New-to-Market Product Innovation and Firm Performance: Using Innovation Survey from Japan

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What motivate this research?

Using the Community Innovation Survey, we shed light on the nature of product innovation on the following aspects:

1. Does product innovation contribute to firm profitability?
2. Does product innovation exhibit technological spillovers?

We use the Innovation Survey conducted in Japan to answer these questions.

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Preview of the Results

1. Product innovation indeed contributes to firm profitability.
   – Total sales increase, more than making up for a decrease from cannibalization with existing goods.
2. Product innovation exhibits technological spillovers.
   – The roles of university and patent appears important in invigorating product innovation, which are synergetic to other firms.

This paper reports evidence consistent with the presence of market failure in the creation of product innovation.

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Community Innovation Survey

- Firm-level survey based on a standardized format, originating from Yale survey (Levin, Klevorick, Nelson, and Winter, 1983), developed by Carnegie-Mellon Survey (Cohen, Nelson, and Walsh, 1994), and now guided by the OECD (based on the Oslo Manual).
  – Focuses on firms innovation activities and their outcomes.
  – Designed to allow for international comparability in survey results.
- EU did the first survey in 1993, and on a regular basis after 2005.
- Approximately 50 countries have adopted this format to conduct a survey.
  – Korea conducts the survey every three years since 2003.
  – Japan (NISTEP under the MEXT) did in 2003, 2009, and 2013.

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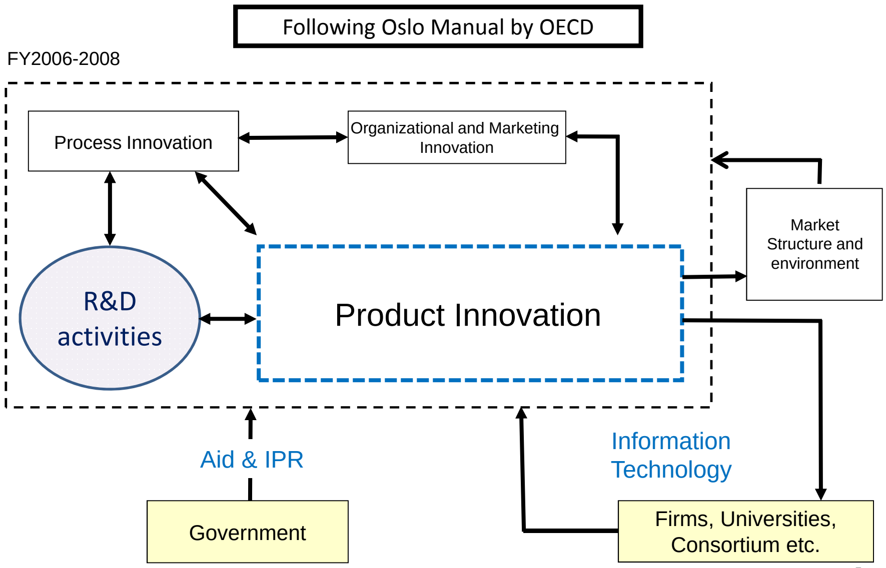
Japanese National Innovation Survey



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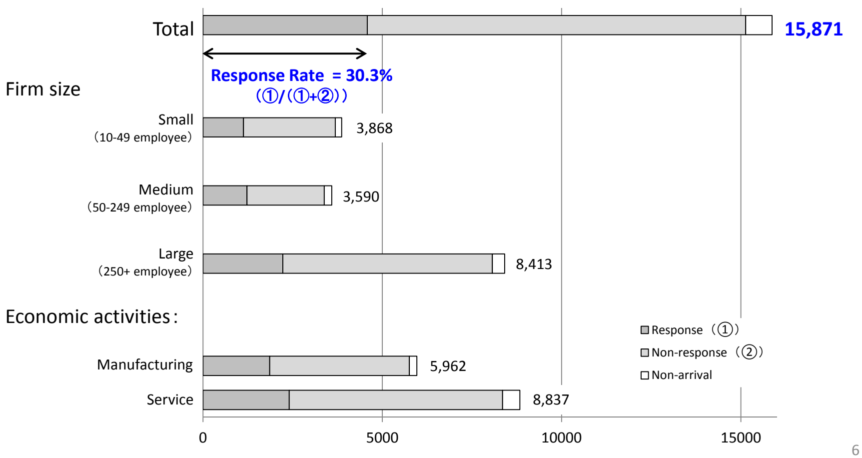
Sample Summary from JNIS

Strata : Firm Size and Economic Activities
Sampling methods : Stratified Random Sampling



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Important Survey Questions and Caveats

Product innovation

- "During FY2006-2008, did your firm introduce new good(s) or service(s) into your market? New goods or new services include not only goods or services with new functions, performance characteristics, design, raw materials, components and applications, but also existing goods or services with more advanced technologies." (Q3)

⇒ The data do not identify multiplicity of innovations.

"New-to-Market" (in contrast to "New-to-Firm") Product Innovation

- "During FY2006-2008, did your firm introduce any new product innovations into the your markets before your competitors?" (Q2)

⇒ The data classify two types of product innovation, according to the degree of novelty. We are interested in "new-to-market."

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Examples

Product Innovation

- Portable Audio Player
  - Walkman (SONY, 1979)
  - iPod (Apple, 2001)
- Blu-ray DVD Recorder
  - BDZ-S77 (SONY, 2003)
- Organic LED TV
  - XEL-1 (SONY, 2007)
- Motor-assisted Bicycle
  - PAS (YAMAHA MOTOR CO., 1993)





Process Innovation

- Rechargeable Contactless Smart Card Ticketing System
  - SUICA (JR EAST, 2001), ICOCA(JR WEST, 2003), PASMO (Tokyo Metro, 2007)
- Cloud Computing
  - Amazon Web Services, Windows Live, Google App Engine

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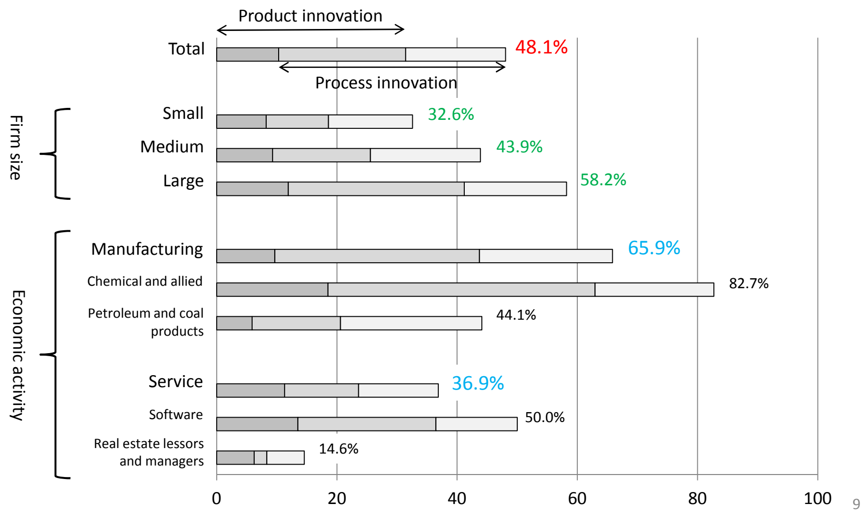
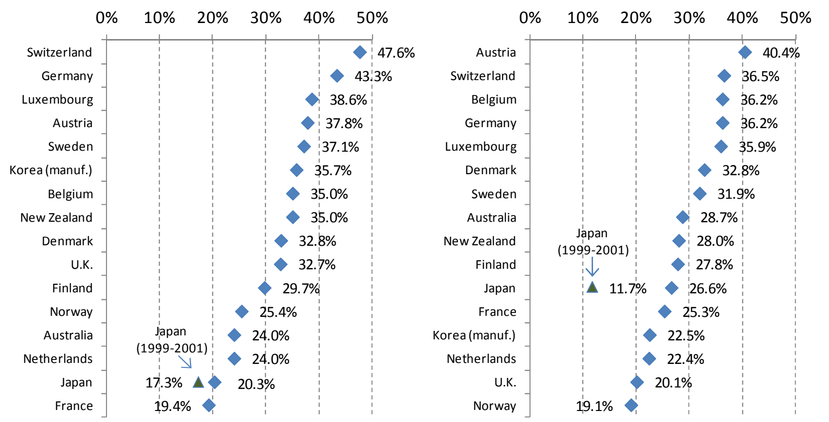
%Innovations by firm size and industry

Reference Period : FY2006-2008



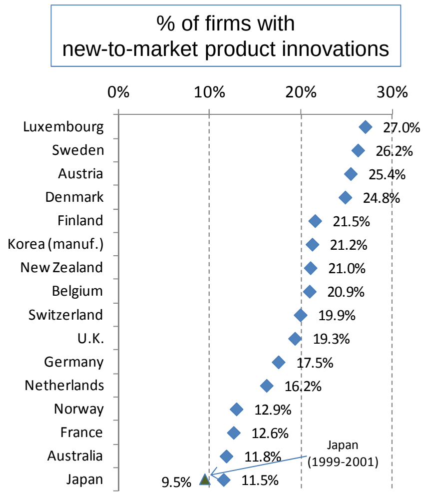
%Innovations in international scale

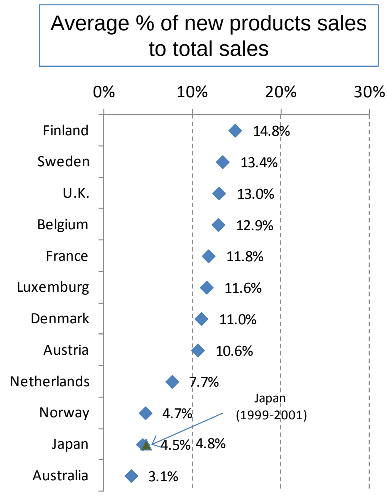


OECD(2009), *Innovation in Firms*, OECD publishing

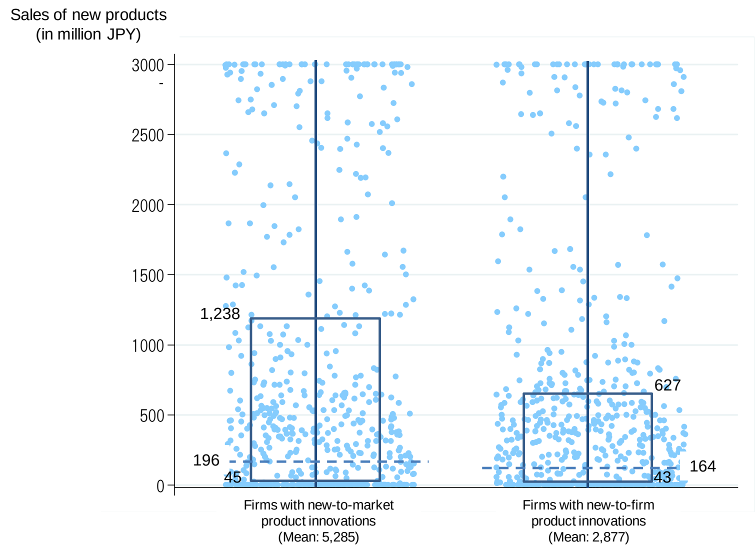
* Japan: 2006-2008, Switzerland: 2003-2005, Australia and New Zealand: 2004-2005, Others: 2002-2004.
* % of innovations is adjusted by considering differences in firm-size distribution by country.

Novelty and Sales in international scale

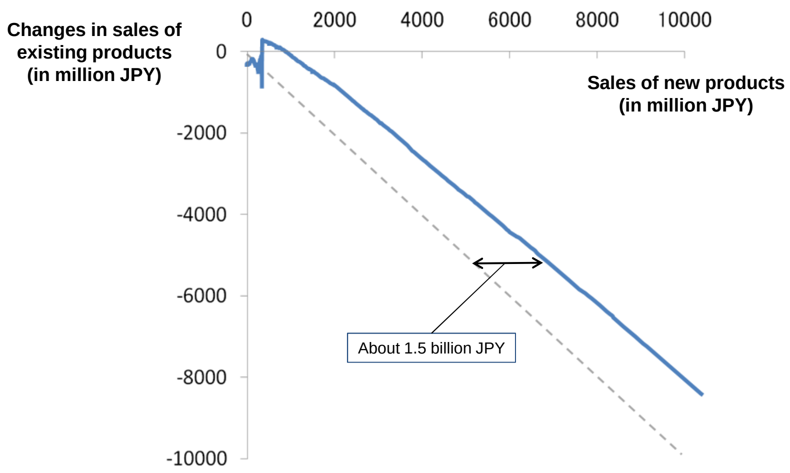




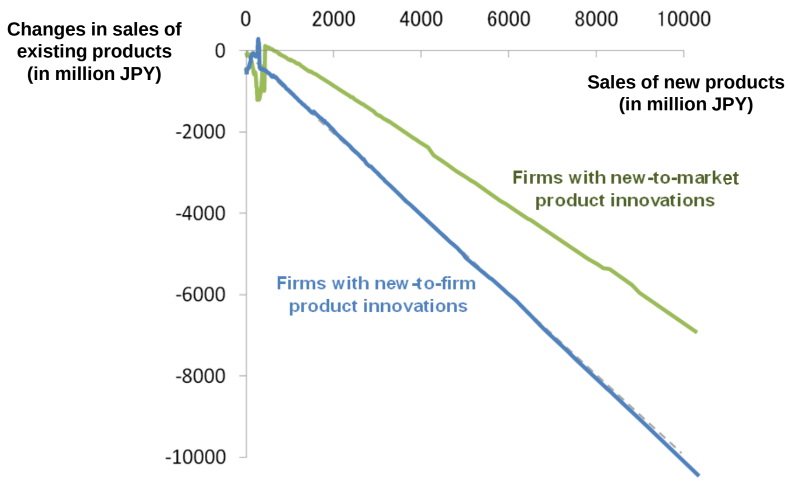
Novelty and Sales



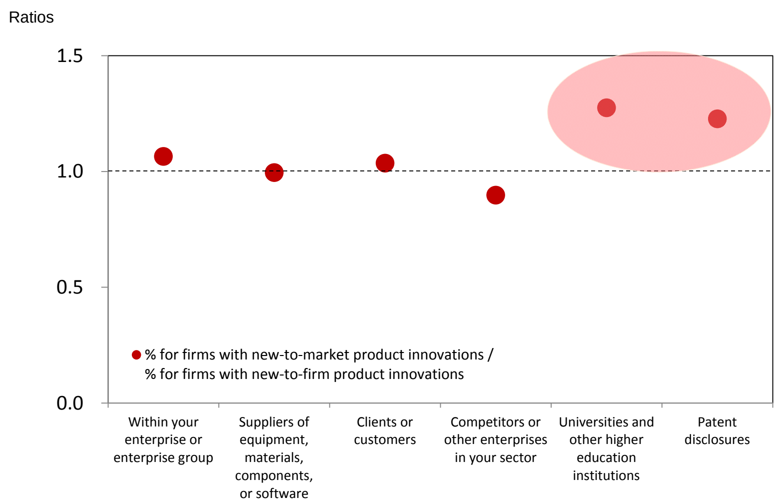
Sales of New and Old Goods



"New to market" and "New-to-Firm"



Information Sources



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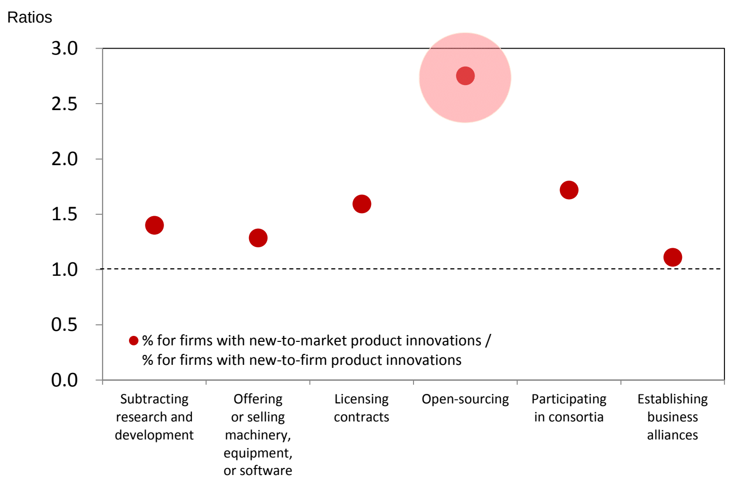
Technology Transfer



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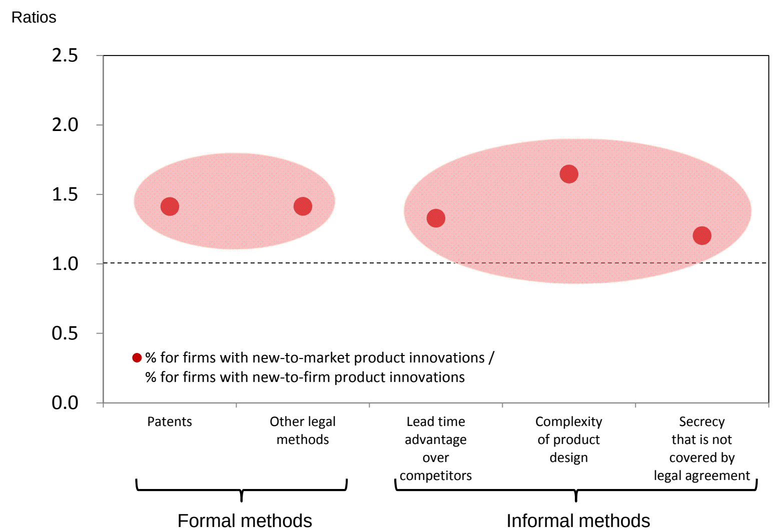
How to Appropriate Innovation Outcome



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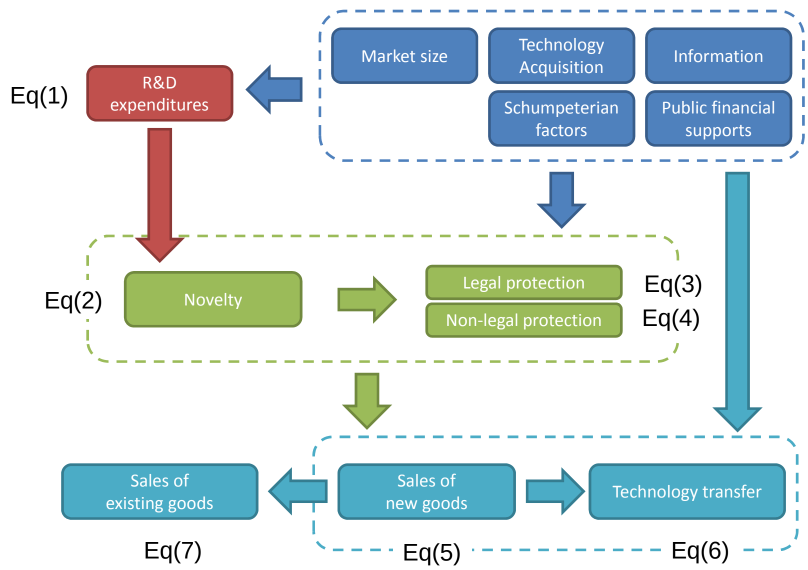
Overview of Econometric Model



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Further Research

- This paper finds that “new-to-market” product innovation improves firm profitability, and exhibits technological spillovers.
- The CIS provides information on product market rivalry, which is another dimension of externality (e.g., Bloom, Schankerman, van Reenen, 2013).
- The CIS also provides information on public subsidy status, which may enable us to assess to what extent market failure is corrected, and whether and how government failure is present.

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Thank you for your attention

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New-to-market product innovation and firm performance: Using innovation survey from Japan

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Abstract

This study evaluates the economic impact of new-to-market product innovation in Japan by using firm-level data obtained from the Community Innovation Survey conducted in Japan. It accounts for possible technological spillovers from innovation activities, and examines the extent to which new-to-market product innovation contributes to firm performance. Casual observations from the data reveals that new-to-market product innovation are likely to contribute higher sales for the firm with less cannibalization with existing products, generate higher degree of technological spillovers to other innovations, and be brought by firms that corroborate with universities and other academic institutions. An econometric analysis on simultaneous equations confirms these observations.

Keywords: Product innovation; Novelty; Spillovers; Innovation survey

JEL classification: C36; O31; O33; O38

1. Introduction

Product innovation is, by definition, deemed novel, but the degree of novelty differs by product (e.g., Arundel and Hollanders, 2005). The OECD (1992, 1996, and 2005) classifies a 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 type should be newer and more drastic than the former (OECD, 2009), and thus is called new-to-market product innovation in this paper. The concept of new-to-market product innovation sheds new insights on the existing literature in two folds. First, new-to-market product innovation may contribute in a greater extent to firm performance, as it can provide a firm with temporary market power (Petrin, 2002). Second, new-to-market product innovation may exhibit technological spillovers for innovation activities of other firms, a research topic which has attracted much attention in both theoretical and empirical studies.[1] For example, recent studies of 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 play an important role. If new-to-market product innovation results in significantly positive spillovers, a policy to promote such innovation can be beneficial from a social welfare point of view (Spence, 1984).

This study quantitatively examines the nature of new-to-market product innovation, in order for us to understand its contribution to firm performance, and its possible need for public policy. We use firm-level data obtained from the Japanese National Innovation Survey (JNIS). We propose an econometric model that comprises technological spillovers, legal protection measures, and other important variables relevant to new-to-market product innovation. Our model is reminiscent of that proposed by Crépon et al. (1998) (CDM); however, we address possible endogeneity in our estimation, the issue that is largely neglected in CDM.

Despite its economic importance, few empirical studies focus on the novelty of a firm's product innovation. To the best of our knowledge, Duguet (2006) is an exception. The present study differs from Duguet (2006) in three important ways. First, Duguet (2006) crudely lumps together product and process innovations into one basket, even though the underlying economics between these innovations work differently (e.g., Klepper, 1996). Rather we focus solely on product innovation to make our analysis and its interpretation clear.

Second, we use sales as a measure of firm performance, rather than productivity. It has been argued that productivity may not be an appropriate measure to assess product innovation (e.g., Van Leeuwen and Klomp, 2006, De Loecker, 2011). Third, we utilize technology outflow, as well as inflow, in order to capture the influence of technological spillovers, whereas existing studies including that by Duguet (2006) focus only on the inflow of technology. Incorporating technology outflow provides us with an unbiased picture of technological spillovers in the context of JNIS.

The rest of this paper is organized as follows. Section 2 provides an overview of the various approaches to the measurement of the economic outcomes of innovation, and describes the data set used in the study. Section 3 proposes eight hypotheses related to new-to-market product innovation. Section 3.1 is dedicated to firm performance, Section 3.2 to technological spillovers, and Section 3.3 to the characteristics of a novel innovator. Section 4 formulates and estimates an econometric model to test the formulated hypotheses. Section 5 concludes.

2. Approaches to Evaluating Innovation Outcomes

Demand estimation, patent data and R&D data analyses are three primary quantitative approaches

[1] Arrow (1962) points out that an innovating firm cannot appropriate the outcome of its innovation activities owing to inherent technological spillovers. Accordingly, many researchers have tried to quantify spillovers, especially in terms of the social rate of return on R&D investment, as discussed in Griliches (1992).

commonly used to measure economic outcomes accrued by product innovation. Demand estimation has been performed on various new products such as computed tomography scanners (Trajtenberg, 1989) and minivans in the automobile market (Petrin, 2002). This method has an advantage of evaluating the impact of product innovation on consumer surplus. Under the category of the second approach that uses patent data, studies such as those presented by Pakes (1986) and Schankerman (1998) estimate the value of patents, an intermediate input in the overall innovation process. Finally, among the works that have utilized R&D data are studies that estimate the social rate of return on R&D investment (Griliches, 1992).[2] However, while R&D data have an advantage of quantifying the economic impact, R&D investment only accounts for a proportion of a firm's innovation activities (Mairesse and Mohnen, 2010). As pointed by Arundel et al. (2008), many firms conduct innovation activities without reporting their R&D expenditures.[3]

Turning to inputs, the program evaluation technique is popular for exploring innovation policy (see, for example, Almus and Czarnitzki (2003) and González et al. (2005), which focus on R&D subsidies). While this technique helps solve the endogeneity problem of subsidy assignment, however, it ignores how these subsidies affect other firms through spillovers. This shortcoming has fostered a recent trend of empirical studies using innovation surveys based on the Oslo Manual (Mairesse and Mohnen, 2010), which offer a wide range of information on a firm's innovation activities and their outcomes including innovation novelty.

JNIS follows the Oslo Manual, and has a basis on the survey conducted in the period from April 1, 2006 to March 31, 2009. By using the stratified sampling, surveyed firms are selected among those listed in the Establishment and Enterprise Census 2006, which is conducted by the Statistics Bureau, Ministry of Internal Affairs and Communications. They are further restricted to firms with more than 10 employees that operate in the industries in Table 1. The response rate is 30.3%, corresponding to a sample of 4,579 firms. Note that questions about a firm's product innovation are asked for the market in which the firm supplies its staple goods.

Table 1: Classification of Industries in JNIS

Industry	Japan Standard Industrial Classification (Rev. 12)
Agriculture and forestry	A01–02
Fisheries	B03–04
Mining and quarrying of stones and gravel	C05
Construction	D06–08

2 Recent examples of R&D data analyses include those by Bloom et al. (2013), which focuses on the identification of spillovers, and Xu (2006), which captures the dynamic properties of R&D investment.
3 The results of JNIS 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 other countries.

Manufacturing	E09–32
Electricity, 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
Accommodation, eating and drinking services	M75–77
Compound services	Q86
Services, n.e.c.	R89

3. Hypotheses on New-to-Market Product Innovation

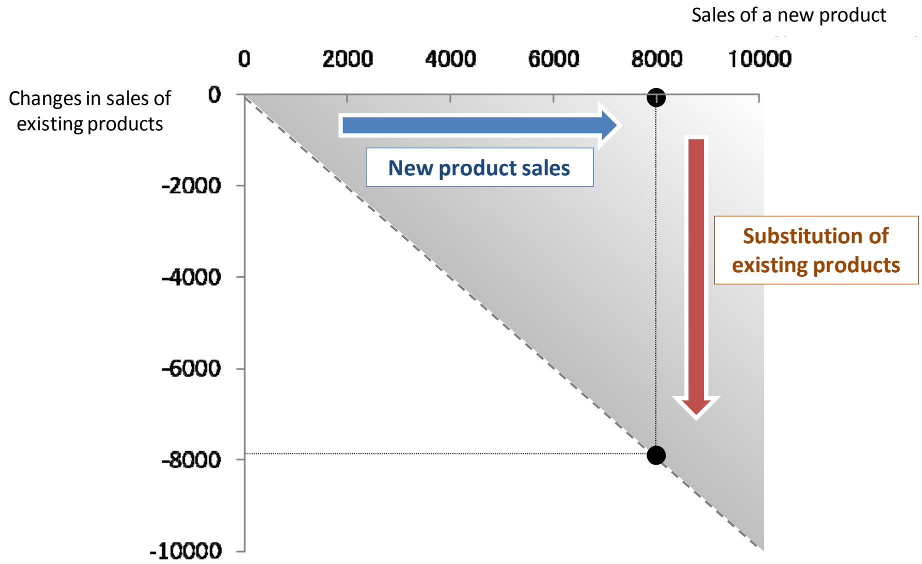
In this section, we propose eight hypotheses on new-to-market product innovation from three aspects:. In Section 3.1, we formulate hypotheses on how new-to-market product innovation influences firm performance. Section 3.2 is dedicated to hypotheses on technological spillovers in innovation activities. Lastly, Section 3.3 is associated with innovation policy, where we propose hypotheses on the characteristics of a novel innovator.

3.1. Firm Performance

To analyze French manufacturing firms, CDM conduct a three-step regression analysis that estimates the research equations, innovation equations, and productivity equations. Their results indicate that firm productivity is positively correlated with innovation output such as number of patents or share of innovation-related sales. Many researchers in several countries have since taken a CDM-like approach to analyze firm innovation, including Griffith et al. (2006) for France, Germany, Spain, and the UK and Chudnovsky et al. (2006) for Argentina. Furthermore, CDM's approach has been extended in various directions. Jefferson et al. (2006), Lööf and Heshmati (2006), and Van Leeuwen and Klomp (2006) use measures other than productivity to capture firm performance, while Duguet (2006) classifies innovations into radical and incremental ones.

In the present study, we use the sales of a new product and of existing products to measure firm performance in order to decompose product innovation into two affects. 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. The vertical axis captures the cannibalization effect, which means that the new product competes with the firm's existing products and thus reduces their sales. The net effect of product innovation on a firm's total sales, which is determined by the difference in the degree of these two effects, is shown gradationally in the figure. The net effect is zero on the 45-degree line, but this becomes positive with lighter graduation.

Figure 1: Product Innovation and Firm Sales



The sales of a new product are considered to be affected by those of existing products in the market. For new-to-firm product innovation (i.e., the introduction of a product already provided by other firms), the firm faces severe competition particularly in the market of a homogeneous product. 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 innovations can improve firm performance. Barlet et al. (1998) also indicate that innovation novelty can increase the share of innovation-related sales in situations where technology is important. Therefore, we propose the following hypothesis.

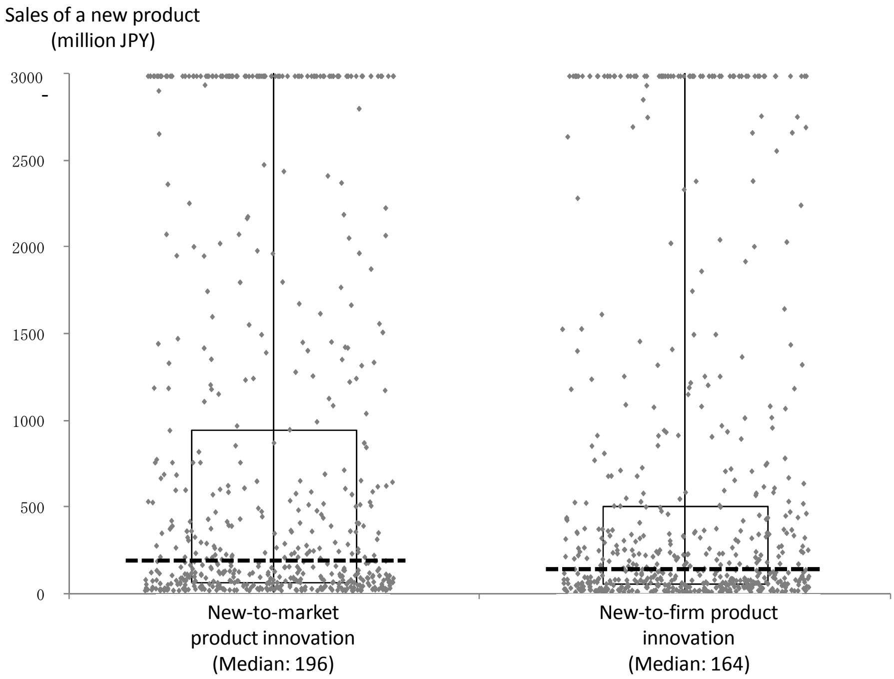
Hypothesis 1: The sales of a new product are larger for a firm with new-to-market product innovation than for one with new-to-firm product innovation on average.

According to the sales information in JNIS,[4] the average sales of a new product in FY2008 were 5,586 million JPY for a firm with new-to-market product innovation and 3,004 million JPY for other firms, which is consistent with Hypothesis 1. In addition, Figure 2 boxplots the sales of a new product for a firm with new-to-market product innovation and for one with new-to-firm product innovation. The

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

rectangle in this figure represents the interval between the 25th and 75th percentiles of sales and the dashed line represents the median. Median sales are 185 million JPY for a novel innovator and 165 million JPY for other innovators. Furthermore, the 75th percentile of sales for a novel innovator is much larger than that for other firms, which implies that some novel product innovations generate huge sales.

Figure 2: Novelty and the Sales of New Products



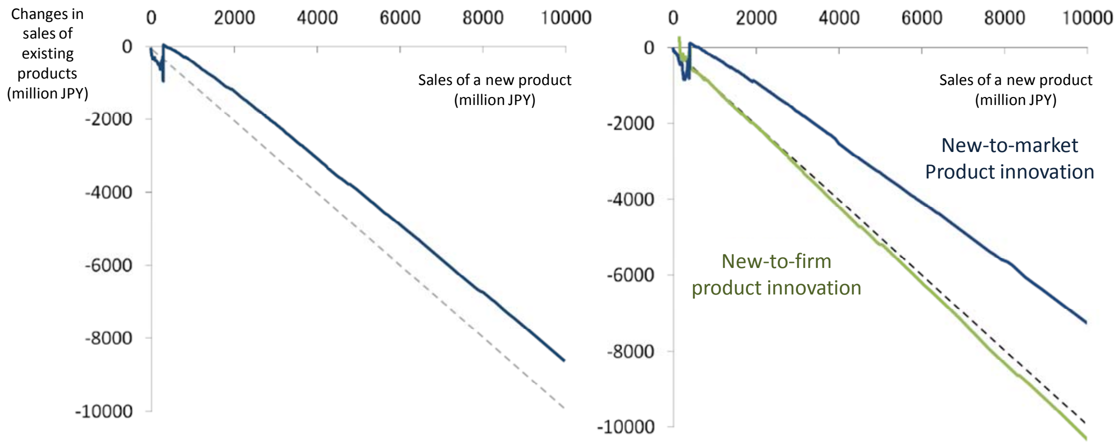
Next, we turn to the sales of an innovator's existing products. Jefferson et al. (2006) point out that innovation does not necessarily improve firm performance, and suggest that cannibalization with the firm's existing products may severely deteriorate the firm's profitability. This is expressed by the following two hypotheses.

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

Hypothesis 3: The decrease in the sales of a firm's existing products 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.

To test Hypotheses 2 and 3, we need to capture the effect of product innovation on the sales of a firm's existing products. For this purpose, we calculate changes in the sales of existing products during FY2006–FY2008. The left side of Figure 3 plots the relationship between the sales of a new product and changes in the sales of existing products.[5] Larger sales of a new product decrease those of existing products, which is consistent with Hypothesis 2. Changes in 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 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 the decrease in the sales of existing products. On the contrary, 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 an increase in the firm's total sales. These observations are consistent with Hypothesis 3. Combining the observations in Figure 2 and Figure 3 suggests that novel product innovation can increase the sales of a new product and reduce the loss of existing product sales, both of which increase a firm's total sales.

3.2. Technological Spillovers

Many researchers including Arrow (1962) have pointed out that an innovating firm cannot appropriate the outcomes of its innovation activities because of the existence of technological spillovers. In contrast to some previous studies (e.g., Bloom et al., 2013), we 3directly identify technological spillovers from information on a firm's technology acquisition (i.e., inflow) and provision (i.e., outflow). 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 spillover when making decisions on innovation activities, innovation in the private sector could be undersupplied.

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

Furthermore, some recent studies of 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 technological spillovers from firms at the technological frontier through 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.

Of the empirical studies that focus on inflow, Kaiser (2002) considers incoming spillover effects to analyze the relationship between research cooperation and research expenditures. His results indicate that horizontal spillovers lead to a firm's aggressive innovation investment through research cooperation. Similarly, Branstetter and Sakakibara (2002) examine research consortia based on the approach taken by Katz (1986), finding that spillover effects in research consortia have a positive impact on a firm's outcomes. These findings suggest the following hypothesis.

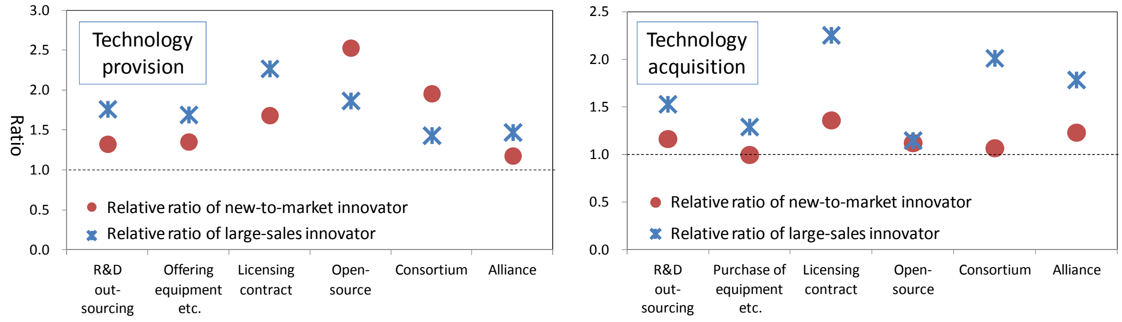
Hypothesis 5: The sales of a new product are larger for a firm that acquires technology through consortia than for one that does not on average.

Figure 4 summarizes a firm's technology acquisition and provision based on the information provided by JNIS. The 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 channel, while the snowflakes are the relative ratio of technology acquisition (or provision) for a firm with above-median product innovation to one with below-median product innovation by channel.[6] The left side of the figure is for a firm's technology provision. While above-median product innovation is associated with channels that are more likely to be accompanied by monetary compensation (e.g., 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 a firm's technology acquisition. Innovation novelty seems to have little association with technology acquisition, whereas a firm with above-median product innovation tends to acquire technology through licensing and participation in consortia, which is consistent with Hypothesis 5. By combining this observation with the results on the left side of the figure, we can suggest that participation in consortia plays a significant role in technological spillovers. Indeed, Figure 4 indicates that a firm with new-to-market product innovation provides its technology to other firms through consortia and that the spilled over technology contributes to their high sales of a new product.

[6] The median amount here relates to sales (i.e., 168 million JPY).

Figure 4: Technology Acquisition and Provision



3.3. Other Characteristics of New-to-Market Product Innovation

In this subsection, we focus on the characteristics of a firm with new-to-market product innovation from three aspects: information sources, means of protecting the innovation benefit, and public financial support. Since the previous subsections have implied that novel product innovation leads to significant improvements in firm performance and technological spillovers, public policy for encouraging a firm's new-to-market innovation should work well. To implement such a policy effectively, however, we need to know what types of firms are novel product innovators.

3.3.1. Information sources

Previous studies have examined the relationship between information sources and innovation novelty. Belderbos et al. (2004) examine the relationship between cooperative R&D and firm performance, showing 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 such contact does not necessarily result in cooperation. With a few exceptions,[7] most studies imply that information from universities positively affects innovation novelty, and thus we propose the following hypothesis.

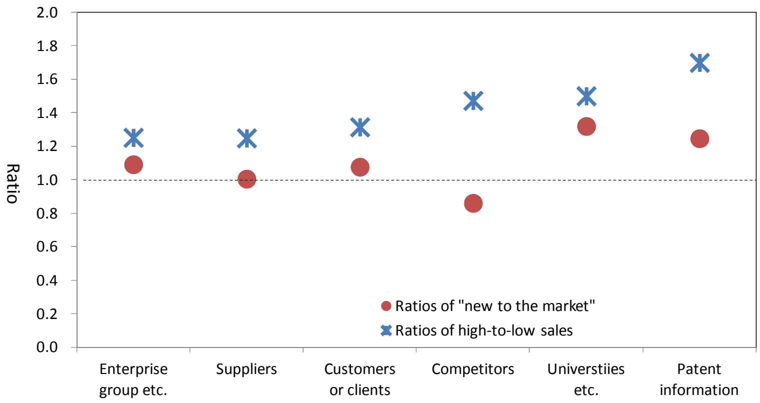
Hypothesis 6: A firm with new-to-market product innovation is more likely to obtain information from universities for its innovation activities than one with new-to-firm product innovation on average.

Figure 5 shows the utilization ratio of information sources for innovation activities. As explained above, the circles are for innovation novelty and snowflakes are for the sales of a new product. Whereas a firm with above-median product innovation aggressively uses various sources, one with new-to-market

[7] Monjon and Waelbroeck (2003) suggest that information from universities encourages innovation that is not radical. In this regard, since they also show that cooperation with foreign universities leads to radicalness, there may be some link between contact with universities and radicalness.

product innovation tends to obtain information from universities or patents held by other firms, which is consistent with Hypothesis 6.

Figure 5: Information Sources



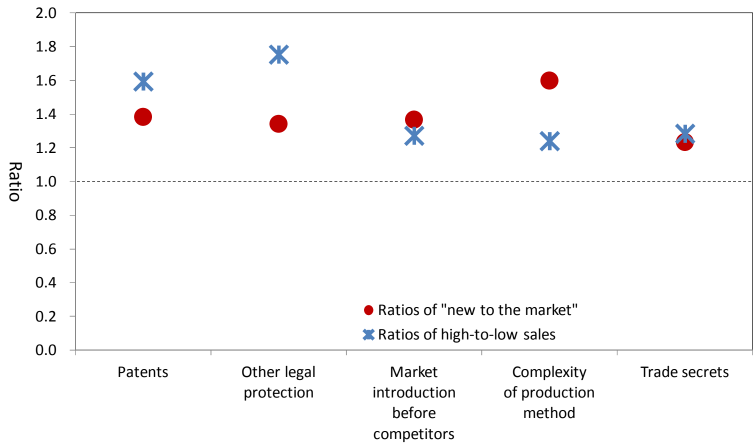
3.3.2. Means of protecting the innovation benefit

While we have already noted the difficulty of appropriating the innovation benefit, a firm can protect it by legal means such as patent protection and non-legal means such as trade secrets. Theoretically, legal means can serve to encourage a firm's innovation activities by giving it a premium for creating innovations. Among recent empirical studies, Duguet and Lelarge (2006), for example, show the effectiveness of patent protection for defending a firm's product innovation. However, legal protection cannot necessarily prevent firms from circumventing inventions (Levin et al., 1987). In particular, considering the possible positive spillovers to novel product innovation, legal means may not effectively protect the profit from the new-to-market product, which leads to the following hypothesis.

Hypothesis 7: A firm with new-to-market product innovation is no more likely to use legal protection relative to non-legal protection than one with new-to-firm product innovation on average.

Figure 6 summarizes means of protecting a firm's innovation benefit. As before, circles are for innovation novelty and snowflakes sales of a new product. While a firm with above-median innovation tends to use legal protection actively, one with new-to-market product innovation uses it only as frequently as it applies non-legal means. This finding is consistent with Hypothesis 7 and indicates that legal means may find it difficult to protect novel product innovation relative to above-median product innovation.

Figure 6: Protection Measures for the Innovation Benefit



3.3.3. Public financial support

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

Meanwhile, of the few studies of the relationship between public financial support and innovation novelty, Mohnen and Hoareau (2003) raise the possibility that contact with public institutions, by using them as information sources, leads to novel product innovation. If contact with public institutions through channels other than information sources were also to encourage novel product innovation, public financial support could have a positive effect on novelty. Hence, we propose the final hypothesis.

Hypothesis 8: A firm with new-to-market 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 Support Classified by Firm Size

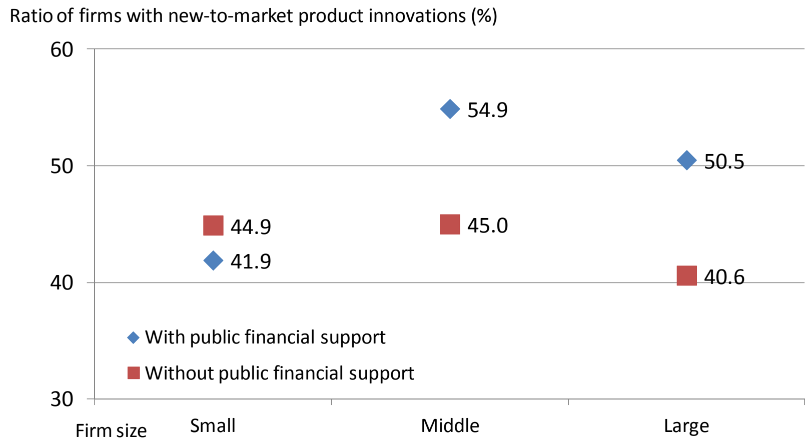


Figure 7 plots the relationship between the ratio of firms with new-to-firm product innovation and public financial support[8] by firm size.[9] While this ratio is higher for middle-sized and large firms, this is not the case for small firms. Hence, Hypothesis 8 is not necessarily confirmed, perhaps because nonfinancial bottlenecks exist for small firms that are attempting to be novel innovators. In particular, small firms are less likely to use information from universities (Nishikawa et al., 2010), which discourages new-to-market innovation as implied in Figure 5. Therefore, policy intervention intended to increase contact between firms and universities may work well.

4. Econometric Analysis

In the previous section, we proposed hypotheses on a firm's novel product innovation and confirmed that most observations in JNIS seem to be consistent with them. However, concluding only from such data descriptions is inadequate for two reasons. First, omitted variable bias could be present. A firm's innovation activities and their outcomes are affected by a number of factors, which if correlated with an object of interest and not controlled for properly would lead us to draw the wrong conclusions. Second, endogeneity biases are also of concern. Since ignoring endogeneity in variables can distort the estimation results, we must overcome this issue by using techniques such as the instrumental variable method.

In this section, we present an econometric analysis that deals with these problems (Section 4.1) and thus allows us to test the hypotheses previously formulated (Section 4.2). In particular, we construct and estimate a comprehensive econometric model that is a variant of the one proposed by CDM.

4.1. Econometric Model and Estimation

[8] Financial support includes tax credits, subsidies, loan guarantees, and so on.

[9] Small firms have fewer than 50 employees, middle-sized firms have 50–249 employees, and large firms have more than 250 employees.

The proposed model is represented by a system of three sets of equations. The first is for a firm's R&D investment. As is widely known, R&D expenditures are endogenously determined and any analyses ignoring this endogeneity may suffer from biased estimates. CDM deal with this issue by formulating research equations. In line with CDM and other empirical studies, we consider several factors that may affect a firm's R&D investment. The first factor is related to consumer demand, expressed by market size herein. Demand structure is considered to be a major determinant of a firm's innovation activities (e.g., Levin and Reiss, 1984), which is often called *demand pull*. While CDM base their analysis on the influence of market demand, we control for the market size effect by using industry dummies[10] and a dummy variable that indicates whether the market expanded during the survey period.

Another factor considered a fundamental determinant of innovation activities is technological opportunity (e.g., Rosenberg, 1974, Levin and Reiss, 1984) or *technology push*. To capture this effect, we focus on a firm's technology acquisition, which is also interpreted as the inflow of technological spillovers as noted in Section 3. Specifically, we create technology acquisition dummy variables based on the answers to the JNIS question on through which channels a respondent acquires its technology (see the right side of Figure 4).[11]

In addition, we take into account information sources. Some past studies such as Belderbos et al. (2004) have focused on information sources to measure the inflow of technological spillovers. Again, JNIS asks a respondent which information sources it uses (Figure 5), the answers to which we use to create information dummy variables. Besides, demand pull or technology push, CDM also explore those factors involved in the so-called "Schumpeterian hypotheses" on the effect of firm size and market power.[12] Similar to them, we use firm size dummies, the number of competitors in the domestic market,[13] and a dummy variable that indicates whether the market experienced product diversification during the survey period.

Lastly, we consider public financial support for a firm's innovation activities, the issue which are not covered in CDM. As described in Section 2, a number of studies have sought to identify the effect of public aid on firm innovation. We thus create a dummy variable that indicates whether a firm receives any public financial support from local public agencies or the central government (coded 1) or not (coded 0).

The second set of equations captures a firm's innovation output. As the measure of output, we focus on innovation novelty, which is analyzed by Duguet (2006) but not by CDM, and the protection of the innovation benefit, which CDM proxy for by using number of patent applications. However, for the latter,

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[10] The industry classification used is the same as that defined in Section 2.1.

[11] CDM use the answers to a question about the influence of technological developments.

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

[13] This number is for FY2008. Since the corresponding question is an interval one, we assign the intermediate value to each interval.

we do not restrict our attention to patents since firms use various means of protecting their innovation benefits including both legal protection and nonlegal protection such as market introduction before competitors, the complexity of production methods, and trade secrets. We therefore identify whether a firm uses legal or nonlegal protection methods and create a dummy variable for each. For the regressors, we use a similar set of variables as that adopted in the first step. We add a firm's R&D expenditures, which are endogenously determined in the first stage since many empirical studies including CDM consider a firm's R&D investment to be an innovation input. Moreover, we omit the number of competitors in the domestic market from this stage, just as CDM omit market share from their second one. In addition to these variables, we use innovation novelty as a regressor to explain the protection of the innovation benefit (Hypothesis 7).

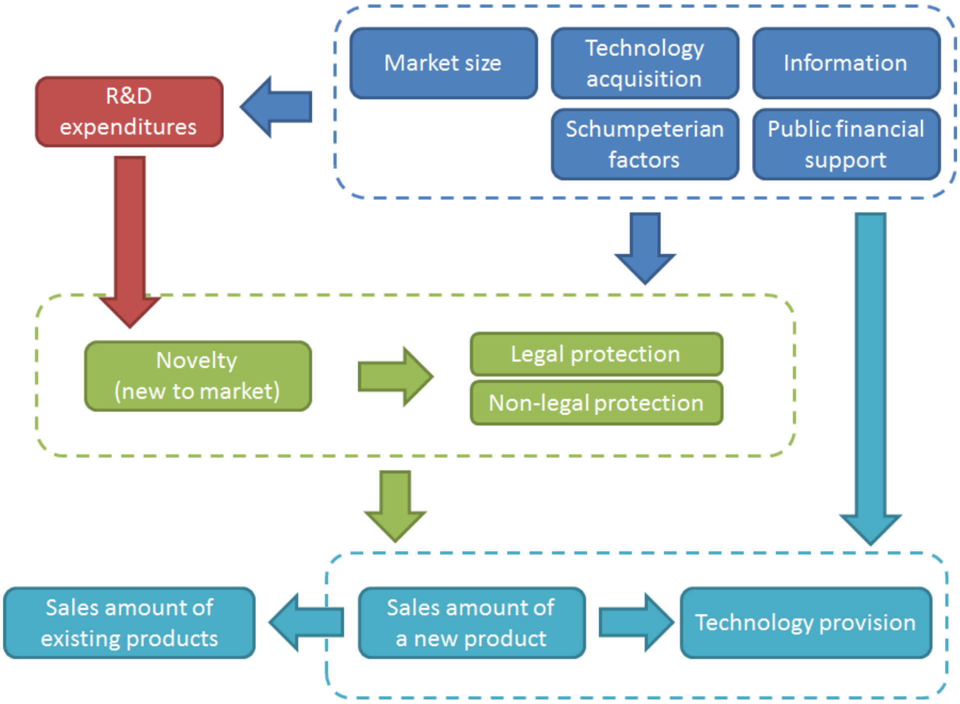
The third set of equations is for a firm's sales and its technology provision. For the former, we consider not only the sales of a new product but also those of existing products, which are important for examining the economic outcomes of product innovation because they can capture the cannibalization effect. For a firm's technology provision, we focus on channels that are less likely to accompany monetary compensation. In particular, we create a dummy variable that takes one if the firm provides its technology through the channels of open sourcing and participation in consortia.

We include three types of regressors for the equations that determine the sales of a new product and technology provision. First, we include innovation novelty and the protection of the innovation benefit, which are endogenously determined it the first stage as above. Following CDM and Duguet (2006), these innovation outputs may have a positive impact on firm performance. Second, we use the same regressors as adopted in the second stage as control variables. As a result, we control for the effect of demand and technological conditions, firm size (number of employees), and product diversification. Third, we consider the acquisition of tangible fixed assets and number of R&D workers, which correspond to regressors in the third stage of CDM.[14] On the contrary, for the regressors in the equation that determines the sales of existing products, we consider innovation novelty, the sales of a new product and the control variables of a firm's total sales in FY2006 and the firm size and industry dummies. With this equation, we aim to quantify the degree of cannibalization and examine how innovation novelty affects this 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

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



4.1.1. Comparison with CDM

Although our model is a variant of CDM, there are four significant differences other than the practical measures of the model variables. First, we incorporate innovation novelty into the model. As stated 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 be associated with technological spillovers. Second, we consider both legal and nonlegal means of protecting the innovation benefit given the insufficiency of using patent protection only (Levin et al., 1987). Third, we separately consider the firm's sales of both new and existing products as measures of firm performance. While CDM consider the percentage of a firm's innovation-related sales in their second stage, which is the combination of a firm's sales of new and existing products, only examining a firm's sales of a new product and that of existing ones separately may not be able to capture the cannibalization effect. Fourth, we consider both the inflow and the outflow of technology by using information on a firm's acquisition and provision of technology. In particular, most studies including CDM have not included outflow in their analyses.

4.1.2. Estimation equations

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

$$R\&D_i^* = x_{1,i}\beta_1 + u_{1,i}, \tag{1}$$

$$R\&D_i = \begin{cases} R\&D_i^* & if \quad R\&D_i^* > 0, \\ 0 \; otherwise. \end{cases}$$

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

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

$$Novelty_i = \alpha_2 R\&D_i + x_{2,i}\beta_2 + u_{2,i},$$

$$where\ u_{2,i}, \sim N(0,1) \quad and \quad Novelty_i = \begin{cases} 1 & if \quad Novelty_i^* > 0, \\ 0 \; otherwise. \end{cases} \tag{2}$$

$$Legal_i = \gamma_3 Novelty_i + x_{2,i}\beta_3 + u_{3,i},$$

$$where\ u_{3,i}, \sim N(0,1) \quad and \quad Legal_i = \begin{cases} 1 & if \quad Legal_i^* > 0, \\ 0 \; otherwise. \end{cases} \tag{3}$$

$$Nonlegal_i = \gamma_4 Novelty_i + x_{2,i}\beta_4 + u_{4,i},$$

$$where\ u_{4,i}, \sim N(0,1) \quad and \quad Nonlegal_i = \begin{cases} 1 & if \quad Nonlegal_i^* > 0, \\ 0 \; otherwise. \end{cases} \tag{4}$$

where $Novelty_i$ represents innovation novelty, $legal_i$ is the legal protection dummy, $Nonlegal_i$ is the nonlegal protection dummy, and $x_{2,i}$ is similar to $x_{1,i}$ except that it does not include the number of competitors in the domestic market.[15]

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

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

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

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

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

where $Newsales_i$ represents the sales of a new product, $Existingsales_i$ the sales of existing products, $Provision_i$ is the dummy for capturing technology provision through open sourcing or participation in consortia, $x_{5,i}$ includes $x_{2,i}$, purchased tangible fixed assets, and the number of workers in R&D, and $x_{6,i}$ includes the logarithm of a firm's total sales and the firm size and industry dummies.

4.1.3. Methodology and estimation sample

We estimate the parameters in this system by using maximum likelihood estimation. Estimation samples are restricted to firms that conduct innovation activities and achieve product innovation, which reflects our interest in innovation output including the novelty of product innovation. This restriction does not

[15] We omit a firm's R&D expenditures from Equations (3) and (4) to avoid a convergence problem.

become a problem as long as we focus on the economic impact of product innovation *conditional on* a firm conducting innovation activities and achieving product innovation. Similarly, CDM's main estimates are obtained with firms that achieve some kind of innovation.

Furthermore, we omit observations with missing values for the model variables. The characteristics of the omitted firms are similar to those without such missing values.[16] The resulting sample size is 539.[17] Table 2 presents the summary statistics of the model variables.

Table 2: Summary Statistics

		Mean	Std. Dev.
Novelty		47.40%	50.00%
Sales of a new product	(million JPY)	5148.1	53945.3
Sales of existing products	(million JPY)	42354.8	188152.8
R&D expenditure	(million JPY)	4508	41395.2
Firm size			
	Middle-sized	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
No. 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%

16 There is little difference in the average size, age, and industry of the sample firms. However, we cannot reject the hypothesis that there is no difference in the average sales and age of the two subsamples based on the t-test results. Similarly, we cannot reject the hypothesis that the existence of missing values and the firm's industry classification are independent based on the results of Pearson's chi-square test.

17 Before omitting observations with missing values, the sample size was 1,224.

	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 sourcing	13.40%	34.10%
	Consortium	11.70%	32.20%
	Alliance	16.30%	37.00%
	Accepting researchers etc.	16.30%	37.00%
Technology provision			
	Open sourcing 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%
Observations		539	

Regarding the sample selection issue, we attempt to correct for possible sampling biases by a following method. First, for all firms in JNIS, we regress a dummy variable that indicates whether the firm is included in our estimation samples on certain control variables, including a firm's total sales, sales cost, total wages, and the firm size and industry dummies. Then, we calculate the residual for each firm and include them in Equations (1) to (7) as an additional regressor. The estimation results differ little from the baseline results reported next.

4.2. Estimation Results

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

Specifications (1-b) and (1-c) omit the industry dummies and technological factors whose coefficients are estimated as insignificant in (1-a). The results are similar to those in (1-a), with the only difference that the coefficient of the large-firm dummy is estimated to be significantly positive. Our results are consistent with the findings of Cohen and Klepper (1996) and Klepper (1996), who 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 sourcing	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-sized	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: ***, **, and * indicate that the estimate is significant at 1%, 5%, and 10%, respectively.

Table 4 shows the estimates for Equation (2). Specification (2-a) includes all the regressors discussed in Section 4.1. Interestingly, R&D expenditures have no significant impact on the achievement of new-to-market product innovation. This result contrasts with that put forward by Duguet (2006), who finds a positive impact of a firm's formal R&D on radicalness. One reason for this discrepancy is that Duguet (2006) does not fully control for the effect of demand and technological opportunity as we do in the presented analysis; hence, the estimated coefficient of R&D in Duguet (2006) might be confounded by the effects of other factors. While we find no positive impact of market expansion on innovation novelty, some of the coefficients of technology acquisition and information are significant. In particular, technology acquisition through accepting new researchers and information from universities seems to positively affect innovation novelty, the latter of which is consistent with Hypothesis 6. Similar to the results of previous studies, universities seem to be influential information sources for novel innovations. Lastly, public financial support has no significant impact on novel innovators, which rejects Hypothesis 8. This finding might be partly because nonfinancial factors, including the utilization of information from universities, are essential for new-to-market innovation, as described in Section 3.3.3.

Specifications (2-b) and (2-c) omit the industry dummies and technological factors whose coefficients are estimated as insignificant in (2-a). The basic implications of 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 sourcing	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-sized	-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 estimated coefficients for Equations (3) and (4).[18] Specifications (3-a) and (4-a) include all the regressors discussed in Section 4.1 except for a firm's R&D expenditures and industry dummies.[19] On the contrary, specifications (3-b) and (4-b) additionally omit the technological factors whose coefficients are estimated as insignificant.

First, we find that innovation novelty has a significant positive impact on both legal and nonlegal protection. Their similar estimated coefficients suggest that a firm with novel product innovation is *no* more likely to use legal protection relative to nonlegal protection. Hence, we cannot reject Hypothesis 7. For the other variables, some technological factors positively affect both legal and nonlegal protection. Looking at (3-a), technology acquisition through public research institutes and professional publications seems 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, while technology acquisition through public research institutes is also significant in (4-b).

[18] Unfortunately, the effectiveness of the instruments is rejected for (3-a), (3-b), and (4-b), which remains a future issue to resolve.
[19] We omit these variables in order to avoid a convergence problem.

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			
	(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 sourcing	-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-sized	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: ***, **, and * indicate that the estimate is significant at 1%, 5%, and 10%, respectively.

Table 6 reports the estimates for Equation (5). We omit the technological variables because otherwise they would all be estimated as being insignificant.[20] Specifications (5-a) and (5-b) include the logarithms of the acquisition of tangible fixed assets and of the number of workers in R&D with and without the industry dummies, whereas specifications (5-c) and (5-d) do not take the logarithms of these variables.

[20] Hence, Hypothesis 5 would not be supported here, in that we find little evidence that technology acquired through consortia directly affects the sales of a new product.

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 helps a firm avoid severe competition when dealing with homogeneous products. On the contrary, the coefficient of legal protection is estimated to be negative. Legal means of protecting the innovation benefit are not associated with firm performance in terms of innovation-related sales here. The other estimates show that a firm with many employees, R&D workers, and tangible fixed assets tends to achieve above-median product innovation.

(5-b) is similar to (5-a) except that the coefficient of public financial support is estimated as significantly negative. However, it is likely that this estimate captures the differences in the market environment because (5-b) omits the industry dummies. Finally, (5-c) and (5-d) are similar to (5-a) but the results of the 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-sized	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)					
	[nonlogarithm]					1.07E-05	***	1.09E-05	***
	(s.e.)					(2.78E-06)		(2.83E-06)	

No. of workers in R&D	[logarithm]	0.58	***	0.55	***				
	(s.e.)	(0.09)		(0.09)					
	[nonlogarithm]					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: ***, **, and * indicate that the estimate is significant at 1%, 5%, and 10%, respectively.

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

For (6-a), the sales of a new product have a significant negative effect on those 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. By contrast, the coefficient of the cross term of innovation novelty with the sales of a new product is significantly positive and nearly cancels out the cannibalization term. Hence, we can interpret this finding as saying that the cannibalization effect is reversed with innovation novelty, which is consistent with Hypothesis 3.

(6-b) is similar to (6-a). For (6-c) and (6-d), the coefficients of the sales of a new product and the cross term are estimated as insignificant, although their signs are the same as 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)					
	[logarithm]					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-sized	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 for Equation (7). We omit the technological variables because otherwise they would all be estimated as being insignificant as before. Specifications (7-a) and (7-b) include the logarithms of the acquisition of tangible fixed assets and of the number of workers in R&D with and without the industry dummies, while specifications (7-c) and (7-d) do not take the logarithms of these.

For all specifications, the coefficient of innovation novelty is estimated as significantly positive. This estimation 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 that are less likely to accompany monetary compensation.

Table 8: Estimation Results of Equation (7)

		Linear model Dependent variable: Technology provision through open sourcing 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-sized	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)		
	[nonlogarithm]			-8.14E-07	-2.77E-07
	(s.e.)			(2.16E-06)	(1.91E-06)
No. of workers in R&D	[logarithm]	0.05	0.02		
	(s.e.)	(0.08)	(0.08)		
	[nonlogarithm]			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

The empirical analyses presented in this study focused on the degree to which new-to-market product innovation influences firm performance (i.e., sales of new and existing products), technological spillovers, and other characteristics of new-to-market product innovation. We proposed eight hypotheses and tested them by use of JNIS for the study period of April 2006 to March 2009.

Overall, our results are consistent with the hypotheses presented. We found that innovators tend to achieve higher sales from new-to-market product innovation, and are less likely to suffer from the cannibalization effect. New-to-market product innovation tends to spill its knowledge over to other firms' innovations through channels that are less likely to be accompanied by monetary compensation.

Considering that new-to-market product innovation significantly improves firm performance and is associated with technological spillovers, policy intervention promoting such innovation may be beneficial. Our empirical results show that firms with new-to-market product innovation are more likely to use information from universities, and less likely to rely on legal protection. In addition, public financial support does not necessarily stimulate new-to-market product innovation, especially for small firms. Rather, for creating such innovation, nonfinancial policies such as using personnel to improve the interrelations between firms and universities are rather important.

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