-0.04
	(0.10)	(0.11)	(0.10)	(0.09)	(0.06)	(0.08)
N	479	479	479	479	479	479