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Innovation Height and Firm Performance: Using Innovation Survey from Japan

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Innovation Height and Firm Performance: Using Innovation Survey from Japan [1]

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Abstract

This study evaluates the economic impact of product innovation 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 on the data reveal that new-to-market product innovation is likely to (1) contribute higher sales for the firm with less cannibalization with existing products; (2) generate higher degree of technological spillovers to other innovations; and (3) be brought by those firms that corroborate with universities and other academic institutions. An econometric analysis on simultaneous equations confirms these observations. Policy implications are also discussed.

Keywords: Product innovation; New to market; Spillovers; Community innovation survey

JEL classification: C36; O31; O33; O38

1. Introduction

While all agree that innovation matters for growth, we have not yet fully understood as to what type of innovation favors firm growth and what factors determine such innovation type. This paper employs an innovation survey conducted in Japan, and attempts to answer such questions with a particular focus on product innovation. As discussed shortly in this section, the innovation survey used in this paper identifies two types of product innovation: new-to-market (or radical) product innovation and new-to-firm (or incremental) product innovation. Since the former is not new to market but new to the firm in question,

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the former encompasses the latter. Data on such innovation types would help us assess whether there is an innovation threshold, and thus innovation height, that leads to higher growth. This paper is the first attempt to examine a cause and consequence of innovation height at a firm-level analysis with an application to an Asian country, in particular Japan. We believe that improving our knowledge on this aspect of innovation activities is crucial for designing innovation policies.

Innovation contains a wide range of activities and processes, including markets, knowledge transfers, and informational spillovers. While innovation is inherently difficult to quantify and measure, an important development has been made on survey-based indicators. The Organization for Economic Cooperation and Development (OECD) developed a manual known as the Oslo Manual (OECD, 1992) and synthesized the results of earlier innovation surveys, notably the Yale Survey on Industrial Research and Development, and the Carnegie-Melon University R&D Survey in the United States.[5] The European Commission, in a joint action between Eurostat and DG-Enterprise, followed up the OECD initiative to implement the community innovation survey (CIS). A notable feature of the CIS is to collect quantitative measures of innovation inputs and outputs at a firm level in the internationally comparable manner. The basic format of CIS has now diffused across many other countries including, most notably, Korea and Japan.

Product innovation is, by definition, deemed novel, but the degree of novelty differs by product in question (Arundel and Hollanders, 2005). 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 provides a firm with temporary market power (Petrin, 2002). Second, new-to-market product innovation may exhibit technological spillovers for innovation activities to other firms, a research topic which has attracted much attention in both theoretical and empirical studies.[6] 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, policies to promote such innovation should be justified from the 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 and non-legal protection measures, and other important variables relevant to new-to-market product innovation. Our model is reminiscent of that

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[5] Smith (2005) and Mairesse and Mohnen (2010) for details of community innovation surveys.

[6] Arrow (1962) points out that an innovating firm cannot appropriate the outcome of its innovation activities owing to inherent technological spillovers. Many researchers since then have tried to quantify the degree of spillover, especially in terms of the social rate of return on R&D investment (See Griliches, 1992, for details).

proposed by Crépon, Duguet and Mairesse (1998) (hereafter CDM), in that our econometric model also consists of a system of equations;[7] however, we address possible endogeneity in our estimation, the issue largely neglected in CDM.

Despite its economic importance, little empirical work focuses on the height and novelty of firm's product innovation. To the best of our knowledge, Duguet (2006) is an exception. The present study tries to build on Duguet (2006), but differs from the work 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). We rather 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). Lastly, we utilize technology outflow, as well as inflow, in order to capture the influence of technological spillovers, whereas the 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 innovation activities across the major countries that conduct innovation surveys. Section 3 proposes hypotheses on new-to-market product innovation with respect to firm performance (Section 3.1), technological spillovers (Section 3.2), and other characteristics including information sources, legal and non-legal protections, and public financial support (Section 3.3). Section 4 presents an econometric model to test the hypotheses. Section 5 concludes.

2. Product Innovation in the Survey [8]

The traditional indicators on product innovation include R&D expenditures and patents. These indicators, however, can be considered as mere inputs in the innovation process, and do not appear to capture key aspects of innovation process and outputs. This point is once remarked by Zvi Griliches: "far too little fresh economics data is collected" (Griliches, 1987, cited in Smith, 2005). To respond to the challenge, innovation surveys have been developed to collect qualitative and quantitative data on innovation activities within firms and on successful introduction of different types of innovation to the market. The original purpose of the surveys was to obtain data on innovation outputs and inputs that were not based on traditional indicators of innovation, such as R&D expenditures and patents (OECD, 2009). [9]

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7 The CDM approach has been adopted by other work, including Griffith, Huergo, Mairesse and Peters (2006) in the application to France, Germany, Spain, and the UK and Chudnovsky, López and Pupato (2006) in their study on Argentina.

8 The description in this section relies heavily on Smith (2005), Mairesse and Mohnen (2010), and OECD (2009).

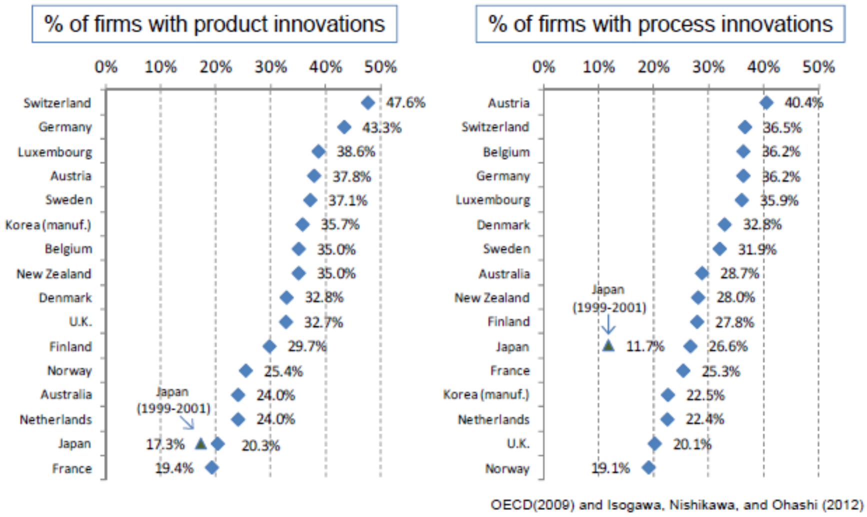
9 The results of JNIS show that 47.3% of firms conducting innovation activities report that R&D expenditure is zero. This is not peculiar to JNIS but also reported in Arundel, Bordoy and Kanerva (2008) and observed in other countries.

In innovation surveys, firms are asked to provide information on inputs, outputs and behavioral dimensions of their innovative activities. On the input side, innovation surveys measure a firm's intangible assets, which include, beyond R&D expenditure, spending on training, and acquisitions of patents and licenses. On the output side, data are collected on whether a firm has introduced a new product or process, and the share of sales due to new products. Other indicators capture the nature of innovative activities, including the impacts of innovation, collaboration and linkage among firms or public research organization, the perceived obstacles to innovation, and flows of knowledge (OECD, 2009).

To ensure the quality of innovation surveys, the OECD introduced the Oslo Manual in 1992, and has identifies product and process innovations as technological innovations. In the Manual, product innovation is defined as the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics. Process innovation is defined as the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software (OECD, 2009).

Figure 1 lists the proportion of respondent firms with either product innovation (on the right panel) or process innovation (on the left panel) in highest orders. The national innovation surveys in the data were conducted over the period from 2002 to 2004, except for Japan in the period from 2006 to 2008, Switzerland from 2003 to 2005, and Australia and New Zealand from 2004 to 2005. The proportions listed in the figure are adjusted by country differences in terms of firm-size distribution, to enable us to make an international comparison. A casual observation indicates that those countries that have higher share of firms with product innovation exhibit higher share of process innovation. A coefficient of rank correlation is 0.71. While it collected only from the manufacturing sector, Korea has 35.7 percent of firms with product innovation, far higher than 20.3 percent of Japan. The order reverses in process innovation: 26.6 percent for Japan and 22.5 for Korea.

FIGURE 1: Product and Process Innovations: International Comparison



Since all innovation features a certain degree of novelty, the Oslo Manual distinguishes two concepts of innovation output: new to the firm and new to the market. The first concept covers the diffusion of an existing innovation to a firm; the innovation may have already been implemented by other firms, but is new to the firm. Firms that first develop innovation can be considered classified as new to the market.

FIGURE 2: Innovation height and Sales of Product Innovation

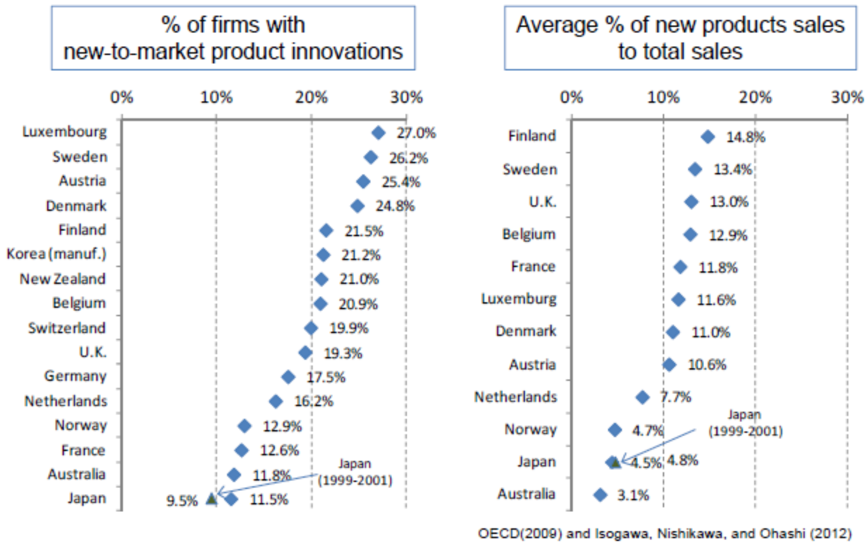
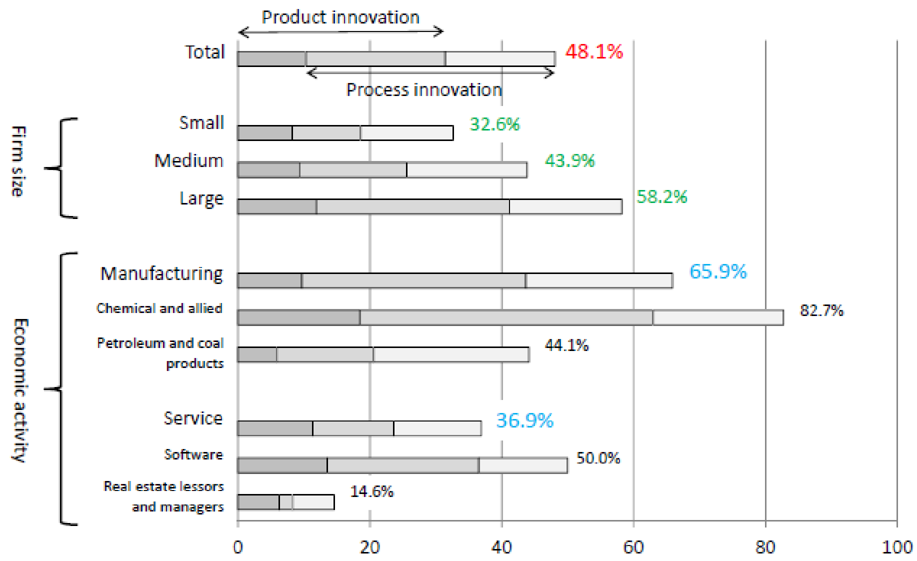


Figure 2 contains two panels on outcomes of product innovation. The right panel presents the proportion of respondent firms that succeeded new-to-market product innovations. We consider that the height of product innovation is represented by new-to-market product innovation. The coefficient of rank correlation between product innovation (on the right panel of Figure 1) and new-to-market product innovation is found to be 0.67. The left panel shows the average percentage of new product sales with respect to total sales. OECD (2009) lists Korea (only for manufacturing sector) on the right panel, but no data on Korea is available for the left panel.

The Japanese National Innovation Survey (JNIS), the data set which we use in this paper, 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. The response rate is 30.3%, corresponding to a sample of 4,579 firms. Figure 3 shows the proportions of respondent firms that succeeded either product or process innovations or both. The figure indicates that 48.1 percent of firms in the survey innovated, and substantial shares account for those firms that succeeded both innovations. The shares of innovative firms increase with firm size, and the share is higher for the manufacturing sector than the service sector.

FIGRUE 3: Summary Statistics of JNIS



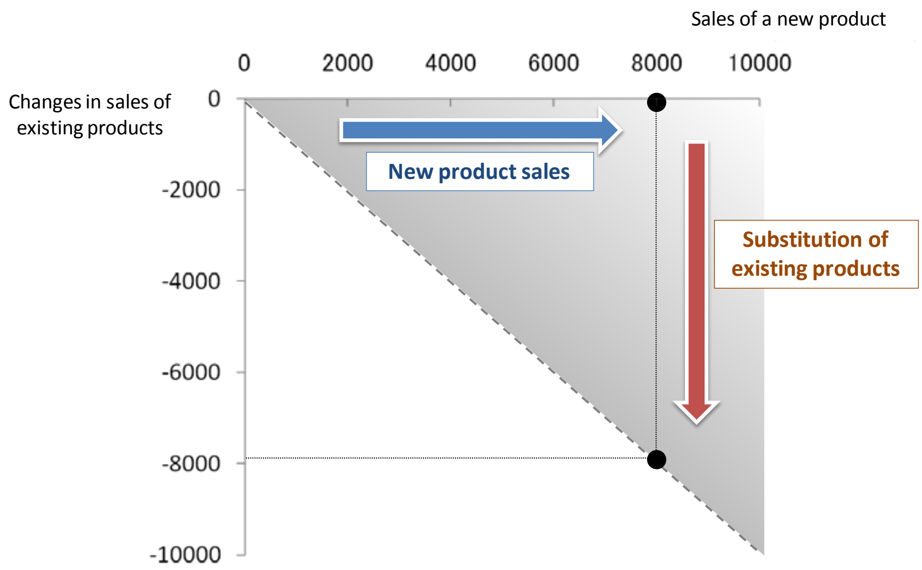
3. Hypotheses on New-to-Market Product Innovation

This section proposes eight hypotheses on new-to-market product innovation, the hypotheses which will be tested in Section 4. It consists of three subsections. Section 3.1 discusses how new-to-market product innovation improves firm performance. The next subsection focuses on technological spillovers in innovation activities, followed by Section 3.3, in which policy issues are discussed.

3.1. Firm Performance

We first examine the effect of product innovation on firm performance. One way to analyze this aspect is to decompose firm performance into two dimensions: sales of a new product and of existing products, as shown in Figure 1. The horizontal axis of the figure represents the changes in the sales of a new product, whereas the vertical axis measures the changes in the sales of existing goods. We usually consider that the introduction of a new product cannibalizes the existing-goods sales. If the demand for a new product perfectly substitutes the demand for existing goods, the net effect of the product innovation on firm sales is shown by the (negative) 45-degree line in the figure. If a new good and existing goods are imperfectly substitutable, the net total sales would be in the area above the (negative) 45-degree line, represented by the grey area in Figure 1.

Figure 1: Product Innovation and Firm Sales

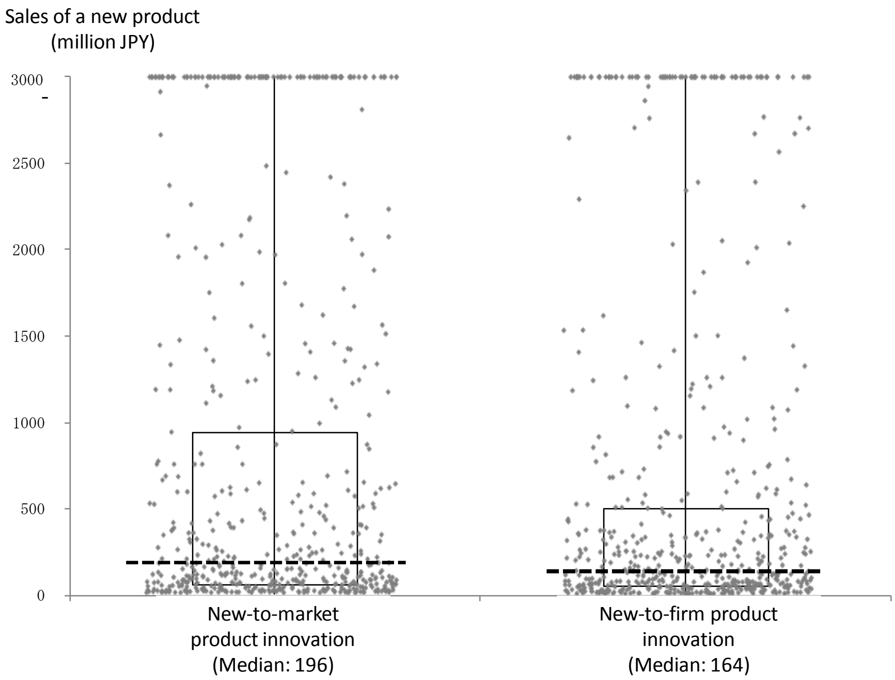


Consistent with this view, Duguet (2006) shows that only new-to-market innovations (namely radical) can improve the net firm performance. Barlet, Duguet, Encaoua and Pradel (1998) also indicate that innovation novelty can increase the share of innovation-related sales in the situations where technology is important. To sum, the following hypothesis reasonably captures our discussion made in Figure 1:

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

According to sales information from JNIS,[10] the average sales of a new product in FY2008 were 5,586 million JPY for those firms with new-to-market product innovation, and 3,004 million JPY for the others. Figure 2 box-plots the sales of a new product for firms with new-to-market product innovation and for one with new-to-firm product innovation. The top and bottom of the rectangle in each panel in the figure represents the 25th and 75th percentiles of the sales distribution, and the dashed line represents the median. The median sales are 185 million JPY for new-to-market product innovations, and 165 million JPY for new-to-firm innovations. It is worthwhile to note in the figure that the 75th percentile of sales for a new-to-market product innovation is much larger than those from new-to-firm product innovations.

Figure 2: Innovation height and the Sales of New Products



Next, we turn to the sales of existing goods. Jefferson, Huamao, Xiaojing and Xiaoyun (2006) point out that innovation does not necessarily improve firm performance, and suggest that cannibalization with the firm's existing products may severely deteriorate firm's profitability. This claim leads to the following two hypotheses.

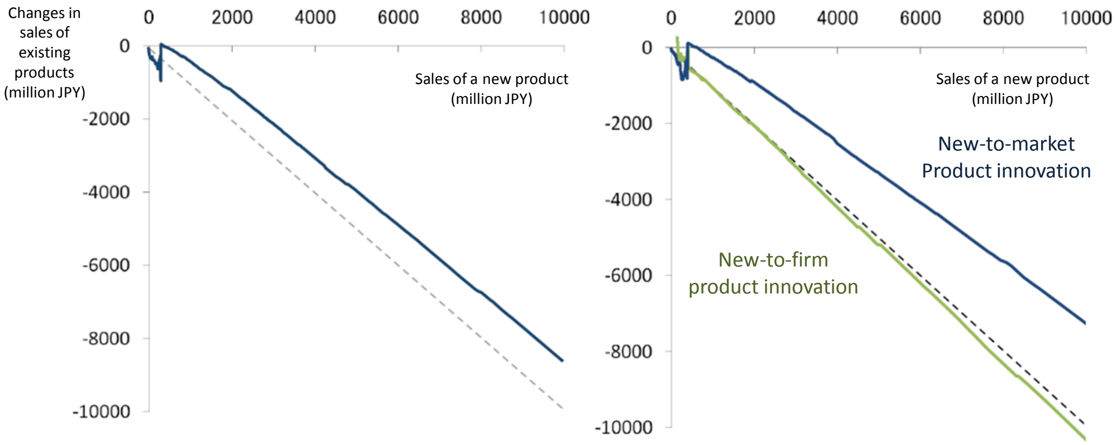
Hypothesis 2: The larger sales of a new product decrease the sales of a firm's existing products.

Hypothesis 3: The more innovative a new product is, the more intense the cannibalization with the sales of existing goods.

[10] To be precise, JNIS asks each firm on the share of its new product sales. We recover the sales from the new product by multiplying the share by firm's total sales reported in FY2008.

To test Hypotheses 2 and 3, we need to understand the impact of product innovation on the sales of firm's existing goods. For this purpose, we calculate the changes in the sales of existing products during FY2006–2008. The left-hand panel of Figure 3 plots the relationship between the sales of a newly introduced product (which include both new-to-market and new-to-firm product innovations) and the changes in the sales of existing products, following the analytical framework discussed earlier in Figure 1.[11] The sales from product innovation appears to cannibalize the sales of existing goods. The observation is consistent with Hypothesis 2 in that the introduction of a new product substitutes demand of existing goods. The change in the total sales, the sum of the changes in the sales from existing goods and in new-to-market product innovation, are uniformly positive and approximately 1,500 million JPY.

Figure 3: Sales of New and Existing Products



The right-hand side of Figure 3 plots the same relationship separately for firms with new-to-market product innovation and for those with new-to-firm product innovation. A significant difference is observed between the different types of innovation. The average relationship for those firms with new-to-firm product innovation lies almost on the (negative) 45-degree line, indicating that the sales of new-to-firm product innovation fully cannibalizes the existing-goods sales. On the contrary, the average relationship for those firms with new-to-market product innovation sits above the (negative) 45-degree line; the sales of a new-to-market product lead to an increase in the firm's total sales. Cannibalization between new and existing goods are less severe on new-to-market product innovation than on new-to-firm product innovation. These observations are consistent with Hypothesis 3. Combining the observations in Figures 2 and 3 suggests that new-to-market product innovation contributes to the total-sales increase for the firm, even at the loss of cannibalization.

3.2. Technological Spillovers

[11] We use LOWESS (Locally Weighted Scatterplot Smoothing) for a smoothing algorithm.

Researchers, most notably Arrow (1962), have pointed out that an innovating firm cannot appropriate the outcomes of its innovation activities because of the presence of technological spillovers. In contrast to some previous studies (e.g., Bloom, Schankerman and van Reenen, 2013), we directly collect self-reported data on technological spillovers accrued from information on firm's technology acquisition (i.e., inflow) and technology provision (i.e., outflow). Of special importance is the technology provision through channels that are less likely to accompany monetary compensation, such as open sourcing and the participation in consortia. If firms do not consider this type of spillover when making decisions on innovation activities, innovation in the private sector could be undersupplied.

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 the presence of technological spillovers arising from firms at the technological frontier through nonmonetary channels. Viewing that the firms with new-to-market product innovation are likely to locate near the technological frontier, we propose the following hypothesis:

Hypothesis 4: Firm with new-to-market product innovation are more likely to provide their technology through open sourcing or through their participation to consortia, than the firm with new-to-firm product innovation are.

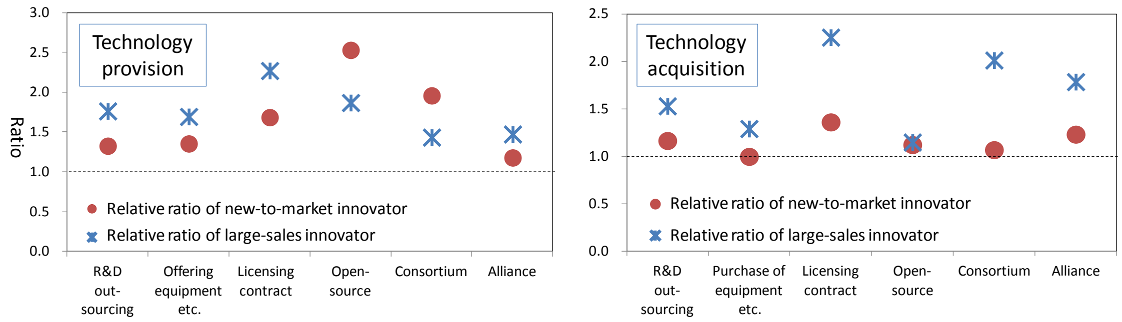
Among empirical studies that focus on inflow, Kaiser (2002) considers incoming spillover effects to examine relationship between research cooperation and research expenditures. His results indicate that horizontal spillovers lead to firms' aggressive innovation investment through research cooperation.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

Hypothesis 5: Sales of a new product are greater for firms that acquire technology through consortia than otherwise.

Figure 4 summarizes firm's technology acquisition and provision based on the information provided by JNIS. Following the Olso Manual, the figure presents six channels, R&D outsourcing, offering equipment etc., licensing contract, outsource, consortium, and alliance. A circle and a star in each channel in the figure represents the ratio in the number of firms: a circle is obtained by the number of firms with new-to-market product innovation, divided by the number of firms with new-to-firm innovation. A star is constructed by the number of firms that attain sales at the median of the sales distribution (namely 168 million JPY) or above, divided by the number of firms with the sales below the median. While the product innovation with sales above the median appears more active at the channels associated with monetary compensation (e.g., licensing), new-to-market product innovation seems clustered at nonmonetary channels such as open sourcing and the participation to consortia. This finding appears consistent with Hypothesis 4.

The right-hand panel of the figure is for firm's technology acquisition. There is little worth the mention regarding new-to-market product innovation in technology acquisition. However, firms with the above-median sales tends to acquire technology through licensing and the participation to consortia, consistent with Hypothesis 5. Combining this observation with the results on the left-hand side of Figure 4 suggests that the participation in consortia plays a significant role in technological spillovers. Indeed, Figure 4 indicates that firms with new-to-market product innovation provides its technology for other firms through consortia, and that such technological spillovers would contribute to higher sales from the introduction of new product.

Figure 4: Technology Acquisition and Provision



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

In this subsection, we focus on firm characteristics with new-to-market product innovation in light of three respects: information sources, means to protecting innovation benefits, and public financial supports. We have found in the previous subsections that new-to-market product innovation leads to significant improvement in firm performance, and exhibits strong technological spillovers. This finding implies that public policy that encourages firms to conduct new-to-market innovation would be justified from the social welfare point of view. To implement such policy effectively, however, it is necessary for us to have deeper understanding on the characteristics of new-to-market product innovations.

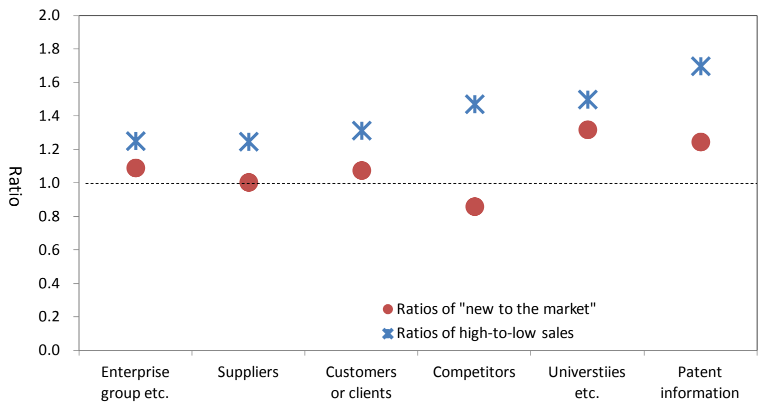
3.3.1. Information sources

Previous studies have examined the relationship between information sources and innovation height. Belderbos, Carree and Lokshin (2004) examine with respect to cooperative R&D and firm performance, finding that information provided by consumers or universities has positive impacts on the sales from new products, and that the cooperation with universities likely leads to new-to-market product innovations. Likewise, Mohnen and Hoareau (2003) study the degree of interaction with universities and resulting propensity to generate new-to-market product innovation, but their results suggest that such interaction does not necessarily result in fruitful outcomes. With a few exceptions,[12] most studies imply that information from universities positively affects innovation novelty, which lead us to summarize in the following hypothesis.

Hypothesis 6: Firms with new-to-market product innovation are more likely to obtain information from universities for their innovation activities than those with new-to-firm product innovation.

Figure 5 shows the utilization ratio of information sources for innovation activities. Similar to the definition we made in Figure 4, a circle is for new-to-market product innovation, and a star represents the sales of new products. While firms that attain the sales at the median or above from product innovation seeks for various information sources, firms with new-to-market product innovation tend to obtain information from universities or patents held by other firms, as claimed in Hypothesis 6.

Figure 5: Information Sources



3.3.2. Means to protecting the innovation benefit

While it is usually difficult for firms to fully appropriate innovation benefits, firms try to protect the benefits from innovation in legal means (e.g., patent protection) or by other means such as the use of trade secrets. In theory, legal means serve to encourage innovation activities by providing them with a premium for creating innovations. Among recent empirical studies, Duguet and Lelarge (2006) show the effectiveness of patent protection for defending the premium that firms can obtain from product innovation. However, legal means of protection may not always work perfect (Levin, Klevorick, Nelson and Winter, 1987). In view of possible positive spillovers featured in new-to-market product innovation reported in the previous section, legal means may not effectively protect the profit from new-to-market product innovation:

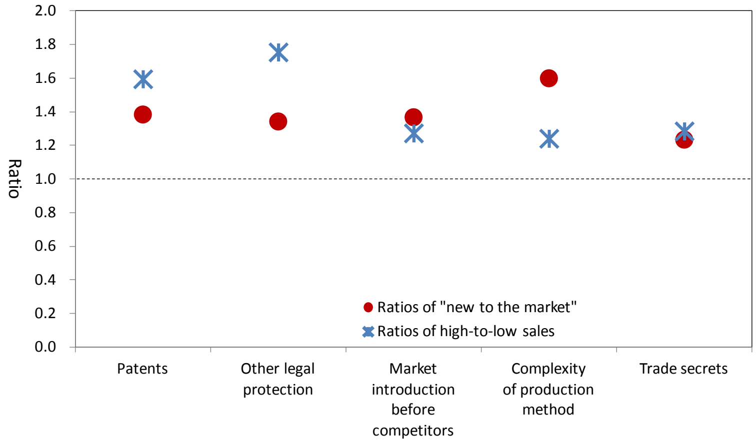
Hypothesis 7: Firms with new-to-market product innovation are no more likely to use legal protection

[12] Monjon and Waelbroeck (2003) suggest that information from universities encourages new-to-firm innovation.

relative to non-legal protection, than those firms with new-to-firm product innovation are.

Figure 6 summarizes means of protecting innovation benefits. As before, a circle is for new-to-market product innovation, and a star represents sales from new products. While firms with the above-median sales from product innovation tend to rely more on legal protection, those firms with new-to-market product innovation show little distinctive pattern in the usage of legal and non-legal means. This finding is consistent with Hypothesis 7, indicating that legal means may find it difficult for firms to protect new-to-market product innovations.

Figure 6: Protection Measures for the Innovation Benefit



3.3.3. Public financial support

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

Meanwhile, among few studies of the relationship between public financial support and innovation novelty, Mohnen and Hoareau (2003) raise the possibility that interacting with public institutions leads to new-to-market product innovation. If the interaction with public institutions through channels other than information sources would also encourage new-to-market product innovation, public financial support could have positive effects on innovation height and novelty. Hence, we propose the following eighth hypothesis:

Hypothesis 8: Firms with new-to-market product innovation are more likely to receive public financial support than those firms with new-to-firm product innovation are.

Figure 7: Novelty and Public Financial Support Classified by Firm Size

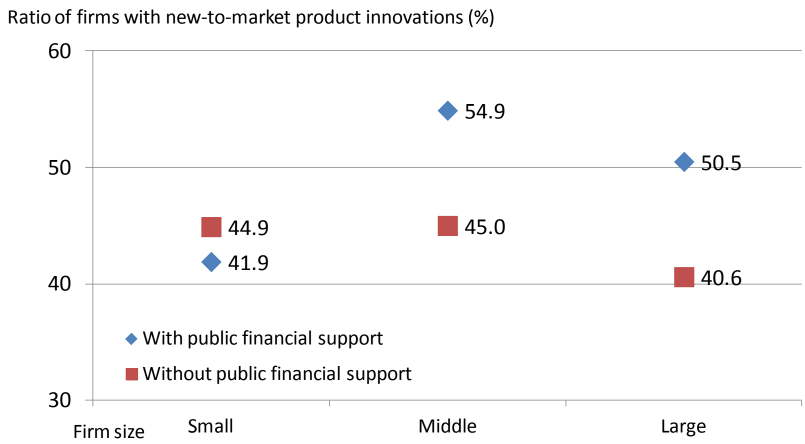


Figure 7 plots the relationship between the ratio of firms with new-to-firm product innovation and public financial support[13] by firm size.[14] While this ratio is higher for middle- and large-sized firms, this is not the case for small-sized firms. Hence, Hypothesis 8 may apply to all firm sizes but to small; perhaps this is because nonfinancial bottlenecks exist for small-sized firms, in order for them to achieve new-to-market product innovation. In particular, small-sized firms are less likely to use information from universities (Nishikawa, Isogawa and Ohashi, 2010), which may well hinder them to produce new-to-market innovation, according to the discussion made in Section 3.3. In this context, policy intervention intended to increase interaction between firms and universities may well work for small-sized firms.

4. Econometric Analysis

We proposed in the previous section the hypotheses on new-to-market product innovation, and find based on the casual observations from statistical correlations that the information from JNIS appear consistent with each of the hypotheses. However, drawing conclusions from the casual observations may be seriously inadequate for two reasons. First, omitted variable bias is known to contaminate the finding based on the eyeball analyses. Firm innovation activities and their outcomes are affected by a number of factors, many of which are not fully controlled for in the previous section. Lack of proper control for such

[13] Financial support primarily includes tax credits, subsidies, and loan guarantees.

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

factors would likely make us draw wrong conclusions. Second, endogeneity bias is also of serious concern. Ignoring endogeneity in some variables of interest could distort estimation results. To address the challenges mentioned above, this section first presents an econometric framework (Section 4.1), and then test the hypotheses proposed in the previous section (Section 4.2) to see how robust our findings were made in Section 3.

4.1. Econometric Model and Estimation

The proposed model here consists of a system of three sets of equations. The first is firm R&D investment. As is well known, R&D expenditure is endogenously determined and any analyses ignoring such endogeneity may suffer from biased estimates. We follow the approach taken by the existing literature and add an equation that models R&D expenditure. Several factors may affect the amount of firm's R&D expenditure. The first factor is consumer demand. Demand structure is considered to be a major determinant of firm's innovation activities (e.g., Levin and Reiss, 1984), sometimes called *demand-pull* factor. While CDM base their analysis on the influence of market demand, we control for the market-size effect by using industry dummies and a dummy variable that indicates whether the market size expanded during the survey period.

Another factor that is considered as a determinant of R&D expenditure is technological opportunity (e.g., Rosenberg, 1974, Levin and Reiss, 1984), or *technology-push* factor. To capture this effect, we focus on firm's technology acquisition, also interpreted as the inflow of technological spillovers as noted in Section 3. Specifically, we create the variables reflecting technology acquisition, based on the information available to JNIS; namely, through which channels a respondent firm acquired its technology (shown in the right-hand side of Figure 4).

We also incorporate information sources in the equation of R&D expenditure. Some past studies such as Belderbos, Carree and Lokshin (2004) have focused on information sources in an attempt to capture the inflow of technological spillovers. Again, JNIS asks a respondent firm as to which information sources it relies on (as shown in Figure 5), and we create a dummy variable to capture this feature. Besides demand-pull or technology-push mentioned just above, CDM explore those factors involved in so-called "Schumpeterian hypotheses" that captures the effect of firm size and market power.[15] Following their approach, we use firm-size dummies, the number of competitors in the domestic market, and a dummy variable that indicates whether the market experienced product diversification during the survey period.

Lastly, we consider public financial support for firm's innovation activities, the issue that is not covered in CDM. As described in Section 2, a number of studies have sought to identify the effect of

[15] Much theoretical work has been done on whether market concentration encourages firm's innovation activities. Replacement effect (Arrow, 1962), and efficiency effect (or the Schumpeterian effect) (Schumpeter, 1943. See also Gilbert and Newbury, 1982; Reinganum, 1983) are well known. Several empirical studies, including Aghion, Bloom, Blundell, Griffith and Howitt (2005), have tried to quantify the net effect of these two types of effects.

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 (taking the value of 1) or not (the value of 0).

The second set of equations captures firm's innovation output. As a measure of output, we focus on innovation height or novelty, which is analyzed by Duguet (2006), and the protection of the innovation benefit, which CDM proxy for by using the number of patent applications. However, for the latter, we do not restrict our attention to patents since firms use various means of protecting their innovation benefits including both legal protection and non-legal ones, the complexity of production methods, and trade secrets, as shown in Figure 6. We therefore construct variables to capture whether a firm uses legal or non-legal means. For the explanatory variables, we use a similar set of variables as that adopted in the first step. We add firm's R&D expenditures, which are regarded as being endogenously determined in the first stage. Many empirical studies including CDM indeed consider 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 an explanatory variable to explain the protection of the innovation benefit (Hypothesis 7).

The third set of equations captures firm 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 the analysis of economic outcomes of product innovation; this is because such variables can in theory capture the effect of cannibalization. As for 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 the value of one if the firm provides its technology through the channels of open sourcing and participation in consortia, and zero otherwise.

We include three types of explanatory variables for the equations that determine the sales of a new product and technology provision. First, we include new-to-market product innovation and the protection of innovation benefits, which are both endogenously determined in the first stage as mentioned above. Following CDM and Duguet (2006), these innovation outcomes may have positive impacts on firm performance. Second, we use the same explanatory variables as adopted in the second stage to employ as control variables. As a result, we control for the effect of demand and technological conditions, firm size (namely, the number of employees), and product diversification. Third, we consider the acquisition of tangible fixed assets and the number of R&D personnel, which correspond to explanatory variables in the third stage employed by CDM.[16] On the contrary, for the explanatory variables 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 firm's total sales in FY2006. We also include the firm-size and industry dummies. With this equation at hand, we aim to quantify the degree of cannibalization, to what extent innovation novelty affects the degree of cannibalization.

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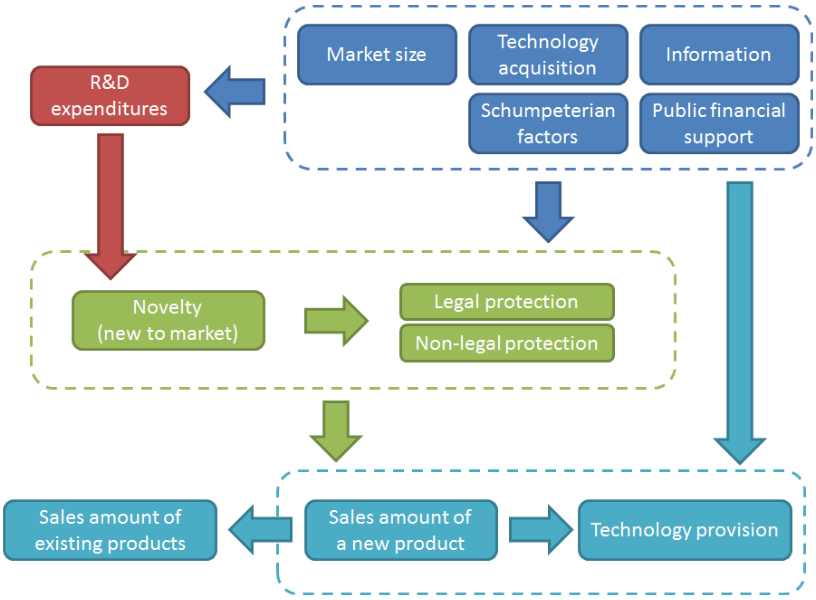
[16] CDM include physical capital and the shares of engineers and administrators in the total number of employees.

Figure 8 summarizes the structure of the model mentioned above. We statistically test 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. First, we incorporate innovation height, or novelty, into the model. As stated in Section 1, it is important for us to discuss product innovation in terms of its height because new-to-market product innovation could likely affect firm performance, leading to technological spillovers. Second, we consider both legal and non-legal means to protecting innovation benefits. Previous literature, while it recognizes that patent is not a sufficient means to protecting knowledge (Levin, Klevorick, Nelson and Winter, 1987), has not sought for non-legal means in a systematic way. Third, we separately consider firm sales of both new and existing products as the measures of firm performance. While CDM consider the percentage of firm's innovation-related sales in their second stage, which is equivalent to the sum of firm's sales of new and existing products, such an approach may not be adequate to capture cannibalization. Fourth, we consider both the inflow and the outflow of technology by using information on firm's acquisition and provision of technology. Most studies including CDM have not included outflow in their analytical framework.

4.1.2. Estimating equations

We propose estimating equations for firm *i* based on the proposed model. Equation (1) corresponds to the first part of the model, the determination of firm R&D expenditures. Because there are many firms with zero R&D expenditures, we choose to use a Tobit model:

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

where $R\&D_i$ represents firm's R&D expenditures, and $x_{1,i}$ includes the dummy variables that capture respectively industry, market expansion, technology acquisition, information, firm size, product differentiation, and public financial support, along with 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 following Probit models:

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

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

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

In which the variables $Novelty_i$ represents whether product innovation is new to market (which takes the value of 1), or otherwise (which takes the value of 0), $legal_i$ 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.[17]

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 the variables $Newsales_i$ 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 the participation to consortia, $x_{5,i}$ includes $x_{2,i}$, purchased tangible fixed assets and the number of workers in

[17] We omit firm's R&D expenditures from Equations (3) and (4) to avoid problems of numerical convergence.

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 Summary Statistics

We estimate the parameters in this system of the equations by using the 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 height and novelty of product innovation. This restriction causes little problem as long as we focus on the economic impact of product innovation *conditional on* firm conducting innovation activities and achieving product innovation. Note that the estimates in CDM are also for firms that achieve innovation.

We omit observations with missing values for the model variables. The characteristics of the omitted firms are similar to those without such missing values.[18] The resulting sample size is 539.[19] 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%

18 There is little difference in the average size, age, and industry of the sampled firms. However, we cannot reject the hypothesis that there is no difference in the average sales and age of the two subsamples based on obtained *t*-tests. Neither can we reject the hypothesis that the existence of missing values and the firm's industry classification are independent based on the Pearson chi-square test statistics.

19 The original sample size was 1,224, before we omit the observations.

	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 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 a possible sampling bias by the 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 control variables, including 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 additional explanatory variables. 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 explanatory variables discussed in Section 4.1. For the demand side, market expansion is estimated and statistically significant. On the contrary, the estimated coefficients of the dummy variables for technology push are mostly insignificant. Two of the exceptions are technology acquisition through corporate reorganization (e.g., buyout or split-up), and open sourcing, which positively affect firm’s R&D investment. Schumpeterian factors are estimated to have little effect on firm’s R&D investment, implying that they do not directly determine firm’s innovation activities once we control both 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 not significantly different from zero under specification (1-a). The results are similar to those under (1-a), with the only difference being that the coefficient of the large-firm dummy is estimated significantly positive. Our results are consistent with the findings of Cohen and Klepper (1996) and Klepper (1996), which argue that firm size has positive impacts 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 explanatory variables discussed in Section 4.1. Interestingly, R&D expenditures have no significant impact on the success of new-to-market product innovation. This result contrasts with the result put forward by Duguet (2006), which finds a positive impact of firm's formal R&D on the degree of novelty in innovation. One reason for the difference in our result is that Duguet (2006) does not fully control for the effect of demand and technological opportunity as we try to do in the presented analysis. While we find no positive impact of market expansion on innovation novelty, some of the coefficients of technology acquisition and information sources are significant. In particular, technology acquisition through accepting new researchers and information from universities both have positive effects on innovation novelty, the latter which is consistent with Hypothesis 6. Similar to the results of previous studies, universities seem to be an influential information source for new-to-market innovations. Lastly, public financial support has no significant impact on new-to-market innovators, rejecting 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	0.29	*	0.28	*	0.33	**

	etc.						
	(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).[20] Specifications (3-a) and (4-a) include all the explanatory variables discussed in Section 4.1 except for firm's R&D expenditures and industry dummies.[21] On the contrary, specifications (3-b) and (4-b) further omit the technological factors whose coefficients are estimated not significantly different from zero.

In the table, we find that innovation novelty has a significant positive impact on both legal and non-legal protection. The estimated coefficients suggest that firms with new-to-market product innovation are *no* more likely to use legal protection relative to non-legal ones. Hence, we cannot reject Hypothesis 7.

[20] Unfortunately, the effectiveness of the instruments is rejected for specifications (3-a), (3-b), and (4-b), the issue which we leave for future research.
[21] We omit these variables in order to avoid a numerical 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 here because otherwise all estimated coefficients became insignificant.[22] 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.

[22] 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 specification (5-a), new-to-market product innovation has a significant positive effect on the sales of new product, which is consistent with Hypothesis 1. This implies that new-to-market product innovation would help firms away from severe competition. On the contrary, the coefficient of legal protection is estimated to be negative. Legal means of protecting the innovation benefits do not affect firm performance in terms of innovation-related sales here. The other estimates show that firms with many employees, R&D workers, and tangible fixed assets tend to increase the sales from product innovation for those innovation that attain more than or equal to the median of the sales distribution.

Specification (5-b) is similar to (5-a), except that the coefficient of public financial support is estimated significantly negative. However, it is likely that this estimate captures the difference in the market environment because specification (5-b) omits the industry dummies.

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)					
						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)					
						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 specification (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 that the cannibalization effect is attenuated with innovation novelty, which is consistent with Hypothesis 3.

Specification (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 to be 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 insignificant. 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 variables.

For all specifications, the coefficient of innovation novelty is estimated significantly positive. This estimate implies that the firm with new-to-market product innovation is more likely to provide its technology through open sourcing and/or consortia, which is consistent with Hypothesis 4. Hence, novel product innovation is likely to exhibit 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)		
				-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)		
				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.

Our results are generally 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 accompany monetary compensation.

In view of our findings that new-to-market product innovation significantly improves firm performance and exhibits 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. As a caveat, public financial support may not always stimulate new-to-market product innovation, especially for small-sized firms. How to make small-sized firms work with university may be an important policy agenda to invigorate innovation across the nation.

This paper mostly focuses on Japanese experience based on the information available from JNIS. While our finding is mostly comparable to French experience found in Duguet (2010), it would be an interesting enterprise for researchers to compare with Korean experience, where product innovation is much more active than either Japan or France, as presented in Figures 1 and 2. International research collaboration between Korea and Japan to match Korean National Innovation Survey (KNIS) with JNIS would warrant fertile research and policy studies not only for both countries, but also for other Asian countries.

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