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Foreign Direct Investment into Asia and Domestic R&D Intensity of Japanese Manufacturers: Firm-level Relationship

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Abstract

This paper reexamines the relationship between R&D and FDI by exploiting firm-level data of more than 118 thousand Japanese manufacturers. The descriptive statistics and regression results confirm that firms with higher R&D intensity tend to undertake more extensive FDI, even if large numbers of no-FDI and/or no-R&D firms are included. The effect of R&D is more substantial on FDI to industrial countries than FDI to Asia. Firms rich in intangible assets, such as human skills, also appear to prefer majority ownership in FDI, as consistent with the theoretical prediction.

Keywords: Foreign direct investment; R&D; Internalization; Firm-level data.

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1. Introduction

As surveyed in Caves (1996), many previous studies have repeatedly showed that the intensity of research and development (R&D) is positively related with the foreign direct investment (FDI).[1] Although these accumulated results from many industries and countries have immensely contributed to our understanding of FDI, they mostly depend on industry-level data or on limited numbers of firms in a particular industry.[2] Besides, the dependence on FDI data inevitably excludes firms undertaking no FDI and concentrates on the comparison within firms who have already invested into foreign countries.[3] Since the development of FDI varies considerably across industries and across firms even within industry, and since the vast majority of firms have no foreign subsidiaries, we need to explore more comprehensive samples to confirm this stylized fact. Our finding that firms not investing abroad at all are on average equally R&D active as firms investing abroad, as reported later, further motivates our use of firm-level data covering firms with no experience in FDI.

This paper reexamines the relationship between R&D intensity and the extent of FDI by exploiting previously unavailable firm-level data, taking account that our FDI measure is a limited dependent variable. The domestic industry survey, from which this paper derives firm-level data, covers more than 118 thousand Japanese manufacturers, including firms in any size, even firms with no FDI and/or no R&D in all manufacturing industries. Unlike previous studies dependent on FDI data, this paper uses R&D and FDI data, both of which are

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[1] Both Caves (1996) and UN (1992) describe R&D as one of the strongest determinants of FDI among many other firm characteristics, such as advertising, skilled managerial labor, and multi-plant operation. Various industry characteristics, such as entry barriers and tariff protection, have also been considered in studies at the industry level.

[2] Previous studies of Japanese FDI often focused on the electric machinery industry and the sample size is at most around two hundred firms. See Fukao et al. (1994) and Belderbos and Sleuwaegen (1996), for example.

[3] As an exceptional previous study, Belderbos and Sleuwaegen (1996) include 65 no-FDI firms in their analysis of the choice among domestic, FDI to West, and FDI to Asia.

consistently collected in the same survey. The coverage and sample size of our data set are substantially larger than those used by previous studies.

This paper not only reexamines the relationship between R&D and FDI by using a newly available comprehensive firm-level data set, but also investigates the two hypotheses inspired by the previous studies as follows. First, FDI into Asia and FDI into industrial countries are compared. Previous studies based on the data of electric machinery manufacturers in the 1980s, such as Belderbos and Sleuwaegen (1996) and Fukao et al. (1994), found that R&D of a Japanese firm tends to have a positive effect on the firm's FDI into industrial countries, but no significant effect on FDI into Asia. Recent drastic development of Asian economies induces us to reexamine this issue with more recent data because FDI into Asia may now require Japanese firms to accumulate technological advantages in the home country. Hence, this paper uses the newer data, which are collected at more recent 1998 and covers substantially larger numbers of firms in wider ranges of industries than were previously investigated.

Second, as inspired by recent empirical studies of FDI, including Barbosa and Louri (2002), this paper investigates the relation between intangible assets of a firm with the ownership structure preference of the firm's FDI. The research along this line suggests that majority ownership is preferred if the FDI is motivated by the firm's strength in intangible assets. The difficulty in defining and monitoring the proprietary rights associated with these intangible assets induces firms to prefer majority ownership shares in FDI to securely internalize the gains from these costly-to-market assets. Consequently, this paper examines whether the effect of R&D on FDI is stronger for majority-owned FDI, compared with minority-owned FDI. By exploiting firm characteristics collected by the survey, this paper also evaluates the impact of human capital, which is another important intangible asset as technology capital accumulated by R&D, on the ownership structure of FDI.

The rest of this paper is organized as follows. Section 2 describes our data. Section 3 explains empirical specifications and estimation methods. Section 4 reports empirical results. Section 5 concludes.

2. Description of data

All the data used for this paper are derived from the firm-level data files of *the Basic Survey of Commercial and Manufacturing Structure and Activity* (Sho-Kogyo Jittai Kihon Chosa in Japanese).[4] The survey, covering all firm sizes and all manufacturing industries, includes various firm-characteristics data at 1998, such as sales, capital, R&D spending, and industry classification.[5] The survey captures FDI in the number of foreign subsidiaries/affiliates with majority ownership (kogaisha in Japanese) and those with share no less than 20 percent but no more than 50 percent (kanrengaisha in Japanese), distinguishing those located in Asia from the world total.[6] A large number of firms with no FDI or no R&D at all are also included within our sample of 118,300 manufacturers. This large size and wide coverage convince us that we can interpret this survey as a good representation of the whole manufacturing in Japan. As plotted in Figure 1, the published aggregate data from this same survey confirm the relatively strong positive correlation between R&D/Sales ratio and FDI at the industry-level.[7] Industry-level values, however, are affected by averaging over heterogeneous firms.

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[4] Although the data for commercial industries are also available in the same survey, this paper focuses on manufacturing firms.

[5] Although it contains similar data, the *Basic Survey of Business Structure and Activities* (Kigyo Katsudo Kihon Chosa in Japanese) covers only limited numbers of large firms (defined as those with more than fifty employees and capital of more than thirty million yen) and is not suited for evaluating total Japanese manufacturing.

[6] The region "Asia" in this survey includes not only ASEAN, but also countries such as China and India. Foreign offices with ownership less than 20% are not recognized with destination disaggregation. Many previous studies also use the dichotomous measure of majority vs. minority ownership, while Asiedu and Esfahani (2001) use continuous actual shares in FDI projects.

[7] The correlation between the percentage ratio of R&D spending over sales and the industry's share in total number of foreign subsidiaries (majority and minority ownership, combined) is as high as 0.731 among two-digit industries.

Table 1 classifies firms by whether or not the firm is involved in any R&D or FDI at all.[8] Noteworthy findings from our micro-data are as follows. Let us abuse abbreviations by calling firms with strictly positive FDI (R&D) as FDI firms (R&D firms) and firms with zero FDI (R&D) as no-FDI firms (no-R&D firms), respectively, in what follows.[9]

First, only two percent of 118,300 firms in our sample undertake both R&D and FDI. Even if we include no-R&D firms, the share of FDI firms is merely around three percent of all firms.[10] This implies that previous studies based on samples solely from FDI firms do not replicate the whole manufacturing. On the other hand, nearly 17 percent of firms conduct R&D.[11] By covering these no-FDI firms and no-R&D firms, our sample is suited for evaluating the impact of R&D on FDI decision in the universe of all firms.

Second, R&D firms appear more active in FDI than no-R&D firms in all categories of FDI, irrespective of destination and ownership structure.[12] This comparison suggests positive relation between domestic R&D intensity and the extent of FDI. Since most of FDI by Japanese firms go either into Asia, U.S., or into E.U. regions, and since no further regional disaggregation is available in the survey, let us approximately interpret the rest of the world other than Asia as

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[8] In the survey, firms are asked whether or not the firm undertakes any R&D or FDI. Since no response is observed for this binary question for no firm in our sample, and since all the firms with no response to questions on R&D spending values and on FDI counts in the survey are the firms explicitly answer that they conduct no R&D and no FDI at all, we treat them as zero. For physical capital and human capital, however, no binary question is set in the survey and it is implausible to assume firms with no response to the question as firms with zero capital.

[9] Although the survey is collected from parent firms, R&D figures may include R&D expenditures by foreign subsidiaries.

[10] Since the firms whose employees are less than fifty are sampled with probability less than one, the share of FDI firms in the whole population of all firms must be even lower if we adjust sampling probability. Although the government does not disclose the rescaling method for different sampling probability, the published aggregate statistics from the same survey reports that only 1.5% of all manufacturers have foreign subsidiaries.

[11] If we consider that the sampling probability is lower for smaller firms, which tend to be less active in R&D, the share of R&D firms must be even lower. According to the published aggregated statistics from the same survey, only 12% of all manufacturers conduct any R&D.

[12] This kind of cross-aggregation is not released in the published aggregated statistics.

industrial countries.[13] The gap between R&D firms and no-R&D firms is particularly evident in FDI with majority ownership into industrial countries. Besides, the share of R&D firms is substantially higher among FDI firms, compared with among no-FDI firms (66%>15%).

Third, however, the R&D intensity of FDI firms is found virtually the same as that of no-FDI firms. The R&D intensity is defined by the ratio of R&D expenditure over sales. Thus, among firms undertaking R&D, the involvement into FDI does not associate with different levels of R&D intensity. This finding, ignored by the comparison among FDI firms, indicates that the comparison with no-FDI firms is necessary to evaluate the R&D impact on FDI. Consequently, this paper controls for various factors simultaneously by regression formats in the next section.

Finally, while the average R&D firm is three to five times larger than the average no-R&D firm, the average FDI firm is 14 to 21 times larger than the average no-FDI firm in terms of sales. This may suggest some forms of increasing returns to scale or fixed sunk entry costs associated with R&D and FDI, especially with FDI.

3. Empirical models

This section explains the empirical models for this paper. The basic specification relating FDI with R&D intensity, as a reduced form, is as follows.

$$FDI_i = \alpha + \beta_1 \ln R\&D/Q_i + \beta_2 \ln Q_i + \beta_3 \ln K_i/Q_i + \beta_4 \ln HS_i + \gamma DUM + u_i \qquad (1)$$

The suffix *i* indexes firm in the cross-section data. *FDI* denotes foreign direct investment either into Asia or into industrial countries, either with majority ownership or minority ownership. The variables *Q*, *K*, *HS*, and *R&D* are the output (sales), the capital (tangible fixed asset), the human

[13] We can confirm this approximation by alternative data sources. For example, the most recent figure from FDI statistics by the Ministry of Finance shows that 87% of aggregate Japanese FDI into non-Asian countries is into U.S., Europe, or Oceania.

skill intensity (measured by per-capita overhead expenditure), and the R&D spending, respectively.[14] The vector of industry dummy variables is expressed by *DUM*.[15] The error term is denoted by *u*. Although this specification is flexible in incorporating variables, we should not interpret the results as suggesting that more active R&D causes more extensive FDI because they are simultaneously determined.[16]

According to the standard theory of FDI, as surveyed by Caves (1996) for example, a firm invests directly into foreign countries if the firm has advantage, compared with local rival firms, in intangible assets, such as technology or managerial skills. Unless a firm possesses these assets costly to transact at arm's length, the firm is not likely to establish their own subsidiaries in foreign countries.[17] Taking account of the technology gap between developed and developing countries, we expect that more active R&D is required for FDI into industrial countries, compared with FDI into Asia.[18] Similarly, for ownership structure, FDI with majority ownership, rather than FDI with minority ownership, is expected to more strongly relate with

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[14] Since the survey contains no data directly related with wage, this paper uses the selling, general and administrative pay (SGA) divided by the number of employees for the index of skill intensity. This measure can be decomposed into the wage share of non-production workers and the average wage of the firm. Although they have been often included in the similar regressions of FDI, the data of advertising expenditure and business group affiliations are not available in the survey. Belderbos and Sleuwaegen (1996) is an excellent study of effect of inter-firm relations on Japanese FDI. On the other hand, although it is available in the survey, the export data is not included because FDI and exports are simultaneously determined and no appropriate instrumental variables are found in our cross-section framework.

[15] The two-digit classification is used as identification of industries, as the inclusion of dummies for all three-digit industries considerably loses the degree of freedom in regressions.

[16] Besides, R&D is measured in flow term: spending during the previous year, while FDI is in stock terms: number of foreign subsidiaries. This inconsistent measuring is due to the limit of data availability at the firm level.

[17] Although they are another important determinant of FDI, host country factors are not considered here due to the limit of data availability. Kogut and Chang (1991) examine the motivation to source advanced local technology in FDI decisions into U.S. at the aggregated industry level. Asiedu and Esfahani (2001) consider local costly-to-market inputs into jointly-owned FDI projects.

[18] If the competition among multinational corporations from other industrial countries investing into Asia is intense, this difference in R&D effect on FDI depending on destination is not obvious. Since no data of FDI from American or European firms is available in our survey of Japanese parent firms, however, this aspect is omitted from this paper.

R&D intensity because the gains from intangible assets are not easily traded in markets.[19] Since human capital is also suited for internalization, similarly as technology capital accumulated through R&D spending, the coefficient on *HS* is expected larger for FDI into industrial countries than FDI into Asia, and for majority-owned FDI than minority-owned FDI. On the other hand, the firm size is expected to have positive effect on FDI into any region and with any ownership structures because FDI incurs fixed sunk costs for establishing subsidiaries. The capital-output ratio is supposed to act as an inverse proxy for richness in intangible assets, or an indicator for tangibility of assets.[20]

This paper conducts robustness checks by using various alternative estimation methods and alternative ranges of data. First, this paper estimates (1) by OLS over the sample of firms with strictly positive FDI and R&D. This can be served as the benchmark of our analysis, comparable with previous studies.

Second, taking account of the fact that the survey measures FDI by counting the number of foreign subsidiaries, this paper estimates (1) not only by OLS, but also by Poisson, negative binomial regressions, or Tobit.[21] Thus, the robustness of our findings will be confirmed by considering that our FDI index is a limited dependent variable.

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19 Although recent studies, including Asiedu and Esfahani (2001) and Barbosa and Louri (2002), have examined FDI ownership, they focused on the effect of parent firm's intangible assets on the ownership choice of individual FDI project, based on affiliate data, excluding by construction no-FDI firms. This paper investigates the effect of intangible asset on parent firm's FDI extent in respective ownership structure, based on survey of parent firms including no-FDI firms. These two approaches should be viewed as complementary.

20 In some previous studies, especially where direct R&D data are not available, for example in Asiedu and Esfahani (2001), the capital-output ratio is used in this context, although our regression simultaneously includes R&D and human skill intensity as well.

21 Although it is the most frequently used for FDI studies, the multinomial logit model forces us to concentrates on the choice among limited numbers of alternative categories (the three-way choice between no-FDI, FDI to West and FDI to Asia in Belderbos and Sleuwaegen (1996), for example). Our FDI count data is more information-rich. When continuous data, such as offshore production share (as in Fukao et al. (1994)) or joint venture share (as in Asiedu and Esfahani (2001), are available for FDI, Tobit model is preferable. Kogut and Chang (1991), based on counts of Japanese FDI into U.S. at industry level, is a rare example of the negative binomial regression for FDI.

Thirdly, this paper includes no-R&D firms into the regression by adding one to R&D intensity before taking logarithm as following:

$$FDI = \alpha + \beta_1 \ln\left(1 + \frac{R\&D}{Q}\right) + \beta_2 \ln Q + \beta_3 \ln\frac{K}{Q} + \beta_4 \ln HS + \gamma DUM + u\,. \qquad (2)$$

The above adaptation substantially increases the numbers of observations available for regressions, since more than eighty percent of firms in our sample have zero R&D value.

The regressions have so far related the absolute level of various forms of FDI with R&D intensity and compared estimated coefficients from separate regressions of different dependent variables. However, it remains to be known whether the destination of FDI (to industrial countries than to Asia) or the ownership structure (majority than minority) relatively dictates the results. Therefore, to discriminate the destination effect from the ownership effect, this paper replaces the dependent variable of absolute level of FDI with the relative share as follows.

$$\frac{FDI\_Ind\_Maj}{FDI\_World\_Maj} = \alpha + \beta_1 \ln\left(1 + \frac{R\&D}{Q}\right) + \beta_2 \ln Q + \beta_3 \ln\frac{K}{Q} + \beta_4 \ln HS + \gamma DUM + u \qquad (3)$$

This equation is estimated by Tobit because any share cannot be beyond zero and one. The positive β_1 in (3) provides support for the destination effect more significant than the ownership effect. Similar regressions are also conducted for the share of industrial countries in all minority-owned FDI, the share of majority-owned FDI in all FDI to industrial countries, and the share of majority-owned FDI in all FDI to Asia. The comparison of these regression results will distinguish whether destination or ownership of FDI is more strongly affected by R&D intensity.

4. Estimation results

4.1. Summary statistics

This section reports empirical results from our sample. Before discussing regression results, descriptive statistics of variables used for estimation is informative. Table 2 clearly shows remarkable cross-sectional variations.[22] The cross-sectional standard deviation is larger than average in all the variables. On average, each FDI firm has two or three foreign subsidiaries, while each R&D firm spends around three percent of their sales on R&D.[23]

The correlation between variables is summarized in Table 3. As expected, among the firms with strictly positive R&D and FDI, the correlation of FDI is high with sales (correlation around 0.47 to 0.52) and also clearly positive with R&D intensity and human skill (correlation around 0.14 to 0.29). However, if all firms with no R&D or no FDI are included, FDI becomes much less correlated with R&D and other variables. The correlation of FDI is now at most 0.2 with sales and far less than 0.1 with other variables. Consequently, it will be fruitful to reexamine the relation between FDI and intangible asset of the firm by including large number of firms with no FDI or no R&D to understand the more reasonable representation of the whole economy.

4.2. Basic OLS results

Table 4 reports the OLS results for the basic specification (1) from the sample restricting to firms with strictly positive FDI and R&D. The investigation of variations among FDI/R&D firms facilitates the comparison with previous studies. Although it is larger than those used in previous studies, the sample size is limited to 1,264 firms. The main findings are as follows.

First, for majority-owned FDI, the R&D effect on the extent of FDI into industrial

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[22] The number of firms of which R&D data are available in this table is smaller than the number of firms with positive R&D in Table I because some firms spend less than one million yen for R&D or did not disclose their R&D spending.

[23] The published aggregated statistics from the same survey report similar figures for average FDI, but slightly higher R&D-sales ratio (3.8%). Since the relation between R&D intensity and firm size is U-shaped, lower representation of small-sized firms may decrease R&D intensity.

countries is substantially larger than FDI into Asia. The coefficient on R&D intensity is estimated around 2.6 times larger in the regression of FDI into industrial countries, compared with that to Asia. Although they do not distinguish ownership structure of FDI, our finding of significant R&D effect on FDI to industrial countries is consistent with the previous results, such as Belderbos and Sleuwaegen (1996).

Second, the R&D has significantly positive effect on FDI into Asia as well. Previous studies, such as Fukao et al. (1994), and Belderbos and Sleuwaegen (1996) based on Japanese firm-level data in the 1980s, reported insignificant or negative effect of R&D on FDI into Asia, but this paper finds, from the data in 1998, the significantly positive effect. Although Belderbos and Sleuwaegen (1996) cited the relative absence of local competing firms in the region as one of the factors for the insignificance, relative R&D strengths and labor costs in Japanese and other Asian firms/economies have drastically changed over the 1990s. Hence, now, not in the 1980s, FDI, not only into industrial countries, but also into Asia, requires active R&D for investing firms. However, we must note that the gap in the magnitude of the R&D effect between Asia and industrial countries still remains very large. We will discuss the comparison between FDI destinations again later.

Third, other variables are also precisely estimated. The firm size is significantly positively related with the extent of FDI both into industrial countries and into Asia. This size effect implies the fixed sunk entry costs for FDI.[24] Various factors, such as the internalization effect already captured by other explanatory variables, may cloud the relation with physical capital intensity. Firms with richer accumulation of human capital in the home country are more likely to directly invest into industrial countries, not significantly into Asia.[25] Thus, as expected,

[24] Some previous studies, such as Fukao et al. (1994), find the negative effect of firm size on FDI, but their comparisons are within FDI firms.

[25] Belderbos and Sleuwaegen (1996) find significantly positive effect of human capital intensity on

intangible assets in technology and in human capital work similarly for FDI, particularly strongly for FDI to industrial countries than to Asia in majority-owned FDI.

Finally, on the other hand, the significant contrast in R&D effects between industrial countries and Asia is not found in minority-owned FDI. Since R&D-driven FDI tends to seek majority ownership to internalize the gain from R&D, FDI with minority ownership tend to be induced by factors omitted in our regressions, such as the proximity to markets, or low production costs in the host country.

4.3. Alternative estimation results

Table 5 confirms that previous results are basically robust even if we consider the count data nature of our FDI measure.[26] Since the assumption of equality between mean and variance is rejected, the negative binomial regression is employed in estimating (1) over the sample consisting of only FDI firms. Since maximum likelihood calculation for negative binomial regressions did not converge within reasonable numbers of iterations, we use the Poisson model, which is another popular model for count data, for the larger sample including no-FDI firms. This table concentrates on the comparison among FDI destination in majority-owned FDI. The estimates reported in the table demonstrate that the R&D effect on FDI is again larger for FDI to industrial countries than that to Asia. Even if firms with no FDI are included, the estimates for R&D intensity and for human skills in FDI to industrial countries remain larger than that to Asia. Consequently, measuring FDI by counts of subsidiaries does not affect our results.

Table 6 reports results from larger samples. By estimating the specification (2) instead of (1), we include no-R&D firms. As a result, the sample size increases to 95,143 firms, reported

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FDI both to West and to Southeast Asia in the 1980s.

[26] As in usual FDI statistics, the survey has no information on exits from FDI or closure of foreign subsidiaries. Thus, all FDI figures are non-negative integers.

in the columns (1) and (2). Besides, by dropping explanatory variables other than output, we cover all the firms in our data set: 118,300 firms, as reported in the columns (3) and (4). In estimations, we consider that FDI cannot be negative.[27] Although the coefficient on ln(*1+R&D/Q)* should not be directly compared with that on ln*R&D/Q*, larger effect of R&D on FDI into industrial countries than that into Asia is again confirmed robust.

4.4. Regression of FDI shares

The regressions of relative FDI shares are reported in Table 7. The estimation results show that the share of FDI into industrial countries in total FDI significantly increases with R&D intensity of the firm both for FDI with majority ownership and with minority ownership. On the other hand, the share of majority-owned FDI both in industrial countries and in Asia has insignificant relationship with R&D intensity. Thus, R&D intensity tends to more strongly affect the destination rather than ownership preference of FDI. Our survey, however, does not distinguish FDI with full ownership in majority-owned FDI. Thus, our finding of insignificant R&D effect on ownership may be partly affected by this mixed-up because the full ownership is supposed to be the distinctively superior way of internalizing the gains from R&D.[28]

The same regression of FDI shares, however, also shows that human skill intensity significantly raises the share of majority-owned FDI in total FDI to industrial countries. Since technology or gains from R&D, compared with human managerial skills, are supposed to be

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[27] Since maximum likelihood calculations for count data models did not converge within reasonable numbers of iterations, this paper employs Tobit model for the sample consisting of all firms. Compared with OLS, Tobit takes account of the corner solution constraint. Since our sample is now larger than 118 thousand, neglecting the integer constraint may not be serious as before.

[28] Barbosa and Louri (2002) find that R&D significantly increases FDI with full ownership, while the relation is insignificant for FDI with less-than-full majority ownership in Portugal. Although they depend on the industry-level data, Kogut and Chang (1991) also report that the effect of domestic R&D on FDI is significant for FDI into new plants, not for FDI in joint ventures in the case of Japanese FDI into U.S.

less difficult to transact in arm's length trade, then, our finding that R&D intensity is more related with FDI destination and that human skill intensity is more related with FDI ownership preference appears rather plausible. Since these regressions of relative shares record very low R^2 due partly to large numbers of censored data in the sample, however, additional investigations will be required before the final conclusion discriminating destination vs. ownership effects.

5. Concluding remarks

This paper has investigated the relationship between R&D intensity and FDI by using firm-level data of more than 118 thousand Japanese manufacturers. As expected, the effect of R&D on FDI is stronger for FDI into industrial countries than FDI into Asia. Also consistent with the theory of FDI, intangible assets such as human capital appear positively related with preference for the majority ownership in FDI.

In spite of these findings, important tasks remain for future independent work. For example, if the firm-level data of this survey is linked with other detailed FDI data, we will be able to control for the size of foreign subsidiaries and to further disaggregate regional destinations of FDI. These developments will certainly enrich the results from this paper.

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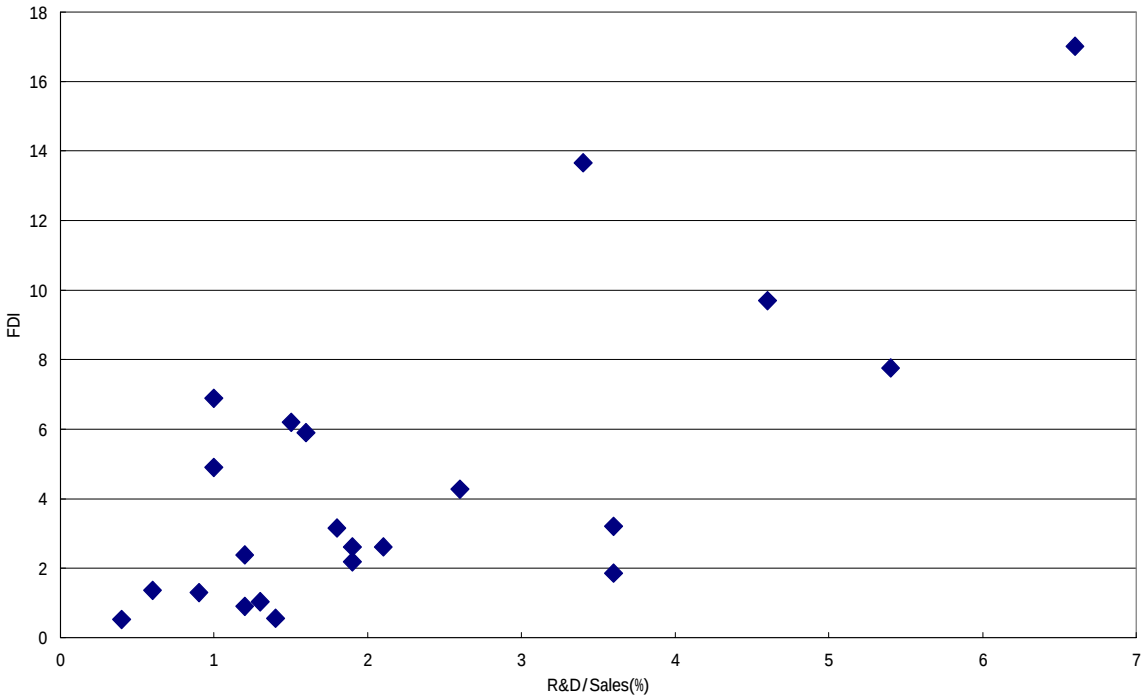
Figure 1 R&D and FDI at the industry level



Notes: The horizontal axis measures the percentage share of R&D expenditure in sales, while the vertical axis counts the number of foreign subsidiaries (majority-owned and minority-owned combined, to all regions total). Each point corresponds to the average for each two-digit industry. All manufacturing industries are plotted. All data are derived from *the Basic Survey of Commercial and Manufacturing Structure and Activity 1998*.

Table 1 Descriptive summary of FDI and R&D

Number of Firms	FDI>0	FDI=0	TOTAL
R&D>0	2,489	17,150	19,639
R&D=0	1,292	97,369	98,661
TOTAL	3,781	114,519	118,300

FDI (FDI>0)	R&D>0	R&D=0	R&D/No-R&D
World_Majority	4.09	1.52	2.68
Asia_Majority	2.53	1.31	1.94
World_Minority	2.42	1.52	1.59
Asia_Minority	2.13	1.48	1.43

	FDI>0	FDI=0	TOTAL
R&D/Q (%) (R&D>0)	2.60	2.73	2.71

Sales (Mil. ¥)	FDI>0	FDI=0	FDI/No-FDI
R&D>0	70,034	3,403	20.58
R&D=0	9,517	678	14.04
R&D/No-R&D	7.36	5.02	Av. Sales=2,629

Notes: The column or row R&D/No-R&D (FDI/No-FDI, respectively) calculates the ratio of corresponding value for firms with positive R&D (firms with positive FDI) over that for firms with no R&D (firms with no FDI).

Table 2 Summary statistics of variables

	NUMBER OF OBSERVATIONS	AVERAGE	STANDARD DEVIATION
FDI (World_Majority)	2,468	3.32	7.29
FDI (Asia_Majority)	1,862	2.14	3.19
FDI (World_Minority)	1,831	2.15	3.16
FDI (Asia_Minority)	1,528	1.93	2.60
R&D/Q	19,314	2.71	15.35
Q	118,300	2,629	45,976
K/Q	96,515	0.43	3.46
HS	118,300	4.11	5.85

Notes: See text for definition of variables. FDI is counted by the number of foreign subsidiaries, while other variables are originally measured in million yen.

Table 3 Correlation between variables

Firms with FDI and R&D both strictly positive (464 observations)

	MajI	*MajA*	*MinI*	*MinA*	*R&D/Q*	*Q*	*K/Q*	*HS*
MajI	1.000							
MajA	0.686	1.000						
MinI	0.684	0.512	1.000					
MinA	0.428	0.629	0.560	1.000				
R&D/Q	0.278	0.286	0.231	0.243	1.000			
Q	0.505	0.518	0.466	0.476	0.337	1.000		
K/Q	0.012	–0.005	0.056	0.077	0.143	0.132	1.000	
HS	0.231	0.232	0.140	0.179	0.173	0.417	–0.011	1.000

Firms with no R&D or no FDI included (95,143 observations)

	MajI	*MajA*	*MinI*	*MinA*	*R&D/Q*	*Q*	*K/Q*	*HS*
MajI	1.000							
MajA	0.666	1.000						
MinI	0.569	0.463	1.000					
MinA	0.429	0.554	0.478	1.000				
R&D/Q	0.079	0.080	0.062	0.062	1.000			
Q	0.171	0.216	0.156	0.187	0.059	1.000		
K/Q	0.009	0.009	0.010	0.008	0.039	–0.072	1.000	
HS	0.055	0.063	0.044	0.053	0.049	0.215	–0.046	1.000

Notes: In FDI, *Maj* (*Min*) represents majority ownership (minority ownership, respectively), and *I* (*A*) denotes industrial countries (Asia, respectively) as destination of FDI. FDI in four categories is in number of foreign subsidiaries, while other variables are in logarithm. In the table including no-R&D firms, the logarithm is taken after adding one to *R&D/Q*.

Table 4 OLS results from restricted sample

	(1) Industrial_Maj	(2) Asia_Maj	(3) Industrial_Min	(4) Asia_Min
$\ln R\,\&\,D/Q$	0.526 (0.094)	0.203 (0.047)	0.135 (0.029)	0.228 (0.045)
$\ln Q$	1.543 (0.154)	0.944 (0.095)	0.242 (0.036)	0.512 (0.055)
$\ln K/Q$	0.249 (0.150)	0.085 (0.102)	0.023 (0.036)	0.047 (0.066)
$\ln HS$	0.590 (0.229)	0.125 (0.114)	0.075 (0.062)	0.096 (0.100)
R^2	0.258	0.276	0.180	0.231
Number of observations	1,264	1,264	1,053	1,053

Notes: See text for definition of variables. This table covers only firms with R&D and FDI both strictly positive. Estimated heteroskedasticity-consistent standard errors are in parentheses. Industry dummies are included.

Table 5 Results from regressions for count data

	(1) Industrial (FDI firms)	(2) Asia (FDI firms)	(3) Industrial (including no-FDI firns)	(4) Asia (including no-FDI firns)
$\ln R\,\&\,D/Q$	0.244 (0.039)	0.060 (0.016)	0.286 (0.046)	0.096 (0.024)
$\ln Q$	0.713 (0.027)	0.329 (0.016)	0.838 (0.026)	0.780 (0 .020)
$\ln K/Q$	0.260 (0.069)	0.037 (0.038)	0.357 (0 .062)	0.211 (0.046)
$\ln HS$	0.268 (0.071)	0.017 (0.037)	0.245 (0 .079)	0.134 (0 .049)
Statistics	Log likelihood = –1749.886 Pseudo R^2 = 0.252	Log likelihood = –2178.601 Pseudo R^2 = 0.162	Log likelihood = – 5367.664 Pseudo R^2 = 0.649	Log likelihood = – 5496.162 Pseudo R^2 = 0.535
Number of observations	1,264	1,264	18,536	18,536

Notes: The dependent variable is FDI with majority ownership in all cases. The columns (1) and (2) are from negative binomial regression only for FDI firms, while the columns (3) and (4) are from Poisson regression including no-FDI firms. Estimated heteroskedasticity-consistent standard errors are in parentheses. Industry dummies are included.

Table 6 Results including no-R&D firms

	(1) Industrial	(2) Asia	(3) Industrial	(4) Asia
$\ln(1+R\&D/Q)$	21.246 (1.764)	9.179 (1.096)	23.665 (1.606)	10.245 (0.987)
$\ln Q$	3.974 (0.094)	1.956 (0.042)	4.257 (0.097)	2.025 (0.042)
$\ln K/Q$	1.397 (0.143)	0.516 (0.057)	-----	-----
$\ln HS$	1.791 (0.157)	0.513 (0.063)	-----	-----
Statistics	Log likelihood = −6181.382 Pseudo R^2 = 0.370 Left-censored obs. = 93,860	Log likelihood = −8989.287 Pseudo R^2 = 0.285 Left-censored obs. = 93,285	Log likelihood = −6306.346 Pseudo R^2 = 0.374 Left-censored obs. = 117,017	Log likelihood = −9134.983 Pseudo R^2 = 0.297 Left-censored obs. = 116,438
Number of observations	95,143	95,143	118,300	118,300

Notes: The dependent variable is FDI with majority ownership in all cases. The sample covers all firms. The equation is estimated by left-censored Tobit. Estimated standard errors are in parentheses. Industry dummies are included.

Table 7 Regression of FDI share

	(1) $\frac{Ind\_Maj}{World\_Maj}$	(2) $\frac{Ind\_Min}{World\_Min}$	(3) $\frac{Ind\_Maj}{Ind\_All}$	(4) $\frac{Asia\_Maj}{Asia\_All}$
$\ln(1+R\&D/Q)$	5.482 (1.111)	7.570 (2.633)	1.377 (1.865)	–0.887 (2.000)
$\ln Q$	0.174 (0.018)	0.185 (0.036)	0.058 (0.030)	0.0892 (0.026)
$\ln K/Q$	0.180 (0.038)	0.177 (0.082)	0.114 (0.070)	0.137 (0.055)
$\ln HS$	0.228 (0.046)	0.046 (0.089)	0.235 (0.084)	–0.005 (0.061)
Statistics	Log likelihood = – 2332.737 Pseudo R^2 = 0.099 Left-censored obs. =1,181 Right-censored obs.= 606	Log likelihood = – 1419.626 Pseudo R^2 = 0.050 Left-censored obs. =1,271 Right-censored obs.=300	Log likelihood = – 1351.271 Pseudo R^2 = 0.021 Left-censored obs. = 271 Right-censored obs.= 999	Log likelihood = – 2903.453 Pseudo R^2 = 0.016 Left-censored obs. = 979 Right-censored obs.= 1,311
Number of observations	2,464	1,826	1,554	2,837

Notes: In the denominator, *All* represents all FDI to each region (both majority-owned and minority-owned FDI combined). The equation is estimated by Tobit with both sides censored. Estimated standard errors are in parentheses. Industry dummies are included.