Foreign versus Domestic Outsourcing: Firm-level Evidence on the Role of Technology

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Abstract

The decision about where to outsource varies across firms and industries. General machinery heavily depends on domestic subcontractors, while outsourcing overseas is prevalent in apparel. Based on firm-level data explicitly distinguishing foreign outsourcing from domestic outsourcing in all manufacturing industries, this paper finds that firms tend to prefer domestic outsourcing to foreign outsourcing when they are R&D-intensive. This finding is consistent with incomplete contracting models, since technologically complex products are likely to require high-quality contracting environment and assembler-supplier proximity. This paper also finds that firms connected with computer networks are actively outsourcing.

JEL Classifications: F12; F23; D20; F14.

Keywords: foreign outsourcing; heterogeneity; firm-level data; R&D; network

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1. Introduction

Outsourcing is increasing its importance in a wide range of firms and industries. While many assemblers have long been outsourcing to subcontractors in proximate locations, outsourcing across borders has been facilitated by information technology development and trade liberalization in recent years. Outsourcing to low-wage countries appears particularly prevalent in firms producing apparel and other labor-intensive goods, as in Nike, the company outsourcing most of its manufacturing tasks across borders. On the other hand, assemblers of technologically complex products tend to depend heavily on domestic suppliers. For example, Toyota employs the just-in-time procurement of customized auto parts from nearby suppliers. The relationship between technology and foreign outsourcing is worth investigating.

The firm's decision about where to outsource has recently been formalized by the incomplete contract theory. For example, in the model by Grossman and Helpman (2005), the production is supposed to require a customized input manufactured by an independent supplier with a relation-specific investment, governed by an incomplete contract. A final assembler searches for a partner supplier close to its input requirement, either in the technologically and legally advanced home country North or in the low-wage foreign country South.

Their model predicts that a firm tends to choose domestic outsourcing (DO) rather than foreign outsourcing (FO) when the firm's product is more technologically complex. The factors behind this choice can be listed as follows. First, customizing inputs is likely to be especially costly for Southern suppliers, many of whom are not equipped with computer-aided design (CAD). Second, these complex products tend to require high-quality legal system for verification/contracting. Third, the assembler-supplier proximity is often critical in customizing complex products. Finally, input markets for these technologically advanced products tend to be thicker in North. Many other recent theoretical models of incomplete contracting are also in line

with this prediction (e.g. Acemoglu et al., 2006; Antràs, 2005; Antràs and Helpman, 2006; Feenstra and Spencer, 2005).

By using firm-level data, this paper empirically examines how technology is related with the firm's choice between FO versus DO. The current paper uses unique and direct data on outsourcing, where contracts with foreign suppliers are explicitly distinguished from those with domestic suppliers. The data set covers 118,300 firms in all manufacturing industries in Japan without any firm-size threshold. A wide range of corporate variables are also included, such as sales, employment, capital, R&D expenditure, foreign affiliates, and computer network connection.

To preview the principal results, firms tend to outsource within the home country rather than across borders when they are R&D-intensive. This paper first uses the multinomial logit model on the firm's outsourcing location choice, but confirms the robustness of the results by the Heckman's two-step estimation procedure with the yen value ratio of outsourced tasks. Descriptive statistics derived from firm-level data are generally consistent with the regression results, and also reveal notable inter-industry variations.

The rest of this paper is organized as follows. Section 2 briefly describes the data set. Section 3 summarizes descriptive statistics. Section 4 explains empirical specifications and reports firm-level estimation results. Section 5 concludes.

2. Data description

All the data used for this paper are derived from *The Basic Survey of Commercial and Manufacturing Structure and Activity* (Sho-Kogyo Jittai Kihon Chosa in Japanese).[1] The survey

[1] Any researcher can access to the same original firm-level data files by obtaining individual official permission from the government in advance, though confidential micro data cannot be publicly disclosed.

covers 118,300 firms in all manufacturing industries without any firm-size threshold.[2] This sample size is remarkably large, matched almost only by the U.S. *Census of Manufactures*. Hence, we can interpret this survey as a relatively precise representation of all manufacturing in Japan. The survey includes a wide range of variables, such as sales, employment, capital, R&D expenditure, the computer network connection, and foreign affiliates. This survey was conducted only once at 1998.

The limited availability of micro-data has prevented previous empirical studies from investigating the location choice in outsourcing.[3] As a unique and direct measure of FO, the survey collects data on the yen values of manufacturing or processing tasks contracted out (*gaichu* in Japanese) to suppliers located in foreign countries, explicitly distinguished from those contracted out to firms located in Japan. While the survey contains no other information on subcontractors, this definition of FO successfully excludes intermediates purchased at marketplace, which inevitably contaminate FO measures dependent on intermediate import data.

3. Descriptive statistics

This section summarizes descriptive statistics derived from the firm-level data. Firms are grouped by their involvement in outsourcing or by industry.

3.1. Comparison of averages

Table 1 disaggregates all the surveyed 118,300 firms into the following four disjoint groups: (1) *FO & DO* (firms with foreign and domestic outsourcing both strictly positive), (2) *FO only* (firms with positive foreign outsourcing but no domestic outsourcing), (3) *DO only* (firms with

[2] Commercial industries are also surveyed, but this paper focuses on manufacturing because the outsourcing captured in this survey is on production-related tasks, as will be explained later.

[3] Few studies have distinguished outsourcing locations at the firm/plant level. As a rare example, Görg and Hanley (2003) include the ratio of imported inputs over total inputs in the productivity regression for electronics plants in Ireland, yet the choice of location is not examined. Based on the same data as this paper, Tomiura (2007) compares productivity across firms involved in export, FO, and FDI, but does not consider DO or R&D.

positive domestic outsourcing but no foreign outsourcing), and (4) *No Out* (firms outsourcing no production at all).

Several contrasts in Table 1 are noteworthy. As shown in the row (1), only around 3% of the surveyed firms are outsourcing production across borders, while nearly half are outsourcing within the home country. On the other hand, around half of the firms are *No Out*: sourcing exclusively in-house or depend totally on intermediates available at marketplace. While the survey does not cover outsourcing of non-production services, this extremely low share of foreign outsourcers should be noted.[4] The firms outsourcing to foreign suppliers are normally outsourcing also to domestic suppliers, reflecting varying difficulties in matching. As a result, the firms involved only in foreign outsourcing (*FO only*) are very exceptional (0.2%).

As the row (2) confirms, foreign outsourcers are on average substantially larger in size than domestic outsourcers. In our sample, domestic outsourcers tend to be larger than the firms without any outsourcing. These imply that large-sized firms should have advantages in outsourcing, especially in foreign outsourcing, possibly due to their strong bargaining position or established reputation in markets. Or alternatively, only large-sized firms may overcome high fixed entry costs for foreign outsourcing possibly because contracting with firms in different legal systems requires rich headquarter functions within a firms (e.g. Antràs and Helpman, 2004; Grossman et al., 2005). The survey, however, contains no data related with management or human skills.

The row (3) shows that the frequency of firms with positive R&D spending among *FO & DO* firms is higher than that in *FO only* or *DO only* firms, which is in turn higher than that in *No Out* firms. However, this observed gap in R&D frequency must be at least partially due to

[4] All the firms with no less than 50 employees (more likely to be FO firms) are surveyed with certainty, but those with less than 50 are sampled with probability of less than one. Therefore, the share of foreign outsourcers must be even lower in the entire population. The sampling frequency for each cell is not disclosed, and thus cannot be adjusted.

the gap in firm size, since the R&D frequency ordering in the row (3) is the same as the firm size ordering in the row (2). Moreover, small-sized firms tend to record no official R&D expenditures, even when they are actively improving production processes. On the other hand, when we compare R&D-sales ratio among R&D-active firms in the row (4), *No Out* firms, which include totally integrated firms, tend to have relatively high R&D intensity. No noticeable differences are observed across other three groups.

On the factor intensity, the row (5) reveals that foreign outsourcers are on average more capital intensive than domestic outsourcers or *No Out* firms. The capital-labor ratios (tangible fixed assets divided by the number of regular employees) in the table appear consistent with the fact that Japan is more capital-abundant than neighbouring Asian low-wage countries. However, the observed gap is slim. Furthermore, we cannot estimate the factor content of outsourced activities from our data. Another scenario consistent with this result may be that only capital-intensive firms can engage in foreign outsourcing due to high fixed entry costs.

The row (6) demonstrates that outsourcers (foreign or domestic), especially *FO & DO* firms, tend to be actively connected with computer networks.[5] The firms without any outsourcing contracts are the least active in this regard. These indicate that the use of computer networks is critical for finding potential partners and coordinating tasks with contracted suppliers.

As shown in the row (7), foreign outsourcers are on average far more often operate affiliates overseas compared with domestic outsourcers or *No Out* firms.[6] This suggests that the operation of foreign affiliates may facilitate matching with foreign suppliers, though this

[5] "Computer networks" include inter-firm, open, and local area networks (LAN).
[6] Affiliates overseas in this paper are majority-owned subsidiaries, minority-owned affiliates, or branch offices/plants (*jigyousho* in Japanese). The survey contains no quantitative data on foreign affiliates, such as local procurement or offshore employment.

difference must be again partly attributable to the gap in firm size.[7]

Although these figures sound consistent with our priors, this paper will control for these factors simultaneously in regression formats in Section 4.

3.2. Comparison of industries

As industry-specific factors inevitably affect the firm's outsourcing decision, this paper aggregates all 118,300 firms into 22 two-digit industries. Figure 1 plots the share of general outsourcers (foreign and domestic combined) in all firms and the share of foreign outsourcers in general outsourcers. Both percentages are on the number of firms within each industry.

Cross-industry variations are remarkable in the graph. First, along the horizontal axis, we observe substantial differences in the extent of outsourcing. The industry with the highest percentage of outsourcers is general machinery (73%), followed by printing-publishing, transport equipment, electric machinery, and precision instruments. On the other hand, merely around 13-15% of the firms are outsourcing production in food and beverage-tobacco-feed industries.

Second, however, many industries are arrayed differently when we look at the extent of foreign outsourcing compared with outsourcing in general. Among the industries most active in general outsourcing, transport equipment and general machinery industries are ranked nearly in the middle along the vertical axis. Furthermore, the printing-publishing industry, which ranks at the second highest in the share of general outsourcers, is one of the industries with the lowest share of FO. On the other hand, apparel, leather, and rubber industries are ranked relatively high in FO, while electric machinery and precision instruments occupy similarly high ranks in both percentages.

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[7] The outsourcing in the survey is defined by contracting out to "other firms," which can include foreign affiliates when they are independent legal entities. This issue will be discussed again later.

The graph indicates that the following five groups can be identified among industries: (a) industries actively outsourcing both within and across borders (e.g. electric machinery, precision instruments), (b) industries actively outsourcing but mostly within the home country (e.g. printing, general machinery, transport equipment), (c) industries active in foreign outsourcing compared with general outsourcing (e.g. apparel, leather, rubber), (d) industries inactive in outsourcing (e.g. food, beverage), and (e) other industries with intermediate ranges of outsourcing (e.g. chemical, metal). These cross-industry contrasts are consistent with our daily observations. For example, manufacturing processes in electronics industries tend to be relatively standardized and easily fragmented around the globe, with components tradable across borders.[8] Printing tasks outsourced from Japanese firms inevitably require extensive knowledge of Japanese language and characters. Outsourcing often requires proximate supplier-assembler contacts in technologically complex and highly differentiated industries. Labor-intensive industries tend to actively seek low-wage subcontractors for their technologically simple products.

Substantial differences are observed across industries, but the next section investigates intra-industry variations by firm-level regressions.

4. Firm-level regressions

While the descriptive statistics reported in the previous section are rather self-explanatory, this section controls for various factors in regression formats as follows.

4.1. Empirical specifications

This paper uses the following log-linear model:

[8] Grossman et al. (2005) show that "in an industry with a larger fraction of firms engage in outsourcing, a larger fraction of firms source their intermediate inputs in the South" when "the economies of scope in management exceed the managerial overload of integration" (p.22). They do not discuss which industry satisfies this condition, however.

$$Out = \alpha + \beta_1 \ln\left(\frac{R\&D}{Q}\right) + \beta_2 \ln Q + \beta_3 \ln\frac{K}{L} + \beta_4 Net + \beta_5 FDI + \gamma IND + u\,. \qquad (1)$$

The dependent variable *Out* is the firm's choice of outsourcing. Although Grossman and Helpman (2005) concentrate on the binary choice of FO vs. DO, many multiple-task firms in the real world are simultaneously involved in both foreign and domestic outsourcing, as reported in Table 1. Hence, this paper considers the following mutually-exclusive four categories: (a) *FO & DO*, (b) *FO only*, (c) *DO only*, and (d) *No Out* in the multinomial logit model.[9] Since the data set is in a cross-section form, one should not interpret (1) as showing the direction of causality.

The explanatory variables are (a) R&D intensity (percentage R&D-sales ratio) *R&D/Q*, (b) firm size *Q* (sales),[10] (c) capital-labor ratio *K/L*, (d) the dummy identifying firms connected with computer networks *Net*, (e) the dummy for the firm's operation of affiliates overseas *FDI*, and (f) 2-digit industry dummy variables *IND*. The error term is denoted by *u*. All variables, other than dummies, are in logarithms.[11]

To investigate the prediction by Grossman and Helpman (2005), this paper chooses R&D intensity as a proxy for the technological complexity.[12] This proxy has already been used for similar purposes (e.g. Acemoglu et al., 2005). Compared with matured standardized commodities, R&D-intensive products are likely to require many differentiated inputs satisfying high and unique requirements, even in some cases protected by patents. R&D expenditures internal to each firm are often made for technologies specific to the firm's mix of products. Market imperfections associated with technology are likely to turn R&D investment into

9 The 2-stage nested logit model (outsourcing or in-house in the first-stage, and domestic or foreign in the second stage) was not tried due to the computer capacity, but we alternatively use Heckman's two-step estimation procedure as explained later.

10 The production scale may be smaller in outsourcers than in firms producing all inputs in house even when they are equal in sales. Considering this problem, *Q* should be interpreted as a proxy for the headquarter function of the firm.

11 To include firms without official R&D, this paper adds a negligible 10^{-8} before taking logarithm. The firms without *K* data are excluded from regressions.

12 Some firms may manufacture multiple products with varying R&D intensities, but product-specific R&D data within a firm are not available.

relation-specific investment. Outsourcing contracts tend inevitably to be especially incomplete for such products, as the performance of suppliers should be less predictable and/or less verifiable. These factors, typically examined in incomplete contract models, suggest that the coefficient on R&D intensity β_1 should be positive for the choice of domestic outsourcing and negative for *FO*.[13] The empirical investigation of this hypothesis is the main target of this paper.

This prediction is also consistent with a wide variety of other recent models of incomplete contracting. For example, Feenstra and Spencer (2005) argue that relation-specific investment, which is likely to result in product customization, makes firms prefer DO to FO. Acemoglu et al. (2005) predict outsourcing more likely when the producing industry is less technology intensive, with supportive empirical evidence from pairs of supplying-producing U.K. industries. Acemoglu et al. (2006) prove that greater contractual incompleteness reduces supplier investments and leads to the adoption of less advanced technology. Antràs (2005) shows that firms outsource overseas in the last stage along the Vernon-type product cycle. Antràs and Helpman (2006) show that firms choose to integrate rather than to outsource when contractual frictions are more serious for headquarter services than material inputs. While none of these papers squarely investigates the foreign vs. domestic decision in outsourcing,[14] all these studies are basically in line with the negative relation between foreign outsourcing and technological complexity.[15]

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[13] If outsourced components need R&D of the firm who produce them, the outsourcer's R&D is a negatively biased indicator of the product's technological complexity. On the other hand, if the firm is outsourcing labor-intensive production processes, the R&D-sales ratio is upward biased. However, the current paper focuses on the contrast between FO vs. DO, rather than outsourcing vs. in-house.

[14] Feenstra and Spencer (2005) consider DO vs. FO in their theoretical model, but DO data are not available in their dataset on Chinese processing trade. Acemoglu et al. (2005, 2006) do not distinguish FO from DO. Antràs (2005) compares export, FDI, and FO, assuming DO away.

[15] Glass and Saggi (2001) argue that increased profit by FO creates greater incentives for innovation, but do not consider DO or incomplete contracts. R&D or technology choice is not examined in the models on the four-way choice (integration vs. outsourcing as well as foreign vs. domestic) by

Other right-hand side variables in (1) are expected to have the signs as follows. First, large-sized firms should be active in outsourcing not only within the home country but also across borders because they generally have strong bargaining position and/or rich management skills necessary for contracting, especially for international contracting. Second, capital-intensive firms may find profitable to outsource abroad. As the thick market effect in Grossman and Helpman (2005) suggests, capital-intensive Japanese final assemblers are more likely to turn up a partner supplier for outsourcing labor-intensive tasks in neighbouring low-wage Asian countries where more input suppliers are active in labor-intensive tasks, compared with labor-scarce Japan. An alternative scenario that only capital-intensive firms can overcome high entry costs for foreign outsourcing is observationally equivalent in the reduced-form (1). Third, the computer network connection should be positively related with outsourcing, since it reduces search costs and facilitates business-to-business matching, and since contracting tends to be relatively easy on information-based transparent tasks. Finally, the operation of foreign affiliates should facilitate contacts with potential foreign subcontractors and thus enhance foreign outsourcing.

The control of industry-specific factors is also important to discuss the technological complexity of products. For example, chemical products are normally characterized by their high R&D-sales ratios, but tend to depend on few customized parts and components.

The specification (1) assumes that the same variables affect the firm's choice from four disjoint categories, but, for a robustness check purpose, this paper also estimates alternative specifications by imposing restrictions: excluding *FDI* from the choice of *DO* vs. *No Out* , and excluding *Net* from the choice of outsourcing location (*DO* vs. *FO*). These exclusion restrictions are motivated by the following daily observations: the computer network connection is

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Antràs and Helpman (2004) or Grossman et al. (2005).

supposed to facilitate business contacts in any location irrespective of national boundaries, while the operation of foreign affiliates is supposed to facilitate contacts with foreign suppliers but not directly those with domestic suppliers. When we include exactly the same set of explanatory variables into all choices without restrictions as in (1), only through the functional form assumption (independence of each choice's error terms) we can identify whether the variable affects the choice directly as in the model or indirectly through correlations among error terms.[16] While we must note that the restrictions imposed here are not perfect in that *FO&DO* and *FO only* categories still have the same controls, the current paper compares the estimation results from the three cases to check the robustness of our conclusion.

While the equation (1) concentrates on the firm's discrete choice between foreign vs. domestic outsourcing, the survey contains the data on how much each firm is outsourcing within and across borders, respectively. To exploit this important information, this paper estimates the following alternative specification:

$$\frac{DOV}{FOV+1} = \mu + \delta_1 \ln\left(\frac{R\&D}{Q}\right) + \delta_2 \ln Q + \delta_3 \ln\frac{K}{L} + \delta_4 Net + \delta_5 FDI + \eta IND + v\,. \quad (2)$$

The variables on the right-hand side are kept the same to facilitate comparisons with (1). The dependent variable is now replaced by the ratio of tasks contracted out to domestic suppliers *DOV* over those to foreign suppliers *FOV*, both of which are measured in terms of yen value. To include many firms without foreign outsourcing into the regression, this paper adds the value of one to the denominator. This continuous ratio is another appropriate measure because firms in the real world normally perform many tasks, each of which can be formalized by the binary foreign-vs.-domestic decision of a one-task firm (assembler) considered in Grossman and Helpman (2005).[17] The theory predicts that the coefficient on R&D intensity in (2) should be

[16] This problem is pointed out by an anonymous referee.
[17] Shy and Stenbacka (2005) consider multiple inputs for a manufacturer and derive the equilibrium fraction of outsourced inputs, though they do not distinguish FO in outsourcing.

positive. The error term is expressed by *v*.

This paper estimates the equation (2) by the Heckman's two-step procedure. In the first-stage, the selection equation (outsourcing or not) is estimated by probit.[18] In the second-stage, the equation (2) for the DO-FO ratio is estimated with the selectivity correction. The same explanatory variables are used both in the first- and second-stage equations, as no theoretical priors are imposed. As a robustness check, this paper also estimates the alternative specifications excluding *Net* from the second-stage regression and excluding *FDI* from the first-stage selection of *DO* or Not.[19]

4.2. Estimation results

This section reports estimation results and discusses their interpretations. First, Table 2 displays the results from the multinomial logit model. Industry-specific factors are controlled by the dummy variables. Heteroskedasticity-robust standard errors are in parentheses. The base category is *DO only*.

As the most notable finding, low R&D intensity is significantly related with the choice of foreign outsourcing relative to domestic outsourcing. This finding implies that foreign outsourcing is more likely to prevail in technologically simpler, more standardized, or less customized products, as consistent with the theoretical prediction by Grossman and Helpman (2005).

Other results shown in the base specification (1) are also noteworthy. Large-sized firms tend to choose foreign outsourcing, corroborating the descriptive statistics in Table 1. Foreign

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[18] Since *FO only* firms are exceptional, this paper focuses on the choice of *DO* or not in the first-stage selection equation.

[19] The choice of excluded variables is the same as in the previous multinomial logit model. Without restrictions, only though functional form assumption we can identify whether the variable explains *DOV/FOV* directly in the 2nd-stage regression or indirectly though Mill's ratio. This problem is pointed out by an anonymous referee.

outsourcing is preferred when the firms are capital-intensive or connected with computer networks. The operation of affiliates overseas appears positively related with foreign outsourcing, though the relation is insignificant for the exceptional category *FO only*. On the other hand, the firms outsourcing no production tend to be less R&D-intensive compared with domestic outsourcers, small in size, labor-intensive, not connected with computer networks, or source overseas in-house from FDI-integrated subsidiaries. These findings are generally consistent with our expectations.

Alternative specifications (2) and (3) confirm the robustness of our main findings. All the signs of the estimated coefficients are unchanged, with relatively minor changes in magnitudes. Among them, the coefficient on R&D-sales ratio remains significantly negative for the choices involving *FO* in all specifications (1), (2), and (3).

Next, Table 3 reports the result from the Heckman's two-step procedure.[20] Industry dummies are included in all cases, both at the first- and second-stage equations. The signs of all coefficients estimated by the first-stage probit equation (*DO* or not) are confirmed consistent with the logit estimates on the choice of *No Out* against *DO only* in Table 2.

As the most important thing to note in the second-stage regression, higher R&D intensity is related with significantly more tasks outsourced to domestic suppliers relative to foreign suppliers in the yen value.[21] Thus, our previous result from the multinomial choice model is confirmed robust even with this continuous value ratio.

The Heckit estimates reveal other interesting results as well. First, fixed entry costs for outsourcing appear non-negligible, as implied by the significant inverse Mill's ratio.

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[20] Robust standard errors for Heckit are estimated by bootstrap with 200 iterations. The heteroskedasticity-consistent maximum-likelihood estimation did not converge within a reasonable number of iterations.

[21] This finding on the continuous share is consistent with Shy and Stenbacka (2005), as they predict that the fraction of outsourced inputs decreases with the technological complexity.

Second, larger-sized firms tend to significantly more often start outsourcing, but the dependence on foreign outsourcing in yen value does not rise proportionally with the firm size. The firm size here may work as a proxy for headquarter functions, which are required upon entry into outsourcing contracts.

Third, firms appear to outsource more of their tasks within the home country when they are more capital-intensive. Labor-intensive tasks are relatively easy to be outsourced overseas, typically to low-wage countries. This finding is consistent with the theoretical prediction by Antràs (2003),[22] though the coefficient on *K/L* is not statistically significant.[23]

Fourth, the connection with computer networks is significantly related with outsourcing in general, not particularly with foreign outsourcing. This implies that information technology development facilitates business matching in any location. This result from the base specification (1) also confirms the restriction imposed on alternative specifications (2) and (3) excluding *Net* from the allocation of tasks between domestic and foreign suppliers in the second-stage regression.

Finally, the estimated coefficient on R&D-sales ratio in the second-stage regression remains quite stable across specifications (1)-(3), irrespective of exclusion restrictions. Although the coefficient on *FDI* is estimated insignificant or unstable,[24] our principal finding of significantly positive relation between R&D intensity and domestic outsourcing relative to foreign outsourcing has been confirmed to be robust.

5. Concluding remarks

[22] Antràs (2003) predicts active FO in labor-intensive sectors, though he compares FO with intra-firm sourcing from FDI affiliates, not with DO.

[23] The rise of *K/L* as a result of active FO of labor-intensive tasks in the past may offset and weaken the relation between FO and *K/L*.

[24] The outsourcing in this survey includes purchases from foreign affiliates as long as they are independent legal entities. This statistical contamination may affect our results on *FDI*.

This paper has investigated the firm's choice between foreign and domestic outsourcing, based on a firm-level data set covering 118,300 firms in all manufacturing industries without any firm-size threshold. The empirical findings are consistent with the theoretical prediction. R&D intensity is found negatively related with the extent of foreign outsourcing relative to domestic outsourcing. This result is one of the earliest direct evidence on the relationship between technological complexity and the choice of outsourcing location at the firm level.

To cement the generality of this finding, however, several attempts will be desirable in future independent studies. At the aggregate sector level, intermediate import data derived from input-output tables can be combined with R&D data. One will also find it interesting to seek micro data on foreign outsourcing of non-production services, linked with data on human skills at the firm level, preferably in a longitudinal form.

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Table 1 Comparison of averages and shares

	FO & DO	*FO only*	*DO only*	*No Out*
(1) Share (% in total number of firms)	2.48	0.20	46.52	50.81
(2) Average Firm Size (in sales) (relative to *No Out*)	20.99	6.93	2.57	1
(3) Firms active in R&D (% within each group)	46.16	28.21	22.22	9.97
(4) Average R&D-Sales Ratio (%)	2.49	2.59	2.37	3.48
(5) Average Capital-Labor Ratio (relative to *No Out*)	1.15	1.15	0.98	1
(6) Firms connected with Computer networks (%)	52.13	33.76	31.33	13.61
(7) Firms operating Affiliates overseas (%)	26.22	27.35	3.99	1.26

Notes: All 118,300 firms are included. The rows (3), (6), and (7) display the percentage within each group.

Table 2 Multinomial logit estimation

(1)	*FO & DO*	*FO only*	*No Out*
R&D/Sales	–0.0101 (0.0019)**	–0.1704 (0.0097)**	–0.0226 (0.0011)**
Size	0.1220 (0.0129)**	0.2540 (0.0266)**	–0.3647 (0.0059)**
K/L	0.0598 (0.0128)**	0.0916 (0.0198)**	–0.0405 (0.0058)**
Net	0.8350 (0.0379)**	1.2599 (0.0658)**	–0.1846 (0.0196)**
FDI	1.2909 (0.0682)**	–0.5391 (0.3568)	0.7287 (0.0639)**
Log pseudo-likelihood = –71742.843, Pseudo R^2 = 0.2279			

(2)	*FO & DO*	*FO only*	*No Out*
R&D/Sales	–0.0093 (0.0019)**	–0.1699 (0.0097)**	–0.0208 (0.0011)**
Size	0.1318 (0.0128)**	0.2568 (0.0265)**	–0.3526 (0.0060)**
K/L	0.0589 (0.0128)**	0.0920 (0.0198)**	–0.0380 (0.0058)**
Net	0.8293 (0.0380)**	1.2602 (0.0658)**	–0.1778 (0.0196)**
FDI	1.1520 (0.0674)**	–0.6214 (0.3546)*	---------
Log pseudo-likelihood = –71841.756, Pseudo R^2 = 0.2268			

(3)	*FO & DO*	*FO only*	*No Out*
R&D/Sales	–0.0044 (0.0019)**	–0.1594 (0.0094)**	–0.0206 (0.0011)**
Size	0.2375 (0.0126)**	0.3924 (0.0258)**	–0.3470 (0.0060)**
K/L	0.0264 (0.0135)**	0.0225 (0.0177)	–0.0389 (0.0058)**
Net	---------	---------	–0.2337 (0.0194)**
FDI	1.1402 (0.0692)**	–0.5499 (0.3370)*	---------
Log pseudo-likelihood = –72168.549, Pseudo R^2 = 0.2233			

Notes: 110,987 firms are covered. The base category is *DO only*. Industry dummies are included. Robust standard errors are in parentheses. Explanatory variables, except dummies, are in logarithms. The asterisks * and ** denote the statistical significance at 10% and 5%, respectively.

Table 3 Heckman's two-step estimation

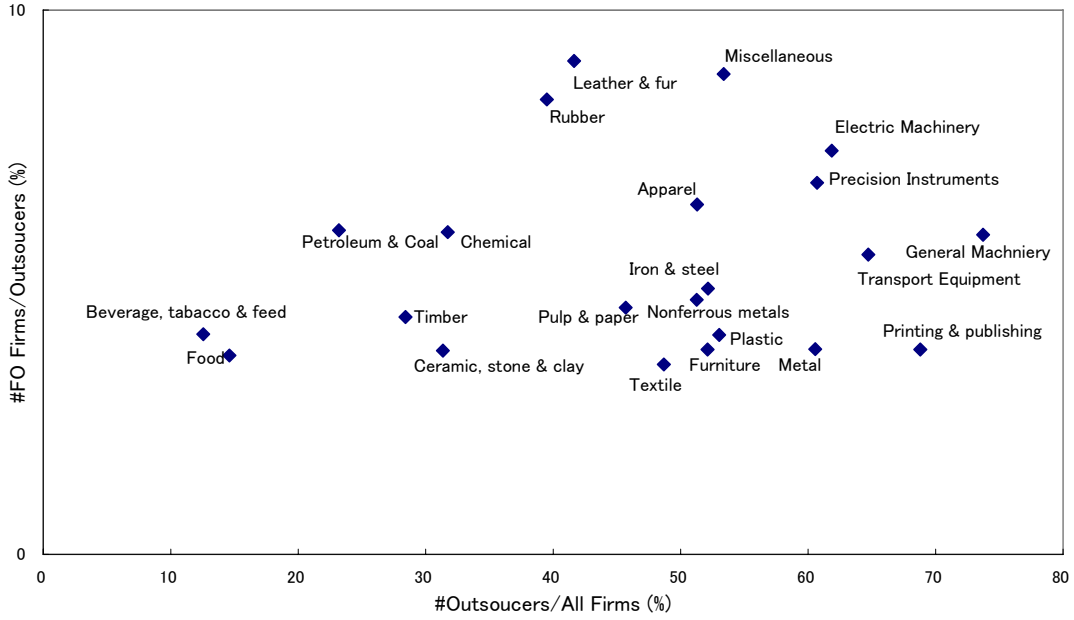
(1)	DOV/(FOV+1) (yen value ratio)	*DO* or Not (1st-stage Selection)
R&D/Sales	86.31 (30.80) **	0.0150 (0.0006) **
Size	1745.04 (571.62) **	0.2034 (0.0035) **
K/L	76.72 (41.24) *	0.0208 (0.0036) **
Net	350.74 (145.53) **	0.1115 (0.0104) **
FDI	–47.70 (464.41)	–0.3656 (0.0321) **
Inverse Mill's ratio	13601.49 (4913.87) **	(Wald χ^2 = 90.77)

(2)	DOV/(FOV+1) (yen value ratio)	*DO* or Not (1st-stage Selection)
R&D/Sales	83.85 (31.99)**	0.0150 (0.0006) **
Size	1698.92 (607.81) **	0.2034 (0.0031) **
K/L	63.43 (34.56) *	0.0208 (0.0032) **
Net	---------	0.1115 (0.0111) **
FDI	76.76 (436.84)	–0.3656 (0.0327) **
Inverse Mill's ratio	12702.55 (5008.37) **	(Wald χ^2 = 70.30)

(3)	DOV/(FOV+1) (yen value ratio)	*DO* or Not (1st-stage Selection)
R&D/Sales	89.19 (32.87) **	0.0140 (0.0006) **
Size	1774.49 (618.27) **	0.1949 (0.0032) **
K/L	85.77 (46.27) *	0.0197 (0.0034) **
Net	---------	0.1072 (0.0108) **
FDI	1625.42 (288.07) **	---------
Inverse Mill's ratio	14178.58 (5382.70) **	(Wald χ^2 = 84.39)

Notes: Among 110,987 firms used for estimation, 39,476 are censored. Industry dummies are included in all equations. Robust standard errors are in parentheses. Explanatory variables, except dummies, are in logarithms. The asterisks * and ** denote the statistical significance at 10% and 5%, respectively.

Figure 1 Inter-industry comparison



Notes: Percentages are on the number of firms within each industry. All 118,300 firms are aggregated to 22 two-digit industries.