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Abstract

This paper evaluates the economic impact of new-to-market product innovation using firm-level data obtained from the Japanese National Innovation Survey. It accounts for possible technological spillovers in innovation activities and examines the extent to which new-to-market product innovation contributes to firm performance. The paper offers several new insights on product innovation.

Keywords: Product innovation; Novelty; Spillovers; Innovation survey
JEL classification: C36; O31; O33; O38

1. Introduction

Product innovation is, by definition, deemed to be novel, but the degree of novelty differs by product (e.g. Arundel and Hollanders, 2005). OECD (1992, 1996, 2005) classifies firm's product innovation into two types; "the introduction of a product only new to the firm" and "the introduction of a product new to the market." The latter innovation is newer and more drastic than the former (OECD, 2009), and is considered to be novel. It is an important research agenda to examine product innovation in light of its novelty in three counts. First, new-to-market product innovation may contribute to firm performance, as it can provide a firm with temporary market power (Petrin, 2002). Second, new-to-market product innovation exhibits possible technological spillovers in firm's innovation activities. Spillovers associated with firm's innovation activities have attracted much attention in both theoretical and empirical studies. [1] Recent studies on the endogenous growth theory (e.g. Grossman and Helpman, 1991, Aghion and Howitt, 1992, Klette and Kortum, 2004) indicate that spillovers from firms at the technological frontier have an important role, and some empirical studies such as Xu (2006) account for technological spillovers from the frontier. Last but not least, new-to-market product innovation is under important public policy debate in various countries. In particular, if novel product innovation makes significantly positive spillovers, A policy to promote such innovation could be beneficial in social welfare point of view (Spence, 1984). For implementing such policy effectively, we need to understand the mechanism by which a new-to-market innovation comes into being.

The purpose of this paper is to quantitatively examine the nature of new-to-market product innovation, in order for us to understand better how such a product innovation contributes to firm performance, and whether we need a public policy to promote such innovation. To do so, we use firm-level data obtained from Japanese National Innovation Survey 2009 (JNIS2009). We propose an econometric model which comprises technological spillovers, legal protection measures, and other important variables relevant to new-to-market product innovation. Our model is reminiscent of Crépon et al. (1998), but we address endogeneity problem in the estimation.

Despite its economic importance, there are few empirical studies focusing on the novelty of firm's product innovation. Duguet (2006) is one of the few exceptions. This paper differs from this existing work in three important ways. First, we focus solely to product innovation. Duguet (2006) defines "radical innovation" as new-to-market product innovation

[1] Arrow (1962) points that a firm which conducts innovation activities cannot appropriate the outcome of the innovation since there are technological spillovers in the activities. Accordingly, many researchers have tried to quantify the spillovers, especially in the term of the social rate of return in R&D investment as discussed in Griliches (1992).

or a process breakthrough, and examines the impact of the radicalness. It is thought to be rather crude to lump together product and process innovations into one basket, as underlying economics work differently between the innovations (e.g. Klepper, 1996). Second, we use sales as a measure of firm performance, in contrast to Duguet (2006), which uses productivity. It is in fact not completely obvious as to how product innovation improves firm's productivity (e.g. van Leeuwen and Klomp, 2006, De Loecker, 2011). Third, we utilize the outflow, as well as inflow, of technology in an attempt to capture the feature of technological spillovers; existing literature including the one by Duguet focuses only on the inflow of technology. This additional aspect would hopefully allow us to accurately measure the feature of technological spillovers.

The rest of this paper is organized as follow. Section 2 provides an overview of various approaches in the measurement of economic outcomes of innovation, along with the description of our data set used in the paper. Section 3 proposes hypotheses related to new-to-market product innovation. Section 3.1 is for firm performance, Section 3.2 is for technological spillovers, and Section 3.3 is for the characteristics of a novel innovator. Section 4 formulates an econometric model and estimate with it to test the hypotheses. Section 5 concludes.

2. Approaches to Evaluate Innovation Outcome and Innovation Policy

Several approaches are commonly known in the measurement of economic outcomes accrued by product innovation. Three of which are (1) demand estimation; (2) patent analysis; and (3) analysis on R&D data. The first approach is to estimate demand structure of a specific market and to quantify the impact of new product introduction by use of simulation. This analysis has been performed on various new products such as computed tomography scanners (Trajtenberg, 1989) and minivans in the automobile market (Petrin, 2002). While the approach has an advantage in evaluate the impact of product innovation on the dimension of consumer surplus. The second approach is to use patent data. Pakes (1986) and Schankerman (1998) are a representative example, in which they estimate the value of patents, an intermediate input in the overall innovation process. The third is the approach that uses firm's R&D data. Among them are studies estimating the social rate of return to R&D investment (Griliches, 1992).[2] Whereas R&D data has an advantage in quantifying the economic impact, R&D investment only accounts for a fraction of firm's innovation

[2] Recent examples of R&D data analyses include Bloom et al. (2010), which focuses on the identification of spillovers, and Xu (2006), which captures the dynamic properties of R&D investment.

activities (Mairesse and Mohnen, 2010). As pointed in Arundel et al. (2008), there are many firms which conduct innovation activities without reporting any R&D expenditures.[3]

As for innovation policy, there is another line of researches based on program evaluation technique. In particular, many studies, such as Almus and Czarnitzki (2003) and González et al. (2005), focus on R&D subsidies. While program evaluation technique helps to solve the endogeneity problem of subsidy assignment, it ignores a side effect of the subsidies on other firms through spillovers.

Meanwhile, given the recent trend that innovation surveys based on the Oslo Manual (OECD, 1992, 1996, 2005) have been conducted in many countries, there is a growing body of empirical studies using them (Mairesse and Mohnen, 2010). This kind of innovation survey contains a wide range of information on firm's innovation activities and their outcome including innovation novelty. Our analysis is based on JNIS2009, which is a Japanese innovation survey conducted in 2009.

2.1. Characteristics of JNIS2009

JNIS2009,[4] which is based on the approval by the Ministry of Internal Affairs and Communications, was conducted in 2009 for collecting fundamental data about private firm's innovation activities by the National Institute of Science and Technology Policy (NISTEP) under the jurisdiction of the Ministry of Education, Culture, Sports, Science and Technology (MEXT). Since JNIS2009 is designed based on the Oslo Manual, results of this survey have international compatibility. JNIS2009 includes firm-level information on firm's innovation activities and their outcome. The survey period is three years from April 1st 2006 to March 31th 2009. Note that questions about firm's product innovation are asked for a market where the firm supplies its staple goods.

Surveyed firms are selected by the stratified sampling method among ones listed in Establishment and Enterprise Census 2006, which is conducted by Statistics Bureau, Ministry of Internal Affairs and Communications. They are further restricted to firms with more than ten employees and operate in the industries in Table 1. The response rate is 30.3% corresponding to 4,579 firms.

Table 1: Classification of Industries in JNIS2009

Industry	Japan Standard Industrial Classification (Rev. 12)

[3] The results of JNIS2009 show that 47.3% of firms conducting innovation activities do not report any R&D expenditures. This percentage is similar to that of Arundel et al. (2008) and that observed in some other countries.

[4] See NISTEP (2010) for the detail of JNIS2009.

Agriculture and forestry	A01-02
Fisheries	B03-04
Mining and quarrying of stons and gravel	C05
Construction	D06-08
Manufacturing	E09-32
Electoricity, gas, heat supply and water	F33-36
Information and communications	G37-41
Transport and postal activities	H42-49
Wholesale and retail trade	I50-60
Finance and insurance	J62, 64-67
Real estate and goods rental and leasing	K68-70
Scientific research, professional and technical service	L71-74
Accommodations, eating and drinking services	M75-77
Compound servies	Q86
Services, n.e.c.	R89

3. Hypotheses on Novel Product Innovation

In this section, we propose several hypotheses on novel product innovation from three aspects along with reviewing existing studies. In Section 3.1, we pick up hypotheses on the effect of new-to-market product innovation on firm performance. Section 3.2 is for hypotheses on technological spillovers in innovation activities. Lastly, Section 3.3 is more associated with innovation policy, and we propose hypotheses on the characteristics of a novel innovator.

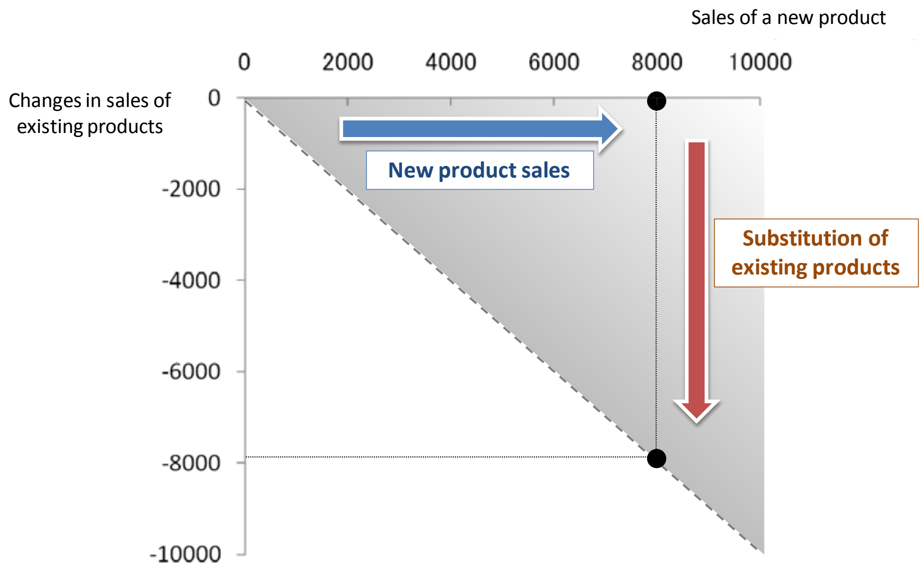
3.1. Firm Performance

It attracts attention of many researchers whether achieving innovation improves firm performance. Crépon et al. (1998, CDM) is a representative example of the existing studies. For analyzing French manufacturing firms, they conduct a three-step regression analysis which includes the estimation of the research equations, the innovation equations and the productivity equation. Their results indicate that firm's productivity positively correlates with innovation output such as the number of patents or the share of innovative sales. Many researchers take the CDM-like approach for analyzing firm's innovation in several countries, among which are Griffith et al. (2006) for France, Germany, Spain and the UK and

Chudnovsky et al. (2006) for Argentina. Furthermore, CDM's approach is extended in various directions. Jefferson et al. (2006), Lööf and Heshmati (2006) and van Leeuwen and Klomp (2006) use measures other than productivity for capturing firm performance and Duguet (2006) classifies innovations into radical and incremental ones.

We use sales of a new product and sales of existing products for measuring firm performance. This enables us to decompose the effect of product innovation into two components. Figure 1 summarizes the economic impact of product innovation on firm's sales. The horizontal axis represents the effect on a new product, which is measured by its sales. On the other hand, the vertical axis captures the cannibalization effect which means that the new product competes with firm's existing products and hurts their sales. The net effect of product innovation on firm's total sales, which is determined by the difference in degree of these two effects, is shown gradationally in the figure. The net effect is zero on the 45-degree line, and becomes positive with lighter graduation.

Figure 1: Product Innovation and Firm Sales

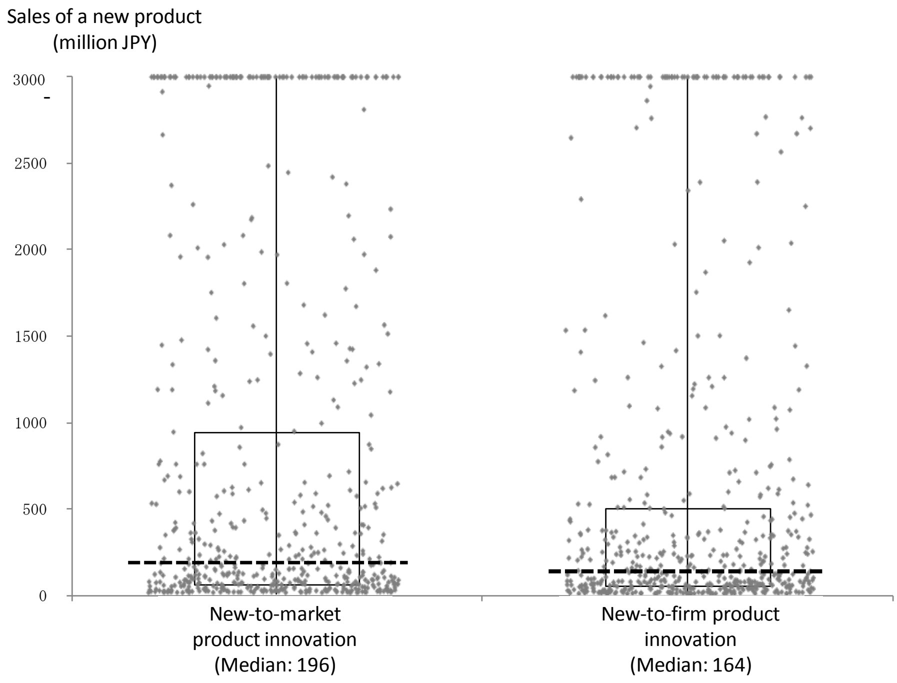


The sales of a new product are considered to be affected by existing products in the market. Especially for new-to-firm product innovation, which means the introduction of a product that is already provided by other firms, the firm faces severe competition with homogenous products. As a result, the price of the new product will drop and its sales will decrease. Consistent with this view, Duguet (2006) shows that only radical innovation can improve firm performance. Barlet et al. (1998) also indicate that innovation novelty can increase the share of innovative sales in situations where technology is important. Therefore, we can propose the following hypothesis.

Hypothesis 1: The sales of a new product are larger for a firm with new-to-market product innovation than for one with new-to-firm product innovation on average.

JNIS2009 includes information on the sales of a new product in FY2008 for firms with product innovation.[5] The average sales of a new product are 5,586 million JPY for a firm with new-to-market product innovation and 3,004 million JPY for the other, which is consistent with Hypothesis 1. In addition, Figure 2 boxplots the sales of a new product respectively for a firm with new-to-market product innovation and for one with new-to-firm product innovation. The rectangle in the figure represents the interval between 25 and 75 percentile of the sales and the dash line represents the median. The median sales are 185 million JPY for a novel innovator and 165 million JPY for the other. Furthermore, 75 percentile of the sales for a novel innovator is much larger than that for the other, which implies that a part of novel product innovation generates huge sales.

Figure 2: Novelty and the Sales of New Products



Next, we turn to the sales of innovator's existing products. Jefferson et al. (2006) point out that innovation does not necessarily improve firm performance, and suggest that the

[5] To be exact, JNIS2009 asks a firm the share of new product sales. We can recover the sales amount of the new product by multiplying the share by firm's total sales in FY2008. Since the question about the share is an interval one, we assign the intermediate value for each interval.

retirement of firm's existing products might occur with innovation. It is expected that the bigger impact of new product introduction leads to more negative effects on the sales of firm's existing products, which is expressed as the following hypothesis.

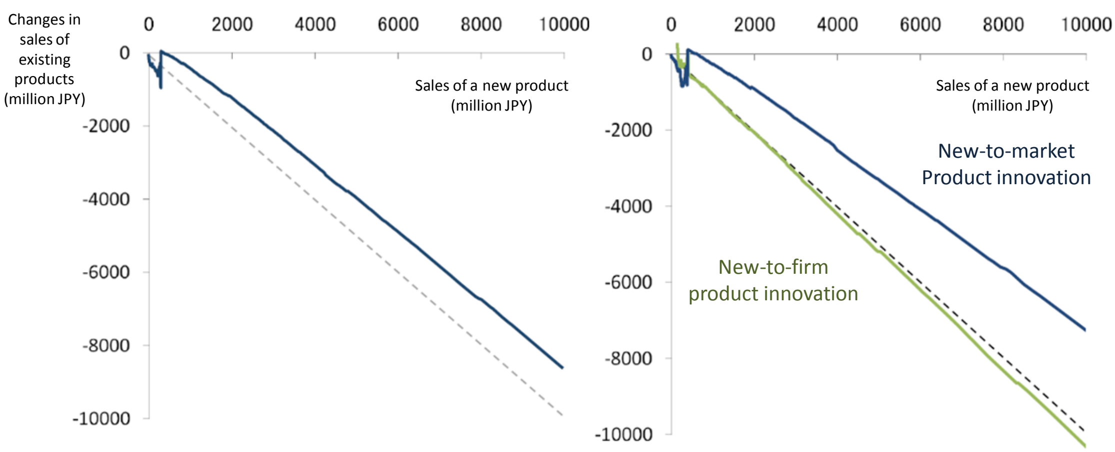
Hypothesis 2: The larger sales of a new product decrease the sales of firm's existing products on average.

As described above, the sales of existing products in the market are considered to be severely affected by new-to-firm product innovation. It is no wonder that the same argument is applied to firm's own existing products. Hence, we propose the following hypothesis.

Hypothesis 3: The decrease of the sales of firm's existing product due to the larger sales of a new product is less for a firm with new-to-market product innovation than for one with new-to-firm product innovation on average.

For testing Hypothesis 2 and Hypothesis 3, we need to capture the effect of product innovation on the sales of firm's existing products. For this purpose, we calculate changes in the sales amount of existing products during FY2006-FY2008 and use them as a measure for the effect. The left side of Figure 3 plots the relationship between the sales of a new product and changes in the sales of existing products.[6] The larger sales of a new product decrease those of existing products, which is consistent with Hypothesis 2. Changes in the total sales, which are represented gradationally in Figure 1, are around 1,500 million JPY regardless of the new product sales.

Figure 3: Sales of new and existing products



The right side of Figure 3 plots the same relationship separately for a firm with

[6] We use LOWESS (Locally Weighted Scatterplot Smoothing) as smoothing algorithm.

new-to-market product innovation and for one with new-to-firm product innovation. There exists a significant difference between them. The curve for a firm with new-to-firm product innovation is almost on the 45-degree line, which indicates that the sales of a new-to-firm product are nearly offset by decreases in the sales of existing products. On the other hand, the curve for a firm with new-to-market product innovation lies above the 45-degree line, which means that the sales of a new-to-market product lead to increases in firm's total sales. These observations are consistent with Hypothesis 3.

Combining the observations in Figure 2 and Figure 3, it is implied that novel product innovation can increase the sales of a new product and reduce the loss of existing product sales, both of which increase firm's total sales.

3.2. Technological Spillovers

Many researchers, including Arrow (1962), have pointed out that an agent conducting innovation activities cannot appropriate their outcome due to the existence of technological spillovers. There are a vast amount of empirical studies to investigate the existence of the spillovers, in particular by estimating the social rate of return in R&D (Griliches, 1992). However, most of the studies suffer from the identification problem of spillovers. Bloom et al. (2010) indicate that there are two distinct types of spillovers among firm's innovation activities, which are technological spillovers and product market spillovers, but few studies identify them separately. They address this issue by using measures of firm's position in technology space and product market space. Instead, we directly identify technological spillovers with information on firm's technology acquisition and provision.

The technological spillovers can be viewed from the perspective of inflow and outflow. The former corresponds to the technology acquisition and the latter does to the technology provision. As for outflow, of special importance is the technology provision through channels that are less likely to be accompanied by monetary compensation, such as open-sourcing and participation in consortia. If a firm does not consider this type of spillovers in making decisions on innovation activities, innovation in the private sector could be undersupplied. Furthermore, some recent studies on the endogenous growth theory (e.g. Grossman and Helpman, 1991, Aghion and Howitt, 1992, Klette and Kortum, 2004) and those on dynamic estimation (e.g. Xu, 2006) assume the technological spillovers from firms at the technological frontier through the nonmonetary channels. Since a firm with new-to-market product innovation is likely to lie near the frontier, we propose the following hypothesis.

Hypothesis 4: A firm with new-to-market product innovation is more likely to provide its technology through open-sourcing or participation in consortia than one with new-to-firm *product innovation on average.*

On the other hand, there are some empirical studies focusing on inflow. Kaiser (2002) considers incoming spillover effects in analyzing the relationship between research cooperation and research expenditures. His results indicate that horizontal spillovers lead to firm's aggressive innovation investment through research cooperation. Similarly, Branstetter and Sakakibara (2002) examine research consortia based on Katz (1986). They obtain the results that spillover effects in research consortia have a positive impact on firm's outcome. Both of the studies suggest the following hypotheses.

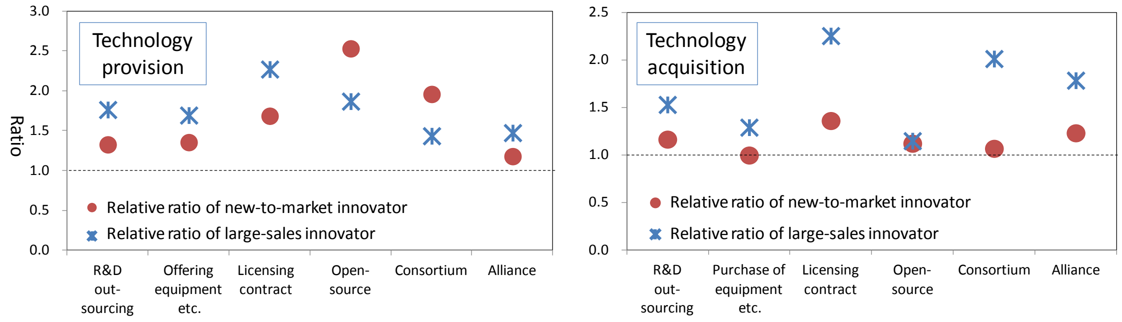
Hypothesis 5: The sales of a new product are larger for a firm which acquires technology through consortia than for one which does not on average.

Figure 4 summarizes firm's technology acquisition and provision in JNIS2009. Circles in the figure represent the relative ratio of technology acquisition (or provision) for a firm with new-to-market product innovation to one with new-to-firm innovation by its channel. On the other hand, snow marks in the figure represent the relative ratio of technology acquisition (or provision) for a firm with large-sales product innovation to one with small-sales product innovation by its channel.[7] The left side of the figure is for firm's technology provision. While large-sales product innovation is associated with channels that are more likely to be accompanied by monetary compensation represented by licensing, new-to-market product innovation is linked to nonmonetary channels such as open-sourcing and participation in consortia, which is consistent with Hypothesis 4.

The right side of the figure is for firm's technology acquisition. Innovation novelty appears to be little associated with technology acquisition. On the other hand, a firm with large-sales product innovation tends to acquire technology through licensing and participation in consortia, which is consistent with Hypothesis 5. Combining this observation with results in the left side, we can guess that participation in consortia plays a significant role in technological spillovers. Figure 4 indicates that a firm with new-to-market product innovation provides its technology to other firms through consortia, and the spilled technology contributes to their large sales of a new product.

Figure 4: Technology Acquisition and Provision

[7] We call product innovation large-sales one if the sales of a new product exceed the median value, 168 million JPY. And we define small-sales product innovation vice versa.



3.3. Characteristics of Novel Innovators

In this subsection, we focus on the characteristics of a firm with new-to-market product innovation in terms of three aspects; information sources, means for protecting the innovation benefit and public financial support. Since the subsections above imply that novel product innovation leads to significant improvement in firm performance and technological spillovers, public policy for encouraging firm's new-to-market innovation can work well. For implementing such policy effectively, we need to know what types of firms achieve novel product innovation.

3.3.1. Information sources

There are some existing studies which examine the relationship between information sources and innovation novelty. Belderbos et al. (2004) examine the relationship between cooperative R&D and firm performance. Among their results are that information from consumers or universities has a positive impact on the sales of a new product and that cooperation with universities leads to novelty. Similarly, Mohnen and Hoareau (2003) study the relationship between contact with universities and innovation novelty, but their results suggest that the contact does not necessarily have the form of cooperation. With a few exceptions,[8] many studies imply the positive effect of information from universities on innovation novelty, and we can propose the following hypothesis.

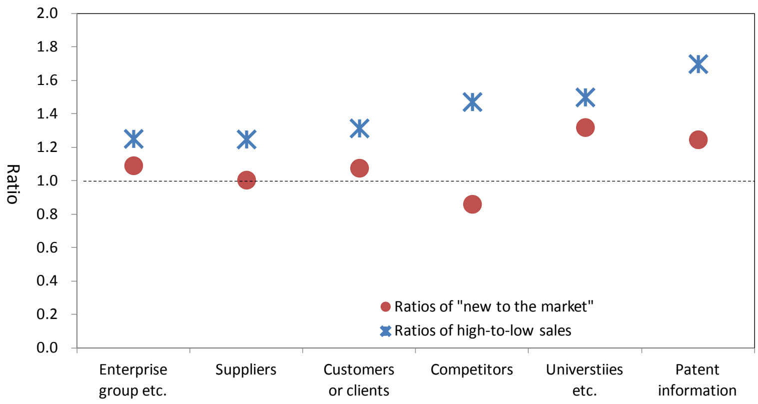
Hypothesis 6: A firm with new-to-market product innovation is more likely to obtain information from universities for its innovation activities than one with new-to-firm product innovation on average.

Figure 5 shows the utilization ratio of information sources for innovation activities. As explained above, circles are for innovation novelty and snow marks are for the sales of a new

[8] Monjon and Waelbroeck (2003) suggested that information from universities encouraged non-radical innovation. In this regard, since they also showed that the cooperation with foreign universities led to radicalness, it is said that there were some link between the contact with universities and radicalness.

product. Whereas a firm with large-sales product innovation aggressively uses various sources as a whole, one with new-to-market product innovation tends to obtain information from universities or patents held by other firms, which is consistent with Hypothesis 6.

Figure 5: Information Sources



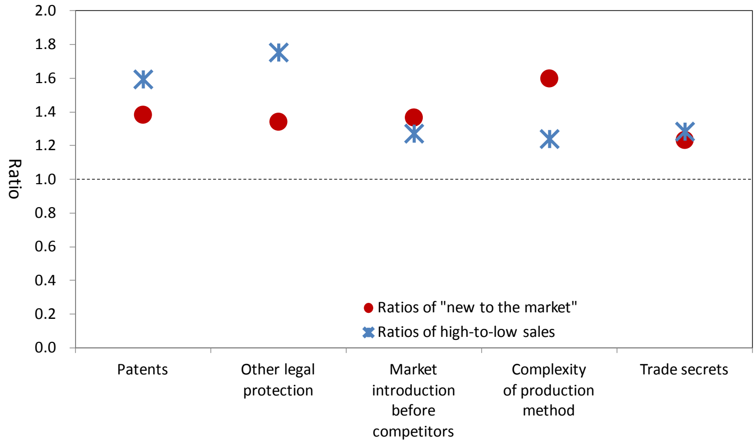
3.3.2. Means for protecting innovation benefit

Next, we focus on means for protecting firm's innovation benefit. While we have already noted the difficulty of appropriating innovation benefit, a firm can protect it by various means. The means are divided into legal ones such as patents protection and non-legal ones such as trade secrets. Theoretically, legal means can work as a device of encouraging firm's innovation activities by giving it a premium for its innovation achievement. Among recent empirical studies, Duguet and Lelarge (2006) show the effectiveness of patent protection as for firm's product innovation. However, it has been also pointed out that legal protection do not necessarily work ideally due to some factors such as circumventing invention (Levin et al., 1987). In particular, considering possible positive spillovers in novel product innovation, legal means may not work effectively for protecting the profit from the new-to-market product, which lead to the following hypothesis.

Hypothesis 7: A Firm with new-to-market product innovation is not more likely to use legal protection relative to non-legal one than one with new-to-firm product innovation on average.

Figure 6 summarizes means for protecting firm's innovation benefit. As before, circles are for innovation novelty and snow marks are for the sales of a new product. While a firm with large-sales innovation tends to use legal protection actively, one with new-to-market product innovation uses it only as frequently as non-legal means. This is consistent with Hypothesis 7 and indicates that novel product innovation could be difficult to be protected by legal means relative to large-sales product innovation.

Figure 6: Protection Measures for Innovation Benefit



3.3.3. Public financial support

Lastly, we pick up public financial support for firm's innovation activities. This topic has been studied mainly in terms of the relationship between R&D subsidies and firm's R&D investment. For example, Almus and Czarnitzki (2003) use a matching method and show that R&D subsidies stimulate firm's innovation activities. González et al. (2005) also indicate that some firms would not conduct R&D investment without subsidies and that there exists no crowding-out of private R&D investment. In addition, some recent studies draw attention to public financial support other than subsidies. Finger (2008) examines the effect of an R&D tax credit with considering the interdependence of firms' R&D investment, and shows that the tax credit encourages firm's R&D investment in a limited way.

Meanwhile, there are few studies which focus on the relationship between public financial support and innovation novelty. As an exception, Mohnen and Hoareau (2003) raise a possibility that contact with public institutions, by using it as information sources, leads to novel product innovation. If contact with public institutions through channels other than information sources also encourages novel product innovation, public financial support can have a positive effect on novelty. Hence, we propose the following hypothesis.

Hypothesis 8: A Firm with new-to-firm product innovation is more likely to receive public financial support than one with new-to-firm product innovation on average.

Figure 7: Novelty and Public Financial Classified by Firm Size

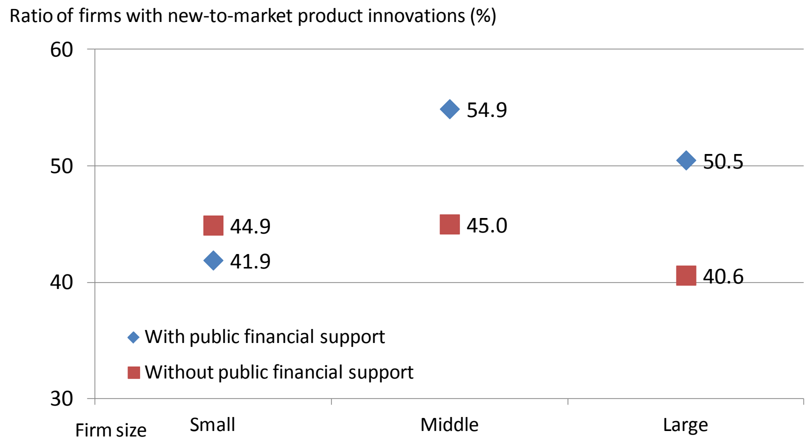


Figure 7 plots the relationship between the ratio of firms with new-to-firm product innovation and public financial support[9] by firm size.[10] While the ratio is higher with the support for middle and large firms, this is not the case for small firms. Hence, Hypothesis 8 is not necessarily confirmed. This might be because there are non-financial bottlenecks at achieving novel innovation for small firms. In particular, small firms are less likely to use information from universities (Nishikawa et al., 2010), which discourages novel innovation as implied in Figure 5. Therefore, policy intervention intended to increase contacts between firms and universities can work well.

4. Econometric Analysis

In the previous section, we propose hypotheses on firm's novel product innovation and confirm that most of observations in JNIS2009 seem consistent with them. However, concluding only with such data descriptions is inadequate for two reasons. First, there can be omitted variable biases. Firm's innovation activities and their outcome are affected by a number of factors, and if we do not control them properly and they are correlated with an object of interest, we would draw wrong conclusions. Second, endogeneity biases are also of concern. Since ignoring endogeneity in variables can distort estimation results, we have to solve it by some technique such as an instrumental variable method.

In this section, we conduct an econometric analysis which deals with these problems for testing hypotheses in the previous section. We construct a comprehensive econometric model, which is a variant of CDM, and obtain estimates based on it. In Section 4.1, we introduce the

[9] The financial support includes tax credits, subsidies, loan guarantees and so on.
[10] Small firms have less than 50 employees, middle firms have 50 or more but less than 250 employees and large firms have more than 250 employees.

econometric model, the system of equations and our estimation technique. In addition, we present summary statistics of model variables here. In Section 4.2, we show the estimation results and test our hypotheses.

4.1. Econometric Model and Estimation

We construct an econometric model which is a variant of CDM. The model is represented as a system of three sets of equations. The first is for firm's R&D investment. As widely known, R&D expenditures are endogenously determined and any analyses ignoring this endogeneity should suffer from biased estimates. CDM deal with this issue by formulating research equation. According to CDM and other existing empirical studies, we consider several factors which can affect firm's R&D investment. One is related to consumer demand, in particular expressed by a market size. The structure of demand is considered to be a major determinant of firm's innovation activities (e.g. Levin and Reiss, 1984), which is often called *demand pull*. While CDM use the answers to a question about the influence of market demand, we try to control the market size effect with industry dummies[11] and a dummy variable indicating whether the market has expanded during the survey period. Another factor considered to a fundamental determinant of innovation activities is technological opportunity (e.g. Rosenberg, 1974, Levin and Reiss, 1984) or *technology push*. For capturing this effect, we focus on firm's technology acquisition, which is also interpreted as the inflow of technological spillovers. JNIS2009 asks a respondent through which channels it acquire technology as in the right side of Figure 4, and we create technology-acquisition dummy variables based on it.[12] In addition, we take into account information sources. Some past studies such as Belderbos et al. (2004) focus on information sources to measure the inflow of technological spillovers. Again, JNIS2009 asks a respondent which information sources it uses as in Figure 5, and we create information dummy variables based on it. Besides demand pull or technology push, CDM also care about factors involved with so called "Schumpeterian hypotheses" focusing on the effect of firm's size and market power.[13] Similarly to them, we use firm-size dummies, the number of competitors in the domestic

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[11] The classification of the industry is the same as one defined in Section 2.1.

[12] CDM use the answers to a question about the influence of technology developments.,

[13] There exists a long history of dispute over whether market concentration encourages firm's innovation activities. It is said that firm's innovation has two distinct types of effects. One is the replacement effect, which is in Arrow (1962), encourages firm's innovation activities in more competitive situations, and the other is the efficiency effect, which is also called the Schumpeterian effect (Schumpeter, 1943) and in Gilbert and Newbury (1982) and Reinganum (1983), encourages them in more concentrated situations. A lot of empirical studies, including Aghion et al. (2005), have tried to quantify the net effect of them.

market[14] and a dummy variable indicating whether the market has experienced product diversification during the survey period. Lastly, we consider public financial support for firm's innovation activities whereas CDM ignore that. As described in Section 2, there are a number of studies which seek to identify the effect of public aid on firm's innovation. We create a dummy variable indicating whether a firm receives any public financial support. If a firm answers that it receives financial support from local public agencies or the central government, we assign the dummy variable to one.

The second set of equations capture firm's innovation output. As the measure of the output, we focus on innovation novelty and protection of innovation benefit. The former is our direct interest and analyzed in Duguet (2006) among past studies whereas CDM do not consider that. The latter is more related to CDM, which look at the number of patent applications. Here, we do not restrict our attention to patents. As in Figure 6, a firm uses various means for protecting innovation benefit; legal protection including patents or nonlegal protection such as market introduction before competitors, complexity of production methods or trade secrets. We can identify whether a firm use legal or nonlegal protection, and create a dummy variable for each of them. As for regressors, we use almost the same set of variables in the first step. We add firm's R&D expenditures to them, which is endogenously determined in the first stage since many of empirical studies including CDM consider firm's R&D investment as innovation input. Moreover, we omit the number of competitors in the domestic market from this stage, just like CDM omit market shares from their second one. In addition to these variables, we use innovation novelty as a regressor for explaining protection of innovation benefit, which is about Hypothesis 7.

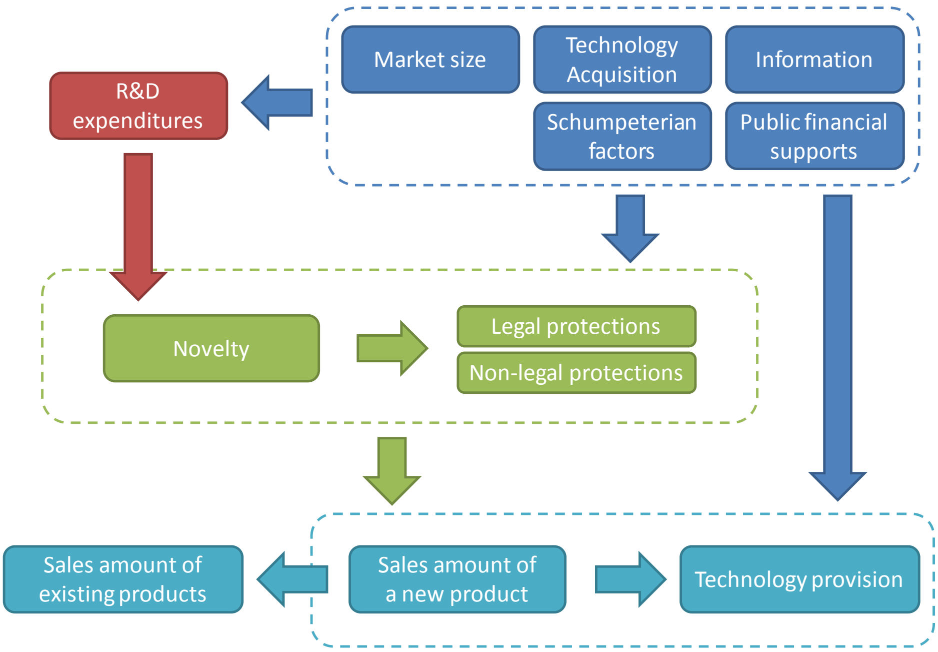
The third set of equations is for firm's sales amount and its technology provision. For firm's sales amount, we consider not only the sales of a new product but also that of existing products. Whereas most of past studies in line with CDM do not deal with the sales of existing products explicitly, we believe that it is nonnegligible for examining the economic outcome of product innovation because it can capture the cannibalization effect. As for firm's technology provision, we focus on channels which are less likely to accompany monetary compensation. In particular, we pick up open-sourcing and participation in consortia, and create a dummy variable which takes one if the firm provides its technology through these channels. We include three types of regressors for the equations determining the sales of a new product and the technology provision. First, we include innovation novelty and protection of innovation benefit, which are endogenously determined it the first stage as above. Following CDM and Duguet (2006), these innovation output can have a positive

[14] The number is for FY2008. Since the corresponding question is interval one, we assign the intermediate value for each interval.

impact on firm performance. Second, we use the same regressors in the second stage as control variables. As a result, we control the effect of demand and technological conditions, firm size (the number of employees) and product diversification. Third, we consider acquisition of tangible fixed assets and the number of workers in research and development, which correspond to regressors in the third stage of CDM.[15] On the other hand, as for regressors in the equation determining the sales of existing products, we consider innovation novelty, the sales of a new product and some control varibles which include firm's total sales amount in FY2006 and firm-size and industry dummies. With this equation, we try to quantify the degree of cannibalization and examine how innovation novelty affects the degree.

The structure of the model is summarized in Figure 8. We can statistically test all of the hypotheses in Section 3 based on this model.

Figure 8: Overview of the Model



4.1.1. Comparison with CDM

Although our model is a variant of CDM, there are four significant differences other than practical measures for model variables. First of all, we incorporate innovation novelty in the model. As described in Section 1, it is important to discuss product innovation in terms of its novelty since new-to-market product innovation could affect firm performance strongly and

[15] CDM include physical capital and the shares of engineers and administrators in the total number of employees.

be associated with technological spillovers. Second, we consider both legal and non-legal means for protecting innovation benefit. While CDM only focus on the number of patents, patent protection does not necessarily work ideally (Levin et al., 1987). Third, we use firm's sales of both new and existing products as measures for firm performance. CDM consider the percentage share of firm's innovative sales in their second stage, which is the combination of firm's sales of new and existing products. However, it is necessary to examine firm's sales of a new product and that of existing ones *separately* for capturing the cannibalization effect. Forth, we consider both the inflow and the outflow of technology by using information on firm's acquisition and provision of technology. In particular, most studies including CDM do not care about the outflow.

4.1.2. Estimation equations

We propose estimation equations for firm *i* based on the model. Equation (1) corresponds to the first part of the model, the determination of firm's R&D expenditures. Because there are many firms with zero R&D expenditures, our choice is a Tobit model.

$$R\&D_i^* = x_{1,i}\beta_1 + u_{1,i},$$
$$R\&D_i = \begin{cases} R\&D_i^* & if \quad R\&D_i^* > 0, \\ 0 & otherwise. \end{cases} \qquad (1)$$

where $R\&D_i$ represents firm's R&D expenditures and $x_{1,i}$ include industry dummies, the market expansion dummy, technology-acquisition dummies, information dummies, firm-size dummies, the number of competitors in the domestic market, the product differentiation dummy and the public financial support dummy.

Equation (2), (3) and (4) correspond to the second part. Since all of the dependent variables are binary, we choose a probit model.

$$Novelty_i = \alpha_2 R\&D_i + x_{2,i}\beta_2 + u_{2,i},$$
$$where \ u_{2,i} \sim N(0,1) \quad and \quad Novelty_i = \begin{cases} 1 & if \quad Novelty_i^* > 0, \\ 0 & otherwise. \end{cases} \qquad (2)$$

$$Legal_i = \gamma_3 Novelty_i + x_{2,i}\beta_3 + u_{3,i},$$
$$where \ u_{3,i} \sim N(0,1) \quad and \quad Legal_i = \begin{cases} 1 & if \quad Legal_i^* > 0, \\ 0 & otherwise. \end{cases} \qquad (3)$$

$$Nonlegal_i = \gamma_4 Novelty_i + x_{2,i}\beta_4 + u_{4,i},$$
$$where \ u_{4,i} \sim N(0,1) \quad and \quad Nonlegal_i = \begin{cases} 1 & if \quad Nonlegal_i^* > 0, \\ 0 & otherwise. \end{cases} \qquad (4)$$

where $Novelty_i$ represents innovation novelty, $legal_i$ does the legal protection dummy, $Nonlegal_i$ does the nonlegal protection dummy and $x_{2,i}$ is almost the same as $x_{1,i}$ except that it does not include the number of competitors in the domestic market.[16]

Equation (5) through (7) correspond to the third part. For the technology provision equation, we estimate its parameters based on a probit model.

$$log(Newsales_i) = \alpha_5 R\&D_i + [Novelty_i, Legal_i, Nonlegal_i]\eta_5 + x_{5,i}\beta_5 + u_{5,i}, \quad (5)$$

$$log(Existingsales_i) = [Novelty_i, Newsales_i, Novelty_i{*}Newsales_i]\rho_6 + x_{6,i}\beta_5 + u_{6,i}, \quad (6)$$

$$Provision_i^* = \alpha_7 R\&D_i + [Novelty_i, Legal_i, Nonlegal_i]\eta_7 + x_{5,i}\beta_7 + u_{7,i},$$

$$\text{where } u_{7,i} \sim N(0,1) \text{ and } Provision_i = \begin{cases} 1 & \text{if } Provision_i^* > 0, \\ 0 & \text{otherwise.} \end{cases} \quad (7)$$

where *Newsales*$_i$ represents the sales of a new product, *Existingsales*$_i$ does the sales of existing products, *Provision*$_i$ does the dummy for capturing technology provision through open-sourcing or participation in consortia, $x_{5,i}$ include $x_{2,i}$, purchased tangible fixed assets and the number of workers in R&D, and $x_{6,i}$ include the logarithm of firm's total sales and firm-size and industry dummies.

4.1.3. Methodology and estimation sample

We estimate the parameters in this system by MLE. Estimation samples are restricted to firms which conduct innovation activities and achieve product innovation, which reflects our interest in innovation output including the novelty of product innovation. This restriction does not become a problem as long as we focus on the economic impact of product innovation *conditional on* firm's conducting innovation activities and achieving product innovation. Similarly, CDM's main estimates are obtained with firms that achieve some kinds of innovation.

Furthermore, we drop observations with missing values for variables in the model. The characteristics of the dropped firms are not so different from those without the missing values.[17] The resulting sample size is 539.[18] Table 2 presents the summary statistics of the variables in the model.

Table 2: Summary Statistics

		Mean	Std.
Novelty		47.40%	50.00%
Sales of a new product	(million JPY)	5148.1	53945.3

[16] We omit firm's R&D expenditures from equation (3) and (4). We suffer from a convergence problem otherwise.

[17] There is little difference in firm's average size, age and industry. We cannot reject the hypothesis that there is no difference in their average sales and age between the two subsamples based on t-test. Similarly, we cannot reject the hypothesis that the existence of the missing values and firm's industry are independent based on Pearson's chi-square test.

[18] Before dropping observations with the missing values, the sample size is 1,224.

Sales of existing products	(million JPY)	42354.8	188152.8
R&D expenditure	(million JPY)	4508	41395.2
Firm size			
	Middle	24.90%	43.30%
	Large	62.80%	48.40%
Number of competitors		10.2	7.64
Product differentiation		61.97%	48.57%
Acquisition of tangible fixed assets	(million JPY)	7179.3	47235.0
# of workers in R&D		202.2	1374.6
Information			
	Enterprise group etc.	77.50%	41.80%
	Suppliers	57.90%	49.40%
	Customers or clients	68.50%	46.50%
	Competitors	36.40%	48.20%
	Private research institutes etc.	24.20%	42.90%
	Universities etc.	34.20%	47.50%
	Public research institutes	28.60%	45.20%
	Academic conference etc.	36.40%	48.20%
	Professional publications etc.	43.20%	49.60%
	Exhibitions etc.	53.70%	49.90%
	Patent information	37.50%	48.50%
Technology acquisition			
	Buyout	9.70%	29.60%
	R&D outsourcing	37.00%	48.30%
	Purchase of equipment etc.	51.30%	50.00%
	Company split-up	5.30%	22.40%
	Licensing contract	20.50%	40.40%
	Open-source	13.40%	34.10%
	Consortium	11.70%	32.20%
	Alliance	16.30%	37.00%
	Accepting researchers etc.	16.30%	37.00%
Technology provision			
	Open-source or consortia	11.70%	32.20%
Public financial support		26.20%	44.00%
Protection			
	Legal means	53.80%	49.90%

	Nonlegal means	72.00%	45.00%
Observation		539	

Regarding a sample selection issue, we also try correcting possible sampling biases with a facile method. First, for all firms in JNIS2009, we regress a dummy variable indicating whether the firm is included in our estimation samples on some control variables, including firm's total sales, sales cost, total wages and firm-size and industry dummies. Then, we calculate the residual for each firm and include them in equation (1) through (7) as an additional regressor. The estimation results are not so much different from our baseline results reported below.

4.2. Estimation Results

Table 3 shows the estimates in Equation (1). Specification (1-a) includes all regressors discussed in Section 4.1. As for the demand side, market expansion is significantly estimated to increase R&D expenditures. On the other hand, few dummies for technology push are significantly estimated, except that technology acquisition through corporate reorganization such as buyout and split-up or through open-sourcing positively affect firm's R&D investment. Schumpeterian factors are estimated to have little effect on firm's R&D investment, which implies that these factors do not directly determine firm's innovation activities once we control demand pull and technology push. The coefficient of public financial support is estimated to be significantly positive.

Specification (1-b) and (1-c) omit industry dummies and technological factors whose coefficients are estimated insignificant in (1-a). The results are almost the same as (1-a). The only difference is that the coefficient of the large firm dummy is estimated to be significantly positive. Our results are consistent with some studies including Cohen and Klepper (1996) and Klepper (1996) that argue that firm size has a positive impact on innovation activities.

Table 3: Estimation Results of Equation (1)

		Tobit model Dependent variable: R&D expenditures (million JPY)					
		(1-a)		(1-b)		(1-c)	
Market expansion		8275.22	**	8124.01	**	8135.44	**
	(s.e.)	(4020.59)		(4012.51)		(3965.68)	
Technology acquisition	Buyout	15914.05	**	16204.31	**	19139.71	***

	(s.e.)	(7053.88)		(6984.60)		(6625.08)	
	R&D outsourcing	-2149.15		-2395.67			
	(s.e.)	(4546.19)		(4529.89)			
	Purchase of equipment etc.	-2119.86		-1931.71			
	(s.e.)	(4211.06)		(4182.13)			
	Company split-up	39097.56	***	39021.40	***	40387.06	***
	(s.e.)	(9164.63)		(9152.60)		(8811.41)	
	Licensing contract	828.84		848.65			
	(s.e.)	(5234.19)		(5219.32)			
	Open-source	13447.71	**	13000.43	**	14746.31	***
	(s.e.)	(5648.86)		(5619.70)		(5167.44)	
	Consortium	5190.82		5197.15			
	(s.e.)	(6238.81)		(6204.72)			
	Alliance	7539.55		7107.43			
	(s.e.)	(5582.68)		(5529.69)			
	Accepting researchers etc.	2857.23		2606.04			
	(s.e.)	(5195.53)		(5184.03)			
Information	Enterprise group etc.	-185.12		-609.43			
	(s.e.)	(4735.60)		(4720.39)			
	Suppliers	-2704.37		-3352.89			
	(s.e.)	(4016.86)		(3949.60)			
	Consumers or clients	2703.18		3474.55			
	(s.e.)	(4467.36)		(4417.88)			
	Competitors	1218.17		1059.49			
	(s.e.)	(4205.58)		(4188.76)			
	Private research institutes etc.	1655.63		1186.53			
	(s.e.)	(4536.11)		(4480.14)			
	Universities etc.	1234.78		1885.10			
	(s.e.)	(5068.91)		(5022.86)			
	Public research institutes	3732.63		3876.83			

	(s.e.)	(5142.44)		(5120.27)			
	Academic conference etc.	-5991.11		-5729.08			
	(s.e.)	(5087.50)		(5045.53)			
	Professional publications etc.	2075.06		1701.04			
	(s.e.)	(4976.04)		(4932.46)			
	Exhibitions etc.	-5902.77		-5369.79			
	(s.e.)	(4606.41)		(4568.37)			
	Patent information	5822.03		6718.57			
	(s.e.)	(4691.64)		(4613.64)			
Firm size	Middle	5153.42		6686.65		5862.78	
	(s.e.)	(7529.56)		(7370.43)		(7303.05)	
	Large	9945.24		11271.57	*	12464.83	*
	(s.e.)	(6957.73)		(6783.30)		(6600.65)	
Number of competitors		179.30		123.38		116.50	
	(s.e.)	(248.80)		(243.08)		(241.18)	
Product differentiation		-1118.27		-1771.30		-2960.48	
	(s.e.)	(4078.83)		(4049.63)		(3957.21)	
Public financial support		7638.40	*	7543.09	*	9736.94	**
	(s.e.)	(4554.47)		(4488.56)		(4027.41)	
Industry dummies		Yes		No		No	

Notes: ***, **, *indicate that the estimate is significant at 1%, 5% and 10% respectively.

Table 4 shows the estimates in Equation (2). Specification (2-a) includes all regressors discussed in Section 4.1. Interestingly, R&D expenditures do not have any significant impact on the achievement of new-to-market product innovation. This result does not agree with Duguet (2006), which finds a positive impact of firm's formal R&D on radicalness. One reason for this is that Duguet (2006) does not fully control for the effect of demand and technological opportunity as we do in this analysis. This point leads to an issue of identification; the estimated coefficient on R&D in Duguet (2006) might be confounded by the effect of other factors. While we do not find any positive impact of the market expansion on innovation novelty, some coefficients of technology acquisition and information are significantly estimated. In particular, technology acquisition through accepting new researchers and information from universities seem to positively affect innovation novelty, the latter of which is consistent with Hypothesis 6. Similarly to the existing results, universities seem influential information sources for novel innovation. Lastly, public financial support does not have any significant impact on novel innovation, which rejects Hypothesis 8. This might be partly because non-financial factors, including the utilization of information from universities, are essential for novel innovation as described in Section 3.3.3.

Specification (2-b) and (2-c) omit industry dummies and technological factors whose coefficients are estimated insignificant in (2-a). Basic implications from the results are the same as those from (2-a).

Table 4: Estimation Results of Equation (2)

		Probit model Dependent variable: Innovation novelty		
		(2-a)	(2-b)	(2-c)
R&D expenditures		5.04E-06	5.46E-06	8.07E-06
	(s.e.)	(5.24E-06)	(5.19E-06)	(4.97E-06)
Market expansion		0.01	-0.02	0.03
	(s.e.)	(0.13)	(0.13)	(0.12)
Technology acquisition	Buyout	0.39	0.37	
	(s.e.)	(0.24)	(0.24)	
	R&D outsourcing	0.13	0.12	
	(s.e.)	(0.14)	(0.14)	
	Purchase of equipment etc.	-0.05	-0.07	
	(s.e.)	(0.13)	(0.13)	
	Company split-up	-0.46	-0.49	
	(s.e.)	(0.34)	(0.34)	
	Licensing contract	0.19	0.17	
	(s.e.)	(0.17)	(0.16)	
	Open-source	0.06	0.07	
	(s.e.)	(0.19)	(0.19)	
	Consortium	0.28	0.25	
	(s.e.)	(0.20)	(0.20)	
	Alliance	0.18	0.14	
	(s.e.)	(0.18)	(0.18)	

	Accepting researchers etc.	0.29	*	0.28	*	0.33	**
	(s.e.)	(0.17)		(0.16)		(0.16)	
Information	Enterprise group etc.	0.24		0.21			
	(s.e.)	(0.15)		(0.15)			
	Suppliers	-0.11		-0.07			
	(s.e.)	(0.13)		(0.12)			
	Consumers or clients	0.12		0.09			
	(s.e.)	(0.14)		(0.14)			
	Competitors	-0.16		-0.17			
	(s.e.)	(0.13)		(0.13)			
	Private research institutes etc.	-0.09		-0.15			
	(s.e.)	(0.15)		(0.14)			
	Universities etc.	0.39	**	0.34	**	0.32	**
	(s.e.)	(0.16)		(0.16)		(0.15)	
	Public research institutes	-0.40	**	-0.34	**	-0.33	**
	(s.e.)	(0.16)		(0.16)		(0.15)	
	Academic conference etc.	-0.15		-0.11			
	(s.e.)	(0.16)		(0.16)			
	Professional publications etc.	-0.25		-0.26	*	-0.26	*
	(s.e.)	(0.16)		(0.16)		(0.14)	
	Exhibitions etc.	0.02		0.02			
	(s.e.)	(0.15)		(0.14)			
	Patent information	0.28	*	0.30	**	0.29	**
	(s.e.)	(0.15)		(0.15)		(0.14)	
Firm size	Middle	-0.08		-0.02		-0.02	
	(s.e.)	(0.23)		(0.23)		(0.22)	
	Large	-0.35		-0.25		-0.19	
	(s.e.)	(0.22)		(0.21)		(0.20)	
Product differentiation		0.18		0.14		0.13	
	(s.e.)	(0.13)		(0.13)		(0.12)	

Public financial support		-0.11	-0.02	0.00
	(s.e.)	(0.15)	(0.14)	(0.14)
Industry dummies		Yes	No	No
Exogeneity test	(Wald)	0.01	0.02	0.29

Notes: ** and *indicate that the estimate is significant at 5% and 10% respectively.

Table 5 reports the estimate coefficients in Equation (3) and (4).[19] Specification (3-a) and (4-a) include all regressors discussed in Section 4.1 except for firm's R&D expenditures and industry dummies.[20] On the other hand, specification (3-b) and (4-b) additionally omit technological factors whose coefficients are estimated insignificant.

First of all, innovation novelty has a significant positive impact on both legal and non-legal protection. The estimated coefficients are almost the same between them, which means that a firm with novel product innovation is *not* more likely to use legal protection relative to non-legal one. Hence, we cannot reject Hypothesis 7. As for other variables, some technological factors positively affect both on legal and non-legal protection. Looking at (3-a), technology acquisition through public research institutes and through professional publications seem to have a positive impact. However, this is not robust compared with (3-b). These variables are estimated to be positive in (4-a), too, and technology acquisition through public research institutes is also significantly estimated in (4-b).

Table 5: Estimation Results of Equations (3) and (4)

		Probit model							
	Dependent variable:	Legal protection				Nonlegal protection			
		(3-a)		(3-b)		(4-a)		(4-b)	
Innovation novelty		2.10	***	2.07	***	2.11	***	2.09	***
	(s.e.)	(0.07)		(0.07)		(0.09)		(0.08)	
Market expansion		0.00		-0.03		0.00		0.01	
	(s.e.)	(0.10)		(0.10)		(0.10)		(0.11)	
Technology acquisition	Buyout	-0.29				-0.30	*	-0.20	
	(s.e.)	(0.17)				(0.18)		(0.20)	
	R&D outsourcing	-0.09				-0.09			

[19] Unfortunately, the effectiveness of instruments is rejected for (3-a), (3-b) and (4-b), which is remained continuously as a future issue

[20] We omit these variables for avoiding a convergence problem.

	(s.e.)	(0.11)				(0.11)			
	Purchase of equipment etc.	0.05				0.08			
	(s.e.)	(0.10)				(0.11)			
	Company split-up	0.28				0.34			
	(s.e.)	(0.23)				(0.24)			
	Licensing contract	-0.11				-0.11			
	(s.e.)	(0.13)				(0.15)			
	Open-source	-0.10				-0.08			
	(s.e.)	(0.14)				(0.14)			
	Consortium	-0.18				-0.21			
	(s.e.)	(0.15)				(0.16)			
	Alliance	-0.09				-0.07			
	(s.e.)	(0.14)				(0.20)			
	Accepting researchers etc.	-0.18				-0.22	*	-0.20	
	(s.e.)	(0.14)				(0.13)		(0.14)	
Information	Enterprise group etc.	-0.17				-0.13			
	(s.e.)	(0.12)				(0.14)			
	Suppliers	0.05				0.04			
	(s.e.)	(0.10)				(0.10)			
	Consumers or clients	-0.05				-0.04			
	(s.e.)	(0.11)				(0.14)			
	Competitors	0.11				0.09			
	(s.e.)	(0.10)				(0.13)			
	Private research institutes etc.	0.09				0.10			
	(s.e.)	(0.11)				(0.12)			
	Universities etc.	-0.20				-0.24			
	(s.e.)	(0.14)				(0.15)			
	Public research institutes	0.26	**	0.17		0.31	*	0.29	*
	(s.e.)	(0.13)		(0.12)		(0.17)		(0.15)	
	Academic conference etc.	0.12				0.10			
	(s.e.)	(0.12)				(0.12)			

	Professional publications etc.	0.22	*	0.15		0.22	*	0.18	
	(s.e.)	(0.12)		(0.11)		(0.13)		(0.12)	
	Exhibitions etc.	0.01				0.01			
	(s.e.)	(0.11)				(0.11)			
	Patent information	-0.16				-0.22			
	(s.e.)	(0.14)				(0.13)			
Firm size	Middle	0.10		0.16		0.01		-0.03	
	(s.e.)	(0.20)		(0.19)		(0.18)		(0.18)	
	Large	0.30		0.33	*	0.19		0.13	
	(s.e.)	(0.20)		(0.20)		(0.16)		(0.17)	
Product differentiation		-0.11		-0.11		-0.10		-0.04	
	(s.e.)	(0.10)		(0.10)		(0.10)		(0.11)	
Public financial support		0.01		-0.03		0.01		-0.03	
	(s.e.)	(0.11)		(0.11)		(0.11)		(0.11)	
Industry dummies		No		No		No		No	
Exogeneity test	(Wald)	8.54	***	31.34	***	1.58		9.17	***

Notes: ***, **, *indicate that the estimate is significant at 1%, 5% and 10% respectively.

Table 6 reports the estimates in Equation (5). We omit technological variables because otherwise all of them are estimated to be insignificant.[21] Specification (5-a) and (5-b) include logarithms of acquisition of tangible fixed assets and of the number of workers in R&D with and without industry dummies, and specification (5-c) and (5-d) do not take the logarithm of them.

Looking at (5-a), novel product innovation has a significant positive effect on the sales of a new product, which is consistent with Hypothesis 1 and implies that new-to-market product innovation help a firm avoid severe competition with homogenous products. On the other hand, the coefficient of legal protection is estimated to be negative. Legal means for protecting innovation benefit is not associated with firm performance in terms of innovative sales here. Other estimates show that a firm with many employees, R&D workers and tangible fixed assets tends to achieve product innovation with large sales.

(5-b) is very similar to (5-a) except that the coefficient of public financial support is

[21] Hence, Hypothesis 5 is not supported here. At least, we cannot find evidence that technology acquired through consortia directly affects the sales of a new product.

estimated to be significantly negative. However, it is likely that this estimate captures some differences in market environment because (5-b) omits industry dummies. Finally, (5-c) and (5-d) are not so different from (5-a) but Sargan tests do not support them.

Table 6: Estimation Results of Equation (5)

		Linear model Dependent variable: Sales of a new product (logarithm)							
		(5-a)		(5-b)		(5-c)		(5-d)	
Innovation novelty		1.26	*	1.26		0.95		0.94	
	(s.e.)	(0.73)		(0.78)		(0.72)		(0.77)	
Legal protection		-2.13	***	-2.19	***	-0.28		-0.28	
	(s.e.)	(0.82)		(0.83)		(0.74)		(0.73)	
Nonlegal protection		1.10		1.47		1.49		1.78	*
	(s.e.)	(0.95)		(1.01)		(0.92)		(0.98)	
Market expansion		0.21		0.21		0.53	***	0.54	***
	(s.e.)	(0.19)		(0.19)		(0.18)		(0.18)	
Firm size	Middle	1.20	***	1.13	***	1.73	***	1.71	***
	(s.e.)	(0.38)		(0.38)		(0.37)		(0.38)	
	Large	2.04	***	2.00	***	3.47	***	3.45	***
	(s.e.)	(0.42)		(0.41)		(0.40)		(0.40)	
Product differentiation		0.04		0.06		-0.08		-0.09	
	(s.e.)	(0.19)		(0.19)		(0.18)		(0.19)	
Public financial support		-0.22		-0.34	*	-0.33	*	-0.44	**
	(s.e.)	(0.20)		(0.20)		(0.20)		(0.20)	
Acquisition of tangible	[logarithm]	0.28	***	0.31	***				
fixed assets	(s.e.)	(0.06)		(0.06)					
	[non-logarithm]					1.07E-05	***	1.09E-05	***
	(s.e.)					(2.78E-06)		(2.83E-06)	
# of workers in R&D	[logarithm]	0.58	***	0.55	***				
	(s.e.)	(0.09)		(0.09)					
	[non-logarithm]					1.14E-04	*	1.12E-04	
	(s.e.)					(6.75E-05)		(6.95E-05)	
Industry dummies		Yes		No		Yes		No	
Exogeneity test	(Sargan)	26.04		24.32		35.80	**	32.16	**

Notes: ***, **, *indicate that the estimate is significant at 1%, 5% and 10% respectively.

Table 7 shows the estimates in Equation (6). Specification (6-a) and (6-b) adopts the specification in Section 4.1.2 with and without industry dummies, and specification (6-c) and (6-d) take the logarithm of the sales of a new product.

As for (6-a), the sales of a new product has a significant negative effect on that of existing products. This result is consistent with the view that a new product *cannibalizes* a part of the firm's existing products, which is consistent with Hypothesis 2. In contrast, the coefficient of the cross term of innovation novelty with the sales of a new product is significantly positive and nearly cancel out the cannibalization term. Hence, we can interpret it as saying that the cannibalization effect is reversed with innovation novelty, which is consistent with Hypothesis 3.

(6-b) is the almost same as (6-b). As for (6-c) and (6-d), the coefficients of the sales of a new product and the cross term are estimated to be insignificant although their signs are the same with those of (6-a).

Table 7: Estimation Results of Equation (6)

		Linear model Dependent variable: Sales of existing products (logarithm)							
		(6-a)		(6-b)		(6-c)		(6-d)	
Innovation novelty		-0.03		-0.05		-0.09		-0.11	
	(s.e.)	(0.09)		(0.09)		(0.35)		(0.36)	
Sales of a new product		-1.12E-05	**	-1.21E-05	**				
	(s.e.)	(5.55E-06)		(5.72E-06)					
	[logarithm]					-0.07		-0.08	
	(s.e.)					(0.05)		(0.05)	
Innovation novelty * sales of a new product		1.14E-05	**	1.23E-05	**				
	(s.e.)	(5.74E-06)		(5.94E-06)					
	[logaritm]					0.02		0.02	
	(s.e.)					(0.06)		(0.06)	
Total sales	[logarithm]	0.99	***	1.00	***	1.02	***	1.03	***
	(s.e.)	(0.02)		(0.02)		(0.03)		(0.03)	
Firm size	Middle	0.04		0.03		0.07		0.07	
	(s.e.)	(0.06)		(0.06)		(0.06)		(0.06)	
	Large	0.03		0.02		0.10		0.09	
	(s.e.)	(0.08)		(0.08)		(0.07)		(0.07)	
Industry dummies		Yes		No		Yes		No	
Exogeneity test	(Sargan)	24.38		22.17		29.51		27.09	

Notes: *** and ** indicate that the estimate is significant at 1% and 5% respectively.

Finally, Table 8 shows the estimates in Equation (7). We omit technological variables because otherwise all of them are estimated to be insignificant. Specification (7-a) and (7-b) include logarithms of acquisition of tangible fixed assets and of the number of workers in R&D with and without industry dummies, and specification (7-c) and (7-d) do not take the logarithm of them.

For all specifications, the coefficient of innovation novelty is estimated to be significantly positive. This implies that a firm with new-to-market product innovation is more likely to provide its technology through open-sourcing or consortia, which is consistent with Hypothesis 4. Hence, we can say novel product innovation is associated with technological spillovers through channels which are less likely to accompany monetary compensation.

Table 8: Estimation Results of Equation (7)

		Linear model Dependent variable: Technology provision through open-source or consortia							
		(7-a)		(7-b)		(7-c)		(7-d)	
Innovation novelty		2.29	**	2.09	**	2.52	**	2.25	**
	(s.e.)	(0.93)		(0.82)		(1.23)		(1.04)	
Legal protection		-1.11		-1.01		-1.17		-1.05	
	(s.e.)	(1.06)		(0.97)		(1.12)		(1.00)	
Nonlegal protection		0.28		0.58		0.28		0.63	
	(s.e.)	(0.98)		(0.98)		(1.07)		(1.08)	
Market expansion		-0.04		-0.03		-0.03		-0.02	
	(s.e.)	(0.12)		(0.11)		(0.13)		(0.12)	
Firm size	Middle	0.19		0.13		0.20		0.16	
	(s.e.)	(0.30)		(0.27)		(0.35)		(0.33)	
	Large	0.53		0.41		0.60		0.48	
	(s.e.)	(0.38)		(0.31)		(0.50)		(0.43)	
Product differentiation		-0.10		-0.09		-0.12		-0.10	
	(s.e.)	(0.12)		(0.12)		(0.14)		(0.13)	
Public financial support		0.17		0.08		0.19		0.09	
	(s.e.)	(0.15)		(0.12)		(0.17)		(0.14)	
Acquisition of tangible	[logarithm]	-0.02		0.00					

fixed assets	(s.e.)	(0.04)	(0.04)		
	[non-logarithm]			-8.14E-07	-2.77E-07
	(s.e.)			(2.16E-06)	(1.91E-06)
# of workers in R&D	[logarithm]	0.05	0.02		
	(s.e.)	(0.08)	(0.08)		
	[non-logarithm]			6.20E-06	2.59E-07
	(s.e.)			(4.74E-05)	(4.40E-05)
Industry dummies		Yes	No	Yes	No
Exogeneity test	(Sargan)	7.65	9.20	6.30	8.06

Notes: ** indicates that the estimate is significant at 5%.

5. Conclusion

This paper conducts empirical analyses focusing on new-to-market product innovation. After proposing the hypotheses related to novelty in terms of firm performance, technological spillovers and the characteristics of novel innovators, we test them by an econometric analysis based on a comprehensive innovation model like CDM.

As a whole, our results are consistent with the hypotheses. As for firm performance, we examine the relationship between novel product innovation and firm's sales of a new product and of existing products. A firm with novel product innovation tends to achieve large sales from a new product especially in the high percentile, and is less likely to suffer from the cannibalization effect. The technology from a firm with new-to-market innovation spills out to other firms through channels which are less likely to be accompanied by monetary compensation including consortia.

Considering that new-to-market product innovation significantly improves firm performance and is associated with technological spillovers, policy intervention promoting it can work well. Our results show that a firm with novel innovation is more likely to use information from universities, and that it does not necessarily use legal protection actively. In addition, public financial support does not necessarily stimulate novel product innovation especially for small firms. It implies that for creating novel product innovation, non-financial policy means such as growing persons who can help interrelation between firms and universities are of importance.

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