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# Innovation Height and Firm Performance: An Empirical Analysis from the Community Innovation Survey†

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*This study evaluates the economic impact of product innovation by using firm-level data from the Community Innovation Survey conducted in Japan. It accounts for possible technological spillover from innovation activities and examines the extent to which new-to-market product innovations contribute to firm performance. Econometric analysis using a simultaneous equation model reveals that new-to-market product innovation is likely to increase a firm's sales without cannibalizing those of existing products and generate more technological spillover to other firms. Moreover, such innovation is more likely to emerge from firms collaborating with academic institutions. The paper concludes by discussing policy implications of these findings as well as points to the importance of cross-country comparison between Korea and Japan.*

Key Word: Product innovation, New to market, Spillover, Community innovation survey
JEL Code: C36, O31, O33, O38

## I. Introduction

While there is widespread agreement that innovation matters for growth, there is no conclusive evidence on what types of innovation best foster growth or which factors determine the types of innovation achieved. This paper, drawing on a unique innovation survey conducted in Japan, attempts to answer these questions with a particular focus on product innovation. The innovation survey used here identifies

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two types of product innovations: new-to-market (or radical) and new-to-firm (or incremental).[1] The latter covers the diffusion of an existing innovation to an additional firm; the innovation may have already been implemented by other firms but it is new to the firm in question. Firms that are the first to develop an innovation, in contrast, are classified as having achieved new-to-market innovation. Data on innovation types can help us assess whether there is a threshold level for the extent of innovation (i.e., "innovation height") that leads to higher growth. This paper is the first attempt to examine the causes and consequences of innovation heights using firm-level analysis within an Asian country. Improving collective knowledge on this aspect of innovation is crucial for designing relevant policies.

Innovation encompasses a wide range of activities and processes, including marketing, organizations, and knowledge transfers. Product innovation is, by definition, novel. The degree of novelty, however, differs by the product in question (Arundel and Hollanders 2005). Specifically examining new-to-market product innovation can add new insight to the existing literature in two respects. First, new-to-market product innovation may contribute to firm performance to a greater extent than lesser innovation, as it provides a firm with temporary market power (Petrin 2002). Second, new-to-market product innovation may entail technological spillover to other firms, spurring further innovative activities; this topic has attracted considerable attention both theoretically and empirically.[2] For example, recent studies of endogenous growth theory (e.g., Grossman and Helpman 1991; Aghion and Howitt 1992; Klette and Kortum 2004) indicate that spillover from firms at the technological frontier play an important role. If new-to-market product innovation results in significant positive spillover, policies to promote such innovation would be justified from a social-welfare perspective (Spence 1984).

Given this policy importance, this study quantitatively examines the nature of new-to-market product innovation in an effort to better understand its contribution to firm performance and its possible need for public policy attention. We propose an econometric model that comprises technological spillover, legal and non-legal protection measures, and other important variables relevant to new-to-market product innovation. Our model is similar to that proposed by Crépon, Duguet, and Mairesse (1998) (hereafter CDM) in that it also consists of a system of equations.[3] However, our estimation addresses possible endogeneity, an issue largely neglected in CDM. We then apply this model to firm-level data from the Japanese National Innovation Survey (JNIS).

Despite its economic importance, little empirical work has focused on the height and novelty of product innovation. To the best of our knowledge, Duguet (2006) is the only exception. The present study builds on Duguet (2006) but differs in three important ways. First, Duguet (2006) lumps together product and process innovations into one basket even though the economics underlying the two types of

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[1]Since the former is novel only for the firm in question, new-to-market innovation encompasses new-to-firm innovation.

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

[3]The CDM approach has been adopted by other researchers, including Griffith, Huergo, Mairesse, and Peters (2006) with regards to France, Germany, Spain, and the UK and by Chudnovsky, López, and Pupato (2006) in a study of Argentina.

innovations is significantly different (e.g., Klepper 1996). In contrast, we focus solely on product innovation to clarify our analysis and interpretation. Second, we use sales, rather than productivity, as a measure of firm performance. It has been argued that productivity may be an inappropriate metric for assessing product innovation (e.g., Van Leeuwen and Klomp 2006; De Loecker 2011). Lastly, in order to capture the influence of technological spillover, we consider both technology outflow and inflow; Duguet (2006) focuses only on technology inflow. Incorporating technology outflow provides us with an unbiased picture of technological spillover in the context of JNIS.

The rest of this paper is organized as follows. Section II provides an overview of innovation activities across the major countries that conduct innovation surveys. Section III proposes a series of hypotheses on the relationship between new-to-market product innovation and firm performance (Section III.A), technological spillover (Section III.B), and other characteristics including information sources, legal and non-legal protections, and public financial support (Section III.C). Section IV crafts an econometric model to test the hypotheses and then presents the results of the estimations. Section V concludes the paper.

## II. Surveys of Product Innovation[4]

While innovation is inherently difficult to quantify and measure, there have been several efforts to develop survey-based indicators. Traditional indicators of product innovation include R&D expenditures and patents. These indicators, however, are mere inputs into the innovation processes as they do not capture key aspects of innovation processes and outputs, as noted by Griliches (1987, cited in Smith 2005). As such, targeted innovation surveys have been developed to collect qualitative and quantitative data on innovation activities within firms and on the successful introduction of different types of innovations into the market. These surveys deliberately seek to obtain data on innovation outputs and inputs beyond the traditional indicators of innovation (OECD 2009).[5]

In innovation surveys, firms are asked to provide information on inputs, outputs, and behavioral dimensions of their innovation activities. On the input side, innovation surveys measure a firm’s intangible assets; beyond R&D expenditures, these include 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 attributable to new products. Other indicators capture the nature of the innovative activities, including their impacts, collaborations and linkages with other firms or public research organizations, perceived obstacles to innovation, and knowledge flows (OECD 2009).

To ensure the quality of innovation surveys, the Organization for Economic Cooperation and Development (OECD) developed a manual known as the Oslo

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

[5]The JNIS results show that 47.3% of firms conducting innovation activities report that R&D expenditures are zero; similar phenomena are reported in Arundel, Bordoy, and Kanerva (2008) and have been observed in other countries.

Manual (OECD 1992) and synthesized the results of earlier innovation surveys—notably the Yale Survey on Industrial Research and Development and the Carnegie-Mellon University R&D Survey in the United States.[6] The OECD Oslo Manual identifies product and process innovations as technological innovations; 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, including significant changes in techniques, equipment, and/or software (OECD 2009).

The European Commission, via a joint initiative of Eurostat and the Directorate-General for Enterprise and Industry, followed up the OECD initiative to implement the Community Innovation Survey (CIS), which seeks to collect internationally comparable firm-level quantitative measures of innovation inputs and outputs. The basic CIS format has now been applied in many other countries, including South Korea and Japan. Figure 1 takes advantage of this rich set of data to list the countries with the highest proportions of respondent firms with either product innovation (left panel) or process innovation (right panel).[7] Casual observation indicates that those countries with the highest portions of firms product innovations also exhibit high shares for process innovations; indeed, the rank correlation is 0.71. While the data for Korea refers only to the manufacturing sector, its share of firms with product innovation (35.7%) far higher than that of Japan (20.3%). This order reverses for process innovation: 26.6% for Japan and 22.5% for Korea.

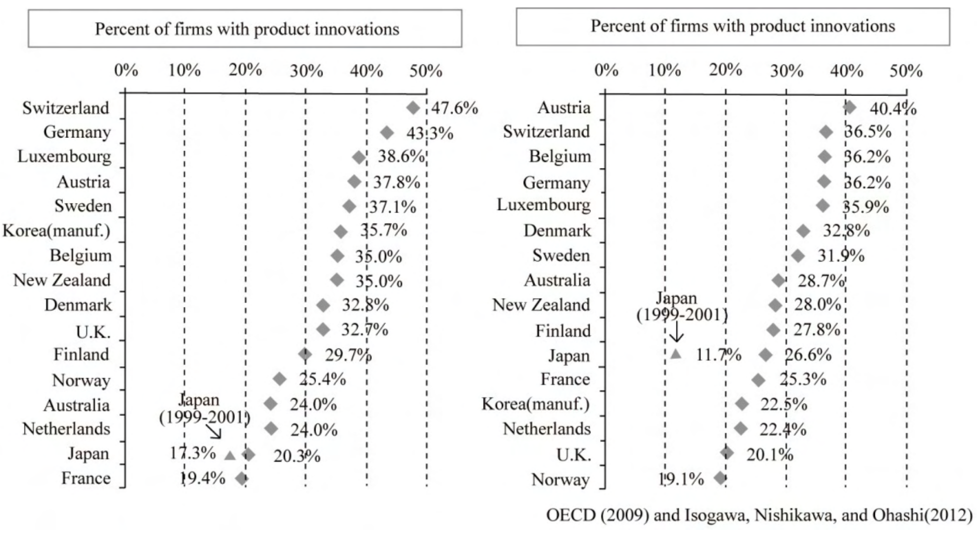


FIGURE 1: PRODUCT AND PROCESS INNOVATIONS: AN INTERNATIONAL COMPARISON

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

[7]The national innovation surveys from which these results come were conducted between 2002 and 2004, except for Japan (2006 to 2008), Switzerland (2003 to 2005), and Australia and New Zealand (2004 to 2005). The proportions listed in the figure are adjusted based on country differences in terms of firm-size distributions to enable us to make an international comparison.

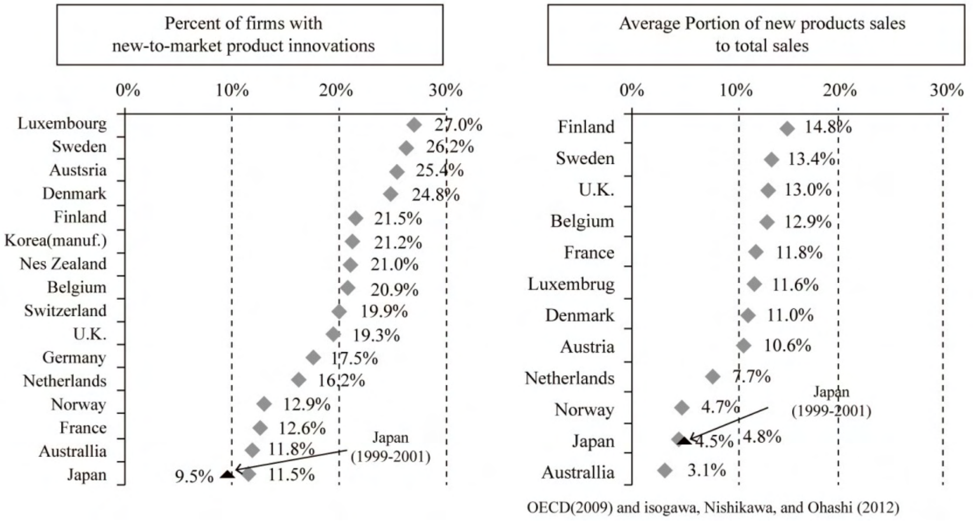


FIGURE 2: PRODUCT INNOVATION HEIGHT AND SALES

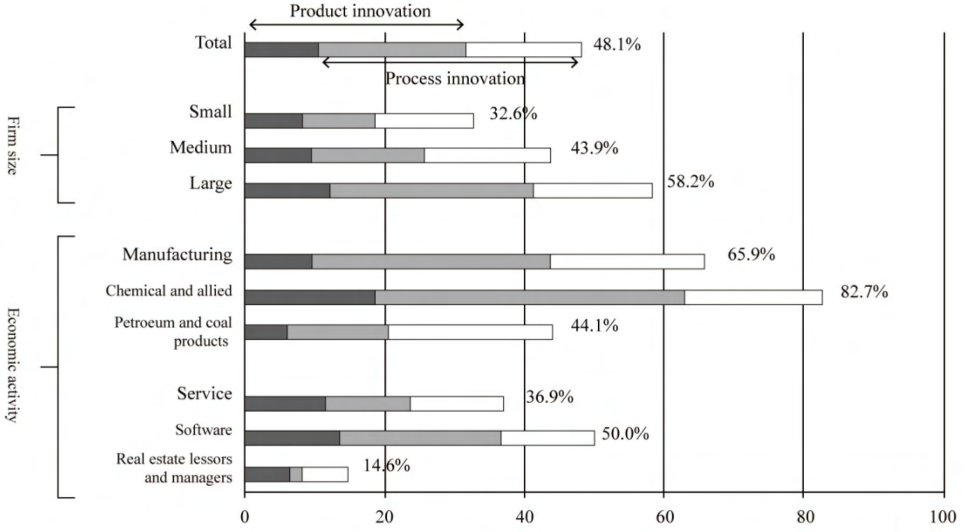


FIGURE 3: SUMMARY STATISTICS OF FOR JNIS

The Oslo Manual distinguishes between the two types of innovation noted in the introduction: new-to-firm and new-to-market. We consider the height of product innovation to be represented by the new-to-market product innovation. Figure 2 thus considers this type of innovation. The left panel presents the proportion of respondent firms that achieved such innovations. The rank correlation between product innovation (the right panel of Figure 1) and new-to-market product innovation is 0.67. The right panel of Figure 2 shows the average share of total sales that are new product sales.[8]

[8]OECD (2009) lists Korea (only for the manufacturing sector) for the share of firms with new-to-market

The Japaneese National Innovation Survey (JNIS), the dataset used in this paper, follows the Oslo Manual with a reference period from April 1, 2006 to March 31, 2009. Using a stratified sampling technique, a sample of firms were selected from those listed in the Establishment and Enterprise Census 2006, which was conducted by the Statistics Bureau of Japan's Ministry of Internal Affairs and Communications. The sample used here is further restricted to firms with more than 10 employees. The response rate is 30.3%, corresponding to a sample of 4,579 firms. Figure 3 shows the proportions of respondent firms that succeeded in either product or process innovations (or both). The figure indicates that 48.1% of firms in the survey innovated, with a substantial share of those firms having succeeded in both types of innovation. The share of firms that innovated increases with firm size and is higher for the manufacturing sector than the service sector.

## III. Hypotheses Related to New-to-Market Product Innovation

This section proposes eight hypotheses related to new-to-market product innovation, which will be tested in Section IV. The present section consists of three subsections. Section III.A discusses how new-to-market product innovation might improve firm performance. The second subsection focuses on technological spillover in innovation activities. Section III.C then discusses policy issues.

### A. *Firm Performance*

First, we examine the effect of product innovation on firm performance. This can be analyzed by decomposing firm performance into two dimensions: sales of new and existing products. This is shown in Figure 4, where the horizontal axis represents changes in sales of a new product and the vertical axis measures changes in the sales of existing goods. It is often assumed that the introduction of a new product

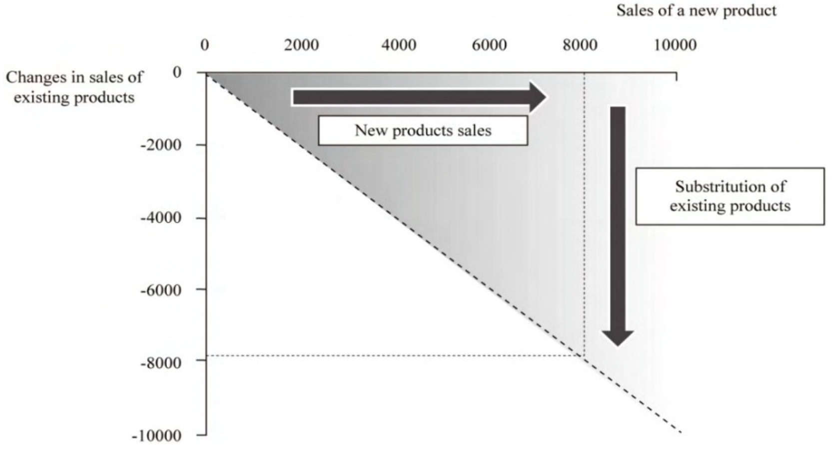


FIGURE 4: PRODUCT INNOVATION AND FIRM SALES

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innovations, but no data for Korea is available for new product sales as a portion of total sales.

cannibalizes existing goods' sales. If demand for a new product is a perfect substitute for demand for existing goods, the net effect of product innovation on the firm's total sales is indicated by the (negative) 45-degree line in the figure. If the new good does not substitute for old goods whatsoever, the net total sales would be in the full area above the (negative) 45-degree line, as represented by the grey area in Figure 1.

Consistent with this view, Duguet (2006) shows that only new-to-market innovations (i.e., radical innovations) can improve a firm's net-performance. Barlet, Duguet, Encaoua, and Pradel (1998) also indicate that the novelty of an innovation can increase the share of sales that are innovation-related in situations where technology is important. The following hypothesis captures this effect:

> Hypothesis 1: *The sales of a new product are larger for a firm achieving new-to-market product innovation than for a firm offering new-to-firm product innovation.*

According to JNIS sales information from JNIS,[9] the average sales value of new products in FY2008 was 5,586 million JPY for firms with new-to-market product innovations and 3,004 million JPY for other firms. Figure 5 shows a box-plot of the sales of a new product for firms with new-to-market product innovation and for those with new-to-firm product innovation. The top and bottom of the rectangle in each graph represent the 25th and 75th percentiles of the sales distribution, respectively, and the dashed line represents the median. Median sales are 196 million JPY for new-to-market product innovations and 164 million JPY for new-to-firm innovations. Moreover, it should be noted that the 75th percentile of sales value for new-to-market product innovation is much higher than that for new-to-firm product innovation.

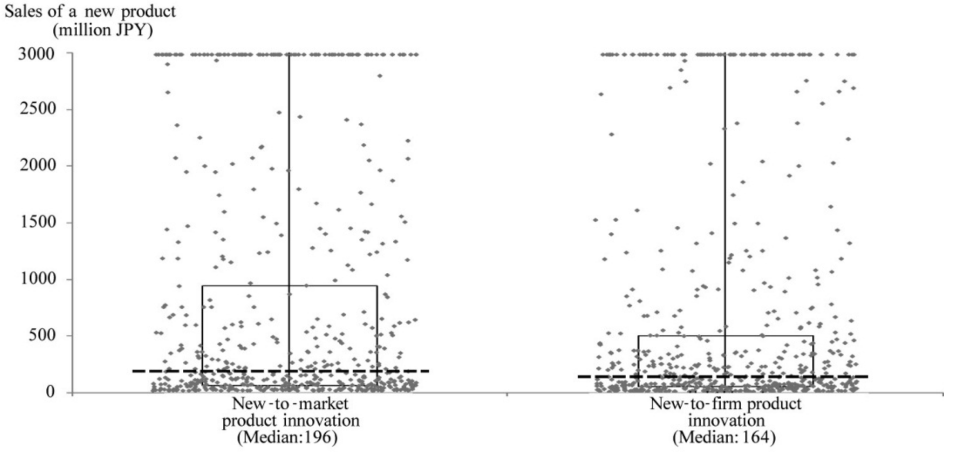


FIGURE 5: INNOVATION HEIGHT AND NEW PRODUCT SALES

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

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

Hypothesis 2: *Higher sales of a new product decrease sales of a firm's existing products.*

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

To test Hypotheses 2 and 3, we must understand the impact of product innovation on the sales of a firm's existing goods. We thus calculate the changes in the sales of existing products from FY2006 to FY2008. The left-hand panel of Figure 6 plots the relationship between sales of a newly introduced product (including both new-to-market and new-to-firm product innovations) and changes in the sales of existing products, following the analytical framework discussed in Figure 4.[10] Sales arising from product innovation appear to cannibalize sales of existing goods. This observation is consistent with Hypothesis 2 in that the introduction of a new product substitutes the demand for existing goods. The change in total sales (i.e., the sum of the changes in the sales of existing goods and of those resulting from new-to-market product innovation) is uniformly positive and approximately 1,500 million JPY on average.

The right-hand side of Figure 6 plots the same relationship separately for firms with new-to-market product innovation and those with new-to-firm product innovation, showing a significant difference between the two. The average relationship for firms with new-to-firm product innovation lies almost on the (negative) 45-degree line, indicating that sales of these new-to-firm products fully

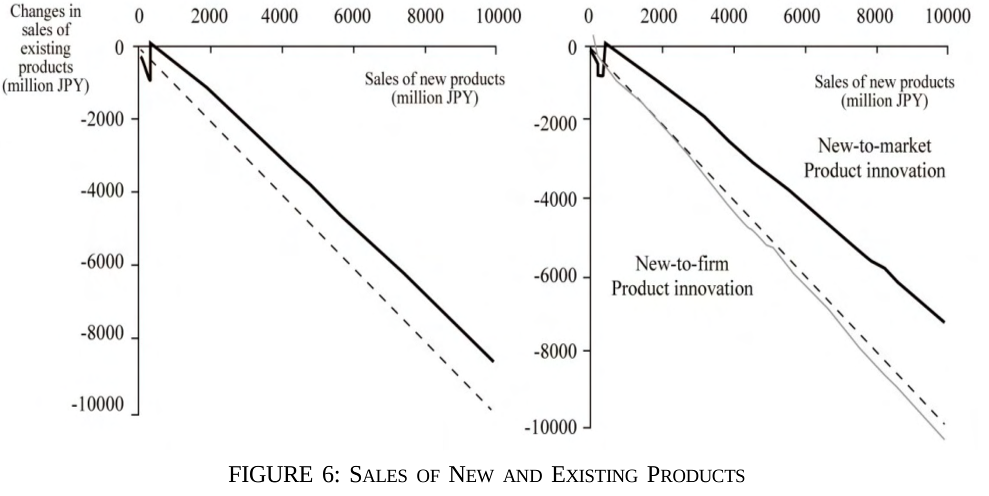


FIGURE 6: SALES OF NEW AND EXISTING PRODUCTS

[10]We use LOWESS (Locally Weighted Scatterplot Smoothing) to smoothen the algorithm.

cannibalize existing-good sales. On the contrary, the average relationship for firms with new-to-market product innovation lies well above the line; sales of a new-to-market product increase the firm's total sales. Instances of cannibalization between new and existing goods is thus less severe with regard to new-to-market product innovation than for new-to-firm product innovation. These observations are consistent with Hypothesis 3. Combining the insights of Figures 5 and 6 suggests that new-to-market product innovation increases a firm's total sales, even with the loss due to cannibalization.

### B. *Technological Spillover*

Economics researchers, most notably Arrow (1962), point out that an innovating firm cannot fully appropriate all outcomes of its innovation activities owing to the existence of technological spillover. In contrast to the findings of several studies (e.g., Bloom, Schankerman, and van Reenen 2013), we directly collect self-reported data on technological spillover as extracted from information on a firm's technology acquisitions (i.e., inflows) and technology provisions (i.e., outflows). Of special importance are technology provisions through channels that are less likely to include monetary compensation, such as open-sourcing and consortia participation. If firms do not consider this type of spillover when deciding whether to undertake innovation activities, innovation could be under-supplied by the private sector.

A number of recent studies of endogenous growth theory (e.g., Grossman and Helpman 1991; Aghion and Howitt 1992; Klette and Kortum 2004) and some on dynamic estimation (e.g., Xu 2006) assume the presence of technological spillover arising from firms at the technological frontier through nonmonetary channels. Considering that the firms undertaking new-to-market product innovation are more likely to be situated near the technological frontier, we propose the following hypothesis:

Hypothesis 4: *Firms with new-to-market product innovation are more likely than firms with new-to-firm product innovation to provide their technology through open-sourcing or participation in consortia.*

Among the empirical studies focused on technology inflow, Kaiser (2002) considers incoming spillover effects to examine the relationship between research cooperation and research expenditures. His results indicate that horizontal spillover leads to firms to engage in aggressive investments in innovation through research collaborations. In a similar vein, Branstetter and Sakakibara (2002) examine research consortia using the approach taken by Katz (1986), finding 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 for other firms.*

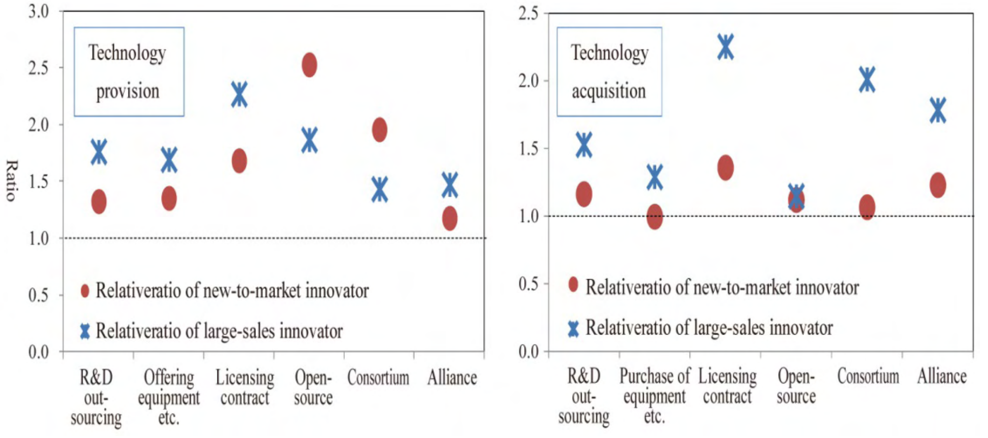


FIGURE 7: TECHNOLOGY ACQUISITION AND PROVISION

Figure 7 summarizes firms' technology acquisition and provision practices based on the information provided by JNIS. Following the Oslo Manual, the figure presents six channels: R&D outsourcing, offering equipment, licensing contracts, outsourcing, consortia, and alliances. The circle and asterisk plotted for each channel in the figure represent the relative firm ratios. The ratios plotted with circles are obtained by dividing the number of firms engaging in the given activity that have new-to-market product innovation by the number of firms engaging in the given activity with new-to-firm innovation. The asterisks refer to the ratio of the number of firms attaining sales at or above the median of the sales distribution (168 million JPY) to the number of firms with sales below the median. While product innovations among those with sales above the median appear to be more common for firms using the channels associated with monetary compensation (e.g., licensing), new-to-market product innovation seems clustered in nonmonetary channels, such as open-sourcing and participation in consortia. This finding is consistent with Hypothesis 4.

The right-hand panel in the figure considers firms' technology acquisition. There is little worth mentioning regarding new-to-market product innovation by means of technology acquisition, but firms with sales above the median tend to acquire technology through licensing and consortia participation in consortia, consistent with Hypothesis 5. Combining this observation with the results shown in the left-hand side of Figure 7 suggests that consortia participation plays a significant role in fostering technological spillover. Indeed, Figure 7 hints that firms with new-to-market product innovation provide their technology to other firms through consortia and that such technological spillover could contribute to higher sales following the introduction of new products.

## C. *Other Characteristics of New-to-Market Product Innovation*

The basic analysis of the previous subsections has suggested that new-to-market product innovation leads to improvements in firm performance and exhibits strong technological spillover. This finding implies that public policies which encourage firms to engage in new-to-market innovation would be justified from a social welfare standpoint. To implement such policies effectively, however, it is necessary to have a deeper understanding of the characteristics of new-to-market product innovation. As such, this subsection focuses on firm characteristics associated with new-to-market product innovation, considering information sources, means of protecting innovation benefits, and public financial support.

1. *Information sources*

Previous studies have examined the relationship between information sources and innovation height. Belderbos, Carree, and Lokshin (2004) examine the relationship between cooperative R&D and firm performance, finding that using information provided by consumers or universities has positive impacts on new product sales and that cooperation with universities likely fosters new-to-market product innovations. Mohnen and Hoareau (2003) also study the degree of firms' interaction between universities and the resulting propensity to generate new-to-market product innovation. However, their results suggest that such interaction does not necessarily result in fruitful outcomes. With a few exceptions,[11] most studies imply that information from universities positively affects innovation novelty, allowing us to summarize this in the following hypothesis:

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

Figure 8 shows the ratios of the different types of firms (innovating and high-selling) utilizing different information sources for their innovation activities. Similar to the definition given in Figure 7, the circles denote the ratios of firms with new-to-market product innovation to firms without among firms using the given information source, and asterisks represent the equivalent for firms with

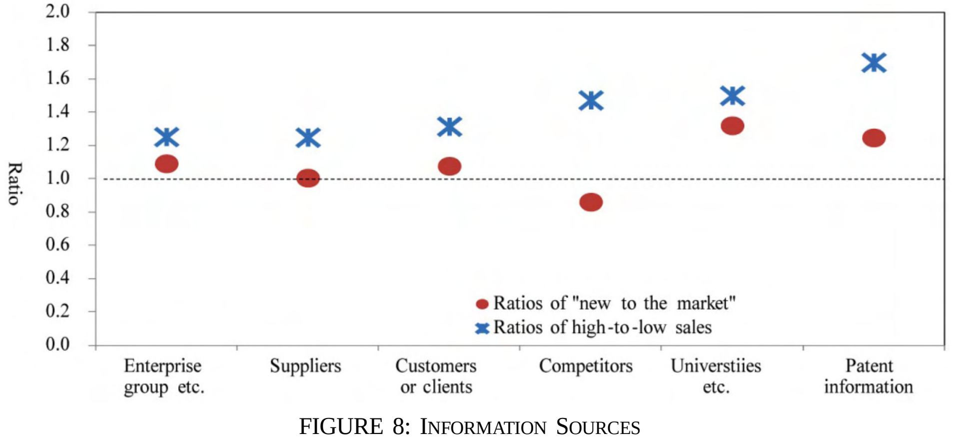


FIGURE 8: INFORMATION SOURCES

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

higher-than-median sales of new products. While firms that attain sales at or above the median from product innovation use various information sources, firms with new-to-market product innovation tend to obtain information from universities or patents held by other firms, supporting Hypothesis 6.

2. *Ways of protecting the benefits of innovation*

While it is usually difficult for firms to fully appropriate innovation benefits, they do make partial efforts to protect them through legal processes (e.g., patent protection) or other means, such as the use of trade secrets. In theory, legal means of protection serve to encourage innovation activities by providing firms with a premium for innovation. Among recent empirical studies, Duguet and Lelarge (2006) examined the effectiveness of patent protection for safeguarding firms' potential rewards from product innovation. However, legal means of protection may not always work perfectly (Levin, Klevorick, Nelson, and Winter 1987). As noted in the previous section, there are potential positive spillover from new-to-market product innovation. In view of this, legal means may not effectively protect the profits arising from new-to-market product innovation. As such, we arrive at the following hypothesis:

> Hypothesis 7: *Firms with new-to-market product innovation are no more likely than firms with new-to-firm product innovation to use legal protection as opposed to non-legal protection.*

Figure 9 summarizes the ratios of firms used to protect innovation benefits. As before, a circle indicates firms with new-to-market product innovation and an asterisk represents new product sales. While firms with above-median sales from product innovation tend to rely more heavily on legal protection, firms with new-to-market product innovation shows no clear patterns with regard to their use of legal and non-legal means. This finding is consistent with Hypothesis 7, indicating that legal means do not fully protect firms' new-to-market product innovations.

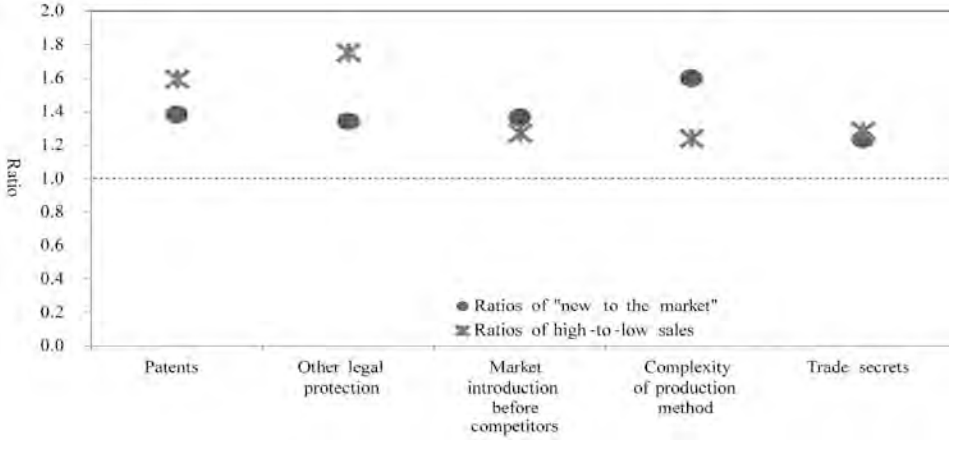


FIGURE 9: MEASURES FOR PROTECTING INNOVATION BENEFITS

3. *Public financial support*

Lastly, we examine public financial support for innovation activities. This topic has been well studied in the literature on R&D subsidies and investment. For example, Almus and Czarnitzki (2003) use a matching method to show that R&D subsidies stimulate firms' innovation activities. González, Jaumandreu, and Pazó (2005) also indicate that some firms would not invest in R&D without subsidies and that this does not crowd-out private R&D investment. In addition, other recent studies consider other, non-subsidy forms of public financial support. Finger (2008), for instance, examines the effect of R&D tax credits by considering the interdependence of firms' R&D investments, showing that such tax credits encourage R&D investments by firms in a limited manner.

Meanwhile, among the 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 such interaction through channels other than information provision also encourages new-to-market product innovation, public financial support could positively impact innovation height and novelty. Hence, we propose the following hypothesis:

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

Figure 10 plots the share of firms with new-to-firm product innovation, indicating whether the firms received public financial support,[12] by firm size.[13]

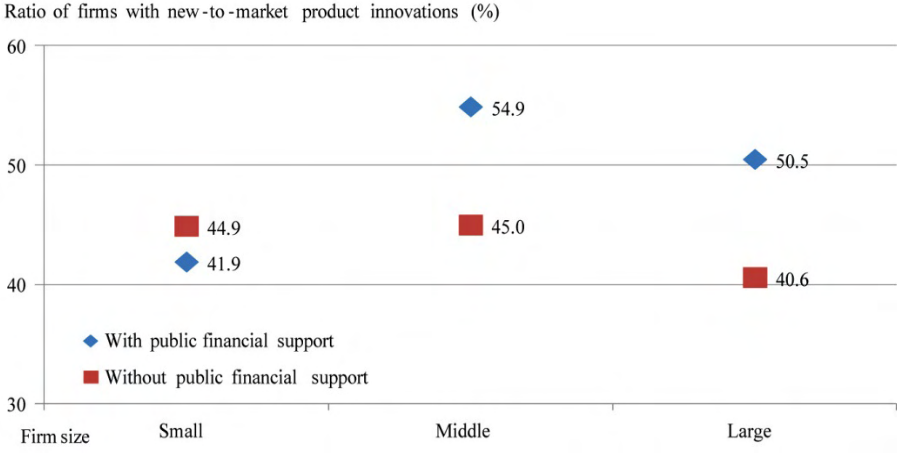


FIGURE 10: NOVELTY AND PUBLIC FINANCIAL SUPPORT, BY FIRM SIZE

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

[13]Small firms have fewer than 50 employees, mid-sized firms have 50–249 employees, and large firms have 250 or more employees.

Among mid- and large-sized firms, a higher share of publicly supported firms produced new-to-market innovations; this is not the case, however, for small-sized firms. Hence, Hypothesis 8 may apply selectively, depending on firm size, perhaps because nonfinancial bottlenecks to new-to-market product innovation exist for smaller firms. For example, small-sized firms are less likely to take advantage of information from universities (Nishikawa, Isogawa, and Ohashi 2010), which may hinder their efforts to conduct new-to-market innovations according to the discussion in Section III.C. In this context, policies that increase interaction between firms and universities may help support innovation among small-sized firms.

## IV. Econometric Analysis

The previous section proposed a series of hypotheses on new-to-market product innovation and examined simple statistical correlations in the JNIS data, which were generally consistent with each of the hypotheses. However, drawing conclusions from such casual observations is inadequate owing to omitted variable bias: firm innovation activities and outcomes are affected by numerous factors, many of which are not controlled for in the previous section. Ignoring the endogeneity of some variables of interest could also distort estimation results. To address these challenges, this section first presents an econometric framework (Section IV.A) and subsequently uses it to determine the robustness of our findings presented in the previous section (Section IV.B).

### A. *Econometric Model and Estimation*

The model proposed here consists of a system of three sets of equations. The first refers to firm R&D investment. As is well known, R&D expenditures are endogenously determined; any analyses that ignore such endogeneity may suffer from biased estimates. We thus follow the approach taken in the existing literature and add an equation to model R&D expenditures. Among the factors that may affect a firm's R&D expenditures, the consumer demand structure is considered to be a major determinant (e.g., Levin and Reiss 1984). This is sometimes called the 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 as well as a dummy that indicates whether the market size expanded during the survey period.

A second factor that may influence R&D expenditures is technological opportunities (e.g., Rosenberg 1974; Levin and Reiss 1984), or the technology-push factor. To capture this effect, we focus on a firm's technology acquisition by firms (i.e., the inflows of technological spillover, as noted in Section III). Specifically, we create variables reflecting technology acquisitions based on the information available in JNIS; namely, we note which channels a respondent firm used to acquire its technology (shown in the right-hand panel of Figure 7).

We also incorporate information sources into the R&D expenditure equation. Certain past studies, including Belderbos, Carree, and Lokshin (2004), focus on information sources as a means of capturing the inflow of technological spillover.

As shown in Figure 8, JNIS includes information on the information sources relied upon by respondent firms, which we use to create a dummy variable. Besides the demand-pull and technology-push factors, CDM explore what is known as the 'Schumpeterian Hypothesis' by including factors that capture the effects of firm size and market power.[14] 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 has undergone product diversification during the survey period. Lastly, we consider public financial support for firms' innovation activities, an issue not addressed in CDM. As described in Section II, 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 financial support from local public agencies or the central government.

The second set of equations captures innovation output by firms. As a measure of output, we focus on innovation height or novelty as analyzed by Duguet (2006), and the protection of the innovation benefits for which a proxy is established by CDM, i.e., the number of patent applications. However, for the latter, we do not restrict our attention to patents as firms use various means of protecting their innovation benefits including both legal and non-legal protection, different degrees of the complexity of production methods, and trade secrets—as shown in Figure 9. We therefore construct variables to capture whether a firm uses legal or non-legal means of protection. For the explanatory variables, we use a set of variables similar to that adopted in the first step, adding a firm's R&D expenditures. These are regarded as endogenously determined in the first stage—indeed, many empirical studies, including CDM, consider a firm's R&D investment to be an innovation input. We omit the number of competitors in the domestic market in this stage, just as CDM omit market share from their second stage. In addition to these variables, we use innovation novelty as an explanatory variable for innovation benefit protection (Hypothesis 7).

The third set of equations captures a firm's sales and its technology provision. For the former, we separately consider sales of both new and existing products. This is important in analyses of the economic outcomes of product innovation as such variables can theoretically capture the effects of cannibalization. With regard to the technology provisions by firms, we focus on the channels less likely to be accompanied by monetary compensation by creating a dummy variable that takes the value of one if a firm provides its technology through open sourcing or consortia participation and zero otherwise.

We include three types of explanatory variables in the equations determining product sales and technology provisions. 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 positively impact firm performance. Second, we use the same explanatory variables identical to those adopted in the second stage as control variables. We thus control for the effects of demand and

[14]Much theoretical work has considered whether market concentration encourages firms' innovation activities. The replacement effect (Arrow, 1962) and the efficiency or Schumpeterian effect (Schumpeter, 1943; 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 impact of these two effects.

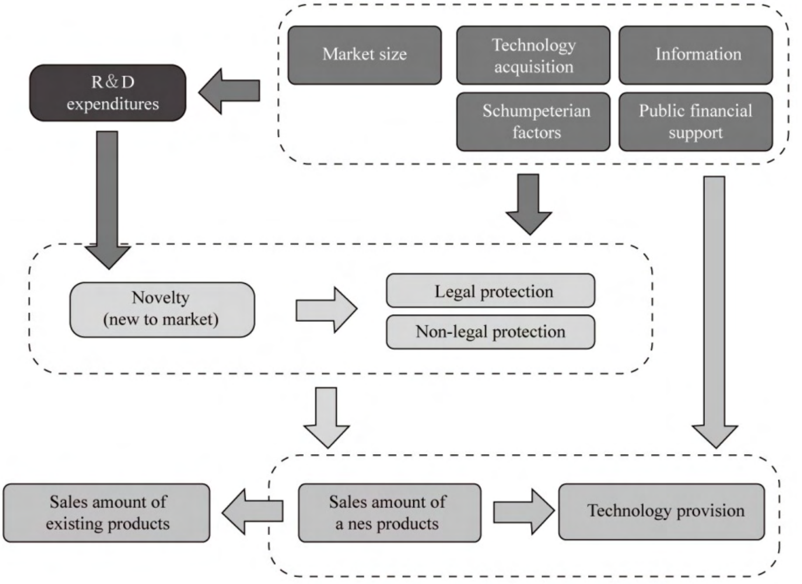


FIGURE 11: OVERVIEW OF THE MODEL

technological conditions, firm size (specifically the number of employees), and product diversification. Third, corresponding to explanatory variables in the third stage of CDM, we consider the acquisition of tangible fixed assets and the number of R&D personnel.[15] In contrast, for the explanatory variables in the equation determining existing products sales, we consider innovation novelty, new product sales, and (as a control variable), the firms' total sales in FY2006. We also include firm-size and industry dummies. With this equation, we aim to quantify the degree of cannibalization and the extent to which innovation novelty affects this. Figure 11 summarizes the structure of the model described above and used to test the hypotheses developed in Section III.

### 1. *Comparison with the CDM model*

Although our model is based on that of CDM, there are four significant differences. First, we incorporate innovation height, or novelty, into the model. As argued in Section I, such an inclusion is important because new-to-market product innovation is likely to affect firm performance, leading to technological spillover. Second, we consider both legal and non-legal means of protecting innovation benefits. Earlier work, while recognizing that patents do not represent a sufficient means of protecting knowledge (Levin, Klevorick, Nelson, and Winter 1987), has not systematically examined non-legal means. Third, we separately consider firm sales of new and existing products as measures of firm performance. While CDM consider in their second stage the share of a firm's sales that is innovation-related (equivalent to the sum of the firms' sales of new and existing products), such an

[15]CDM include physical capital and the portion of employees who are engineers or administrators.

approach may not be adequate to capture cannibalization. Fourth, we consider both the inflow and outflow of technology by using information on the firm's acquisitions and provisions of technology. Most studies, including CDM, do not include outflow in their analytical framework.

## 2. *Estimating equations*

Based on the theoretical framework detailed above, we estimate a set of equations for firm *i*. Equation (1) corresponds to the first part of the model, determining firm's R&D expenditures. Because there are many firms with zero R&D expenditures, we choose to use a Tobit model:

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

$$(1) \qquad R\&D_i = \begin{cases} R\&D_i^* & if \quad R\&D_i^* > 0, \\ 0 & otherwise, \end{cases}$$

where $R\&D_i$ represents the firm's R&D expenditures and $x_{1,i}$ includes the dummy variables that capture, respectively, the factors of industry, market expansion, technology acquisition, information sourcing, 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 of the model. Since the dependent variables are all binary, we choose the following probit models:

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

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

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

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

$$Non\text{-}legal_i = \gamma_4 Novelty_i + x_{2,i}\beta_4 + u_{4,i},$$

$$(4) \qquad where\ u_{4,i} \sim N(0,1) \quad and \quad Non\text{-}legal_i = \begin{cases} 1 & if \quad Non\text{-}legal_i^* > 0, \\ 0 & otherwise. \end{cases}$$

in which $Novelty_i$ is equal to one if the product innovation is new to market (and zero otherwise), $legal_i$ is the legal protection dummy, $Non\text{-}legal_i$ is the non-legal protection dummy, and $x_{2,i}$ is similar to $x_{1,i}$ except that it does not include the number of domestic market competitors.[16]

Equations (5) to (7) correspond to the third part of the analytical framework. For the technology provision equation, we estimate the following probit models:

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

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

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

(7) $$Provision_i^* = \alpha_7 R\&D_i + [Novelty_i,\ Legal_i,\ Non\text{-}legal_i]\eta_7 + x_{5,i}\beta_7 + u_{7,i},$$

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

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

### 3. *Methodology and summary statistics*

We estimate the parameters of this system of equations via 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 (i.e., novelty) of product innovation. This restriction causes few problems as long as we focus on the economic impact of product innovation conditional on a firm conducting innovation activities and achieving product innovation. Note that CDM also examine only firms achieving innovation.

We omit observations with missing values for any of the models’ variables; the characteristics of the omitted firms are similar to those without missing values.[17] The resulting sample size is 539.[18] Table 1 presents summary statistics for the models’ variables.

TABLE 1—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 | | | |
| | Mid-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 |

*(Continued)*

[17]There is little difference in the average size, age, and industry of the sampled firms. However, our obtained t-test results do not allow us to reject the hypothesis that there is a difference in average sales and firm age between the two subsamples. We also cannot reject the hypothesis of a correlation between the existence of missing values and the firm’s industry classification, based on Pearson chi-squared test.

[18]The original sample size was 1,224 before we omitted these observations.

TABLE 1—SUMMARY STATISTICS *(Continued)*

| | | Mean | Std. Dev. |
|---|---|---|---|
| Information | | | |
| | Enterprise group, etc. | 77.50% | 41.80% |
| | Suppliers | 57.90% | 49.40% |
| | Customers or clients | 68.50% | 46.50% |
| | Competitors | 36.40% | 48.20% |
| | Private research institutes, etc. | 24.20% | 42.90% |
| | Universities, etc. | 34.20% | 47.50% |
| | Public research institutes | 28.60% | 45.20% |
| | Academic conference, etc. | 36.40% | 48.20% |
| | Professional publications, etc. | 43.20% | 49.60% |
| | Exhibitions, etc. | 53.70% | 49.90% |
| | Patent information | 37.50% | 48.50% |
| Technology acquisition | | | |
| | Buyout | 9.70% | 29.60% |
| | R&D outsourcing | 37.00% | 48.30% |
| | Purchase of equipment, etc. | 51.30% | 50.00% |
| | Company split-up | 5.30% | 22.40% |
| | Licensing contract | 20.50% | 40.40% |
| | Open 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% |
| | Non-legal means | 72.00% | 45.00% |
| Observations | | 539 | |

We attempt to correct for possible sampling bias via the following method. First, for all firms included in JNIS, we regress a dummy variable indicating whether a given firm is included in our estimation sample on a set of control variables, including the firm's total sales, sales cost, total wages, and firm-size and industry dummies. Then, we calculate the residual for each firm and include these values in Equations (1) to (7) as an additional explanatory variable. The estimation results differ little from the results as reported in the next section.

## B. *Estimation Results*

Table 2 shows the results of estimating Equation (1). Specification (1-a) includes all the explanatory variables discussed in Section IV.A. Considering the demand side, market expansion is estimated to be statistically significant, whereas the estimated coefficients on the dummy variables for technology-push factors are mostly insignificant. Two exceptions are technology acquisition through corporate reorganization (e.g., a buyout or split) and open sourcing, both of which positively affect a firm's R&D investment. Schumpeterian factors are estimated to have little effect on a firm's R&D investment, implying that they do not directly determine a firm's innovation activities once both demand-pull and technology-push factors are controlled for. The coefficient on public financial support is significant and positive.

TABLE 2—ESTIMATION RESULTS, EQUATION (1)

| | | Tobit model<br>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 | Mid-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) | |
| Industry dummies | | Yes | No | No |

*Notes:* ***, **, and * indicate that the estimate is significant at the 1%, 5%, and 10% level, respectively. “s.e.” refers to the standard error.

Specifications (1-b) and (1-c) omit the industry dummies and technological factors with insignificant estimated coefficients in specification (1-a). These results are similar to those of (1-a) except that the coefficient on 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 positive impacts on innovation activities.

Table 3 presents the results of estimating Equation (2). Specification (2-a) includes all explanatory variables discussed in Section IV.A. Interestingly, R&D expenditures show no significant impact on the success of new-to-market product innovation, in contrast to the result of Duguet (2006) that there is a positive impact of a firm's formal R&D activities on the degree of innovation novelty. One reason for the difference in results is that Duguet (2006) does not fully control for the effect of demand and technological opportunity, whereas we attempt to do so in the present analysis. While we find no positive impact of market expansion on innovation novelty, some of the coefficients on the technology acquisition and information source indicators are significant. In particular, the indicator for acquiring technology by accepting new researchers and that for doing so via sourcing information from universities both have positive effects on innovation novelty; the latter effect is consistent with Hypothesis 6. Similar to the results of previous studies, universities appear to be influential sources of information for new-to-market innovations.

TABLE 3—ESTIMATION RESULTS, EQUATION (2)

| | | Probit model<br>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 | 0.390 | 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) |

*(Continued)*

TABLE 3—ESTIMATION RESULTS, EQUATION (2) *(Continued)*

| | | Probit model<br>Dependent variable: Innovation novelty | | |
|---|---|---|---|---|
| | | (2-a) | (2-b) | (2-c) |
| 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 | Mid-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 the 1%, 5%, and 10% level, respectively. "s.e." refers to the standard error.

Lastly, public financial support has no significant impact on new-to-market innovators, leading us to reject Hypothesis 8. This finding might arise partly because nonfinancial factors, including the utilization of information from universities, are essential for fostering new-to-market innovation, as noted in Section III.C.3. Specifications (2-b) and (2-c) omit the industry dummies and technological factors with insignificant coefficients in (2-a); the results are essentially the same for (2-a).

Table 4 reports the estimated coefficients for Equations (3) and (4). [19] Specifications (3-a) and (4-a) include all of the explanatory variables discussed in

[19]Unfortunately, the effectiveness of the instruments is rejected for specifications (3-a), (3-b), and (4-b), an issue we leave for future research.

Section IV.A except for the firm's R&D expenditures and industry dummies[20] whereas specifications (3-b) and (4-b) also omit the technological factors with insignificant estimated coefficients. The results indicate that innovation novelty has a significant positive impact on the likelihood of seeking each type of protection (legal and non-legal). The estimated coefficients, however, do suggest that firms with new-to-market product innovation are no more likely than other firms to use legal protection as opposed to non-legal means. Hence, we cannot reject Hypothesis 7.

TABLE 4—ESTIMATION RESULTS, EQUATIONS (3) AND (4)

| | | Probit model | | | |
|---|---|---|---|---|---|
| | Dependent variable: | Legal protection | | Non-legal 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) |

*(Continued)*

[20]We omit these variables in order to avoid a numerical convergence problem.

TABLE 4—ESTIMATION RESULTS, EQUATIONS (3) AND (4) *(Continued)*

| | Dependent variable: | Probit model: Legal protection (3-a) | Legal protection (3-b) | Non-legal protection (4-a) | Non-legal protection (4-b) |
|---|---|---|---|---|---|
| Information | 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 | Mid-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 the 1%, 5%, and 10% level, respectively. "s.e." refers to the standard error.

Table 5 reports the results of estimating Equation (5). We omit the technological variables from these specifications because otherwise all estimated coefficients become insignificant.[21] Specifications (5-a) and (5-b) include the logarithms of the value of tangible fixed assets acquired and of the number of workers in R&D with and without industry dummies, respectively, whereas specifications (5-c) and (5-d) do not.

The results of estimating specification (5-a) indicate that new-to-market product innovation has a significant positive effect on new product sales, which is consistent with Hypothesis 1. This implies that new-to-market product innovation could help firms stave off severe competition. In contrast, the coefficient on legal protection is estimated to be negative: legal means of protecting the benefits of innovation are not shown to affect firm performance in terms of innovation-related sales in this case. The other estimates show that firms with many employees, larger numbers of R&D workers, and higher values of tangible fixed assets tend to have greater sales from product innovation for those innovations that meet or surpass the median sales distribution.

The results for specification (5-b) are similar to those of (5-a) except that the coefficient on public financial support is estimated to be significantly negative. However, it is likely that this is capturing the difference in the market environment, as specification (5-b) omits the industry dummies.

[21]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.

TABLE 5—ESTIMATION RESULTS, EQUATION (5)

| | | Linear model<br>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) |
| Non-legal protection | | 1.10 | 1.47 | 1.49 | 1.78* |
| | (s.e.) | (0.95) | (1.01) | (0.92) | (0.98) |
| Market expansion | | 0.21 | 0.210 | 0.53*** | 0.54*** |
| | (s.e.) | (0.19) | (0.19) | (0.18) | (0.18) |
| Firm size | Mid-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 fixed assets | [logarithm] | 0.28*** | 0.31*** | | |
| | (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 the 1%, 5%, and 10% level, respectively. “s.e.” refers to the standard error.

Table 6 shows the results of estimating Equation (6). Specifications (6-a) and (6-b) adopt the specification described in Section IV.A.2 with and without industry dummies, respectively, while specifications (6-c) and (6-d) include the logarithm of the sales of a new product.

The results of specification (6-a) indicate that new product sales have a significant negative effect on those of existing products. This is consistent with the view that a new product cannibalizes a part of the sales of a firm’s existing products, consistent with Hypothesis 2. In contrast, the coefficient on the interaction term for innovation novelty and new product sales is significant and positive, nearly cancelling out the cannibalization term. Hence, we can interpret this finding as indicating that the cannibalization effect is attenuated by innovation novelty, which is consistent with Hypothesis 3.

The results of specification (6-b) are similar to those of (6-a). In specifications (6-c) and (6-d), the coefficients on new product sales and the interaction term are estimated as insignificant, although their signs are the same as in (6-a).

TABLE 6—ESTIMATION RESULTS, EQUATION (6)

| | | Linear model<br>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 | 00.02 |
| | (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 | Mid-sized | 0.04 | 0.03 | 0.07 | 00.07 |
| | (s.e.) | (0.06) | (0.06) | (0.06) | (0.06) |
| | Large | 0.03 | 0.02 | 0.10 | 00.090 |
| | (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 the 1%, 5%, and 10% level, respectively. "s.e." refers to the standard error.

TABLE 7—ESTIMATION RESULTS, EQUATION (7)

| | | Linear model<br>Dependent variable: Technology provision<br>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) |
| Non-legal 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 | Mid-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 fixed assets | [logarithm] | -0.02 | 0.00 | | |
| | (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*: ***, **, and * indicate that the estimate is significant at the 1%, 5%, and 10% level, respectively. "s.e." refers to the standard error.

Finally, Table 7 includes the estimates for Equation (7). We omit the technological variables from these specifications because they are all estimated to be insignificant. Specifications (7-a) and (7-b) include the logarithms of the value of tangible fixed assets acquired and of the number of workers in R&D with and without industry dummies, respectively, while specifications (7-c) and (7-d) do not include these variables. For all specifications, the coefficient on innovation novelty is estimated as significant and positive. This implies that a firm with new-to-market product innovations are more likely to provide their technology through open sourcing and/or consortia, which is consistent with Hypothesis 4. Hence, the technological spillover arising from novel product innovation are more likely to occur through channels that seldom entail monetary compensation.

## V. Conclusion

This study has focused on the degree to which new-to-market product innovation influences firm performance (i.e., sales of new and existing products), technological spillover, and other related characteristics. We proposed eight hypotheses and tested them through empirical analysis of JNIS data from April 2006 to March 2009. Our results are generally consistent with the hypotheses. We found that innovators tend to achieve higher sales from new-to-market product innovations and are less likely to suffer from cannibalization of existing sales. Moreover, new-to-market product innovation tends to result in knowledge spillover to other firms through channels that do not normally assume monetary compensation—i.e., consortia and open sourcing. As is always the case with any empirical research, these empirical results of the paper should be taken cautiously; in particular, because the paper’s estimates could be subject to weak instruments. Further studies on this line warrants fruitful research.

Considering the policy implications of our findings, the result that new-to-market product innovation significantly improves firm performance and is associated with technological spillover suggests that policy interventions promoting such innovation may be beneficial to society. 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. However, we also note that public financial support may not always stimulate new-to-market product innovation, especially for small-sized firms. How to better support small-sized firms to work with universities may be an important policy challenge, which, if solved, would encourage more widespread innovation.

This paper has focused on the Japanese experience owing to information availability. While our findings are generally comparable to the French experience, as analyzed in Duguet (2010), it would be interesting to compare these results to the South Korean experience, where product innovation is much more active than in either Japan or France, as shown in Figures 1 and 2. Collaboration between Korean and Japanese researchers to match the Korean National Innovation Survey with the JNIS might yield research and policy insights useful to not only these two countries but also other Asian economies.

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