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Global Sourcing, Technology, and Factor Intensity: Firm-level Relationships

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Abstract

This paper empirically examines how technology and capital intensity are related with the firm's global sourcing decision. Firm-level data are derived from a survey covering all manufacturing industries in Japan without any firm-size threshold. Firms are disaggregated by their make-or-buy decision (in-house or outsourcing) and by their choice of sourcing location (offshore or domestic). Capital-intensive or R&D-intensive firms tend to source in-house from their FDI affiliates rather than outsourcing to independent suppliers. This paper also confirms that high productivity is related with offshore sourcing. These findings are basically robust even after industry and firm-size are controlled for.

JEL Classifications: F23; D23; F12; F14; L23
Keywords: offshore outsourcing; capital-labor ratio; R&D; heterogeneity; firm-level data

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1. Introduction

The make-or-buy decision has been the critical issue for the theory of the firm in economics at least as early as Coase (1937). In recent years, however, firms are sourcing not from only within the same country but also across national borders, partly facilitated by the development of information technology and trade liberalization. The expansion of global sourcing makes the make-or-buy decision intertwined with the globalization decision (domestic-vs.-foreign), and compels firms to form a complicated sourcing strategy. This paper documents how technology and factor intensity are related with the firm's global sourcing decisions, based on the unique firm-level data with an explicit measure of offshore outsourcing.

The seminal paper titled "Global Sourcing" by Antràs and Helpman (2004) squarely considers the four-way procurement-location choice (in-sourcing vs. outsourcing, domestic vs. foreign sourcing). They predict that firms sourcing offshore should be more productive than those sourcing only within the home country because of high entry costs for global sourcing. Among the firms sourcing from foreign countries, they also show that the productivity of in-sourcing firms should be higher than outsourcing firms if entry costs for foreign direct investment (FDI) are higher than those for foreign outsourcing (FO). Thus, their paper provides us with a testable hypothesis on the ordering of firms' productivity.[1]

While the productivity is the main focus in the recent heterogeneous firm models in international economics, the factor intensity has been the critical variable since the standard Heckscher-Ohlin trade theory. The model by Antràs (2003), which is based on the vertical integration (VI) theory by Grossman and Hart (1986), shows that FDI firms should be more capital-intensive than FO firms because the investment cost sharing is relatively easier in physical capital and the role of local suppliers tends to be more important in hiring/monitoring workers.[2] His paper has also provided empirical evidence at aggregated sector-country level.

The model by Antràs and Helpman (2006) generalizes their previous paper (Antràs and Helpman, 2004) by allowing the degree of contractibility to vary not only across countries but also across inputs. They show that firms tend to choose to integrate when contracting is difficult for headquarter services compared with manufactured components. As contracting is supposed to be difficult for technologically complex or advanced inputs, their result suggests that FDI should be more prevalent than FO for R&D-intensive firms. As a closely related result, Acemoglu et al. (2005) report that contractual frictions promote integration in technology

[1] Grossman et al. (2005) also examine the four-way choice and derive basically the same prediction on the productivity ordering, but emphasize the complementarities between domestic and foreign outsourcing in the firm's decision.

[2] Either this paper or Antràs (2003) does not discuss the differences in empirical implications of property rights and transaction-cost theories of the firm. See Whinston (2001) on this distinction.

intensive industries, by combining firm-level location data with US sector-level input-output data.[3]

To investigate the empirical relevance of these recent theoretical models of international trade and FDI by heterogeneous firms, this paper compares productivity, capital-labor ratio, and R&D-sales ratio directly at the firm level, based on micro-data covering all manufacturing industries in Japan without any firm-size threshold. "A firm-level data analysis is needed to answer this question, and no such analysis is available at this point in time" (Antràs and Helpman, 2004: p.553). This paper fills this gap by exploiting unique direct firm-level data on foreign outsourcing explicitly distinguished from domestic outsourcing. To preview the main results, this paper finds that firms sourcing offshore are on average more productive than firms sourcing exclusively within the home country and that firms sourcing internally from FDI affiliates tend to be more capital-intensive or R&D-intensive than firms outsourcing to independent suppliers. The principal results are confirmed basically robust even after controlling for industry and firm size. Consequently, these findings can be regarded as early direct empirical evidence supporting the relevance of recent theoretical models, such as Antràs and Helpman (2004, 2006)

The rest of this paper is organized as follows. Section 2 explains the data source used for this paper. Section 3 documents the distribution of 118,300 firms over eight different procurement-location modes, with disaggregation according to industry or firm size. Section 4 reports how the productivity, capital intensity, and R&D intensity differ depending on the firm's procurement-location choice. Section 5 concludes.

2. Data source

This paper derives firm-level data from *The Basic Survey of Commercial and Manufacturing Structure and Activity* (Sho-Kogyo Jittai Kihon Chosa in Japanese).[4] The survey covers 118,300 firms in all manufacturing industries without any firm-size threshold. The sample size is remarkably larger than those previously used for a similar purpose.[5] The firms

[3] Yeaple (2006) reports active intra-firm trade in capital- and R&D-intensive industries based on aggregated US. data. Feenstra and Hanson (2003) examine the relation between offshore outsourcing and FDI ownership, though no data on domestic outsourcing are available in their data set on the Chinese processing trade.

[4] Though the original firm-level data cannot be publicly disclosed, any researcher can gain access to the same data set by obtaining official individual permission from the government in advance.

[5] Only a limited number of previous studies have used micro data for offshore outsourcing, and their sample size is much smaller than ours: 1,070 firms by Head and Ries (2002), and 1,414 plants by Görg et al. (2004), for example. Acemoglu et al. (2005) investigate the locations of 769,199 firms, but depend on sector-level US. Input-Output Tables in measuring VI.

are surveyed irrespective of their involvement in outsourcing or FDI. Thus, this survey is regarded as an accurate overall replication of all manufacturing in Japan. As the survey was conducted only once at 1998, the data set is in a cross-section format.

The survey contains a wide range of corporate data, including sales, employment, capital, and R&D expenditure. On FDI, the survey captures whether each firm owns affiliates overseas, but contains no information on the size of offshore operations, such as local procurement, intra-firm trade or offshore employment. The location of each foreign affiliate is identified by Asia or the rest of the world. No further geographical disaggregation is available in the survey. Consequently, this paper defines FDI firms by the ownership of at least one affiliate located in Asia, but only if they own shares of at least 20%. Since the overwhelming share of Japanese FDI goes either into the US., Europe, or Asia, the concentration on Asia implies our focus on vertical FDI, i.e. the exclusion of horizontal FDI for local sales (normally located in high-income, high-cost Europe or the US.).[6] The lower bound for ownership share is set for excluding FDI in sales branches or portfolio investment.

As unique data on outsourcing, the survey directly asks sample firms whether they "contract out manufacturing or processing tasks to other firms." As firms (suppliers, subcontractors) overseas and those within the home country are separated in this questionnaire, foreign outsourcing thus defined is explicitly distinguished from domestic outsourcing.[7]

To the knowledge of the author, no previous studies have empirically investigated the firm's procurement decision together with location decision at the firm level.[8]

3. Distribution of firms

3.1. Overall shares

Firms are disaggregated by their make-or-buy decision (in-house or outsourcing) as well as their sourcing location decision (domestic or offshore sourcing). Table 1 presents the percentage share of each type of firms among 118,300 firms (the total number surveyed). "DO"/"FO" denotes firms outsourcing at least some of their production tasks to independent domestic/foreign suppliers, respectively. FDI firms (firms supposed to source at least some

6 Helpman, Melitz, and Yeaple (2004) examine the choice between exporting and horizontal FDI. Tomiura (2007) combines all FDI firms (vertical and horizontal) in comparing productivity with exporters and FO firms, based on the same firm-level data as the current paper.

7 Though it does not cover FO of non-production services, this definition is more appropriate than intermediate import data in excluding procurement of standardized intermediates. See also Tomiura (2007) for the survey's definition.

8 Görg et al. (2004) estimate the relationship between intermediate imports and the productivity of foreign-owned firms in Ireland, but do not consider outward FDI.

inputs in-house from their vertical FDI affiliates) are expressed by "FI."[9] The firms involved in none of these three modes (DO, FO, FI) are labelled as "DI only," for which all the inputs are procured inside the firm or at the marketplace without contracts specifying specs of inputs. The eight categories in the table are mutually exclusive. Since firms in the real world are normally involved in multiple tasks, some of them simultaneously engage in multiple procurement-location modes. For example, "DO*FI" represents firms sourcing in-house and from domestic outside contractors as well as from their foreign affiliates, but not from foreign independent suppliers. "All" denotes firms simultaneously engaged in all four procurement modes (DO, FO, FI, and DI). We note the following points from this table.

First, the share of firms sourcing abroad, even if intra-firm sourcing and arm's-length outsourcing are combined, is less than 5%. As smaller firms, less likely to engage in offshore sourcing, are sampled with lower probability in the survey, the share of firms sourcing abroad must be even lower in the entire population.[10] This may suggest non-negligible entry costs for offshore sourcing. As large-sized firms certainly tend to source a large amount of intermediates across borders, however, the impact of offshore sourcing should not be underestimated.

Second, 45% of the surveyed firms are sourcing only from domestic suppliers ("DO"), while 50% of the firms are sourcing totally within the firm or depend totally on standardized parts and components available at the marketplace ("DI only"). These two modes are dominant in the firms' procurement in the sample covering firms of any size.

Third, the outsourcers perfectly bypassing domestic suppliers ("FO*FI") are exceptional (0.04%). Since finding partner suppliers and concluding contracts are supposed to be much easier in the home country than in foreign countries, this result is as expected.

3.2. Inter-industry variations

As the industry is supposed to affect the firm's sourcing decision, Table 2 disaggregates 118,300 firms into 22 two-digit industries.[11] The following substantial variations are evident across industries.

First, the share of firms totally dependent on domestic intra-firm sourcing ("DI only") is as low as 26% in general machinery, but is as high as 85-87% in food, beverage, tobacco, and feed manufacturing. The firms are actively sourcing from independent suppliers or from their affiliates overseas also in other machinery industries. This inter-industry contrast is natural

9 The survey unfortunately contains no data on intra-firm transactions.
10 All the firms with no less than 50 employees are surveyed with certainty, but the firms with less than 50 are sampled with varying probability of less than one. However, we cannot rescale the differences, as the government does not disclose the sampling frequency for each cell.
11 The disaggregation to three-digit industries is available upon request.

because production processes of machinery goods are characterized by dense inter-firm transactions of specially designed parts and components.

Second, the share of firms actively outsourcing within the home country but not involved in offshore sourcing (DO) is particularly high in printing-publishing and general machinery industries (66-68%). Printing tasks outsourced from Japanese firms inevitably require extensive knowledge of Japanese characters and language. General machinery is characterized by technologically advanced, highly differentiated products, which tend to require geographical proximity for intensive contacts between suppliers and assemblers.

Next, the inter-industry contrasts are also evident in the third-most frequent mode after these two most common modes ("DO" and "DI only"). Intra-firm sourcing associated with FDI ("FI" and "DO*FI") is relatively prevalent in R&D-intensive chemical industries, while arm's-length outsourcing ("DO*FO") is relatively often in labor-intensive apparel and leather industries. The difference appears again related with product characteristics.

Finally, the share of firms active in all four procurement modes ("All") is relatively high in electric machinery and transport equipment industries, notably the most globalized industries in Japan. These two industries, however, differ in the third-most frequent mode after "DO" and "DI only": "DO*FO" in electric machinery and "DO*FI" in transport equipment. This difference is likely to due to the characteristics of intermediates: parts and components for electronics are often general purpose with minor adaptation to final products, but those for automobiles are specially designed for and deeply integrated with specific types of final products.

On the other hand, the firms outsourcing abroad without depending on domestic suppliers are exceptional in all industries. The share of "FO" and "FO*FI" is respectively less than 1%. This suggests non-negligible frictions associated with cross-border contracting in any industry.

3.3. Firm-size variations

Previous discussions have combined firms of any size, but the firm size should be a critical factor in the procurement-location decision. Larger firms are likely to engage in offshore sourcing because they normally have richer human capital, established logistic networks, stronger bargaining positions, and higher retained earnings, for example. Consequently, this section disaggregates 118,300 firms into 40 bins based on the firm size.[12] Figure 1 displays the

[12] The firm size is measured in terms of the number of regular employees. The thresholds for each bin are shown in the graph. The width of each bin is chosen to allocate firms across bins equally as possible. It is impossible, however, to assign exactly the same number of firms to each bin because all the firms with exactly the same number of workers are allocated into the same bin.

percentage distribution of firms across eight procurement-location modes within each firm-size bin. The following points are noteworthy in the graph.

First, the share of DI-only firms is monotonically declining as the firm size becomes larger. This suggests that these DI-only firms in our sample do not utilize FDI-sourcing or arm's-length outsourcing possibly because of their inability to cope with contracting or offshore procurements. Within small-sized firms employing less than 16 workers, DI-only is the most frequently observed mode.

Second, for the firm size of 16-1000 workers, DO occupies the largest share among the eight procurement-location choice patterns. For many size bins within mid-sized firms, DO&FO is the third-most frequent choice.

Third, among large-sized firms, the share of DO&FI rises as the firm becomes larger. Within the largest firms (more than 1,000 workers), DO&FI is the most frequent choice surpassing DO and DI-only. "All" occupies the third-largest share within this firm-size bin.

Consequently, the firm size appears strongly associated with the firm's procurement-location decision. The share of FI (intra-firm sourcing from FDI affiliates) rises steeply as the firm becomes larger among large-sized firms. Among mid-sized firms, the number of firms depending solely on domestic suppliers is larger than firms sourcing totally in-house. Among small-sized firms, intermediates are totally sourced in-house or at marketplace.

However, it is premature to conclude that the firm size dictates the procurement-location decision. The firm-size variations shown in Figure 1 may be partly affected by variations in underlying key variables. Larger firms may tend to source offshore because they tend to be more productive, capital-intensive, and R&D-intensive, not directly because of their large size. This issue will be investigated further in Section 4.2 in regression formats.

4. Firm-level comparisons of productivity, capital intensity, and R&D intensity

4.1. Descriptive statistics

This section is devoted to the comparison of major firm-level characteristics across different procurement-location modes. The comparisons in this paper concentrate on the following three key variables: (a) productivity, (b) capital intensity, and (c) R&D intensity. The focus on these variables is motivated by theoretical predictions, as explained in the Introduction. The productivity is measured in terms of labor productivity[13] (value-added divided by the number of

[13] In a cross-section data set, it is practically impossible to calculate Total Factor Productivity of each firm. Tomiura (2007) has confirmed that the productivity ordering over procurement choices is basically robust irrespective of the choice of various productivity measures.

regular employees).[14] The capital intensity K/L is defined by tangible fixed assets divided by the number of regular employees.[15] The R&D intensity is defined by the percentage of R&D expenditures divided by sales.[16] The firms are again grouped into eight disjoint categories, as in previous tables.

All results in Tables 3-5 are expressed in terms of percentage logarithm difference from the average of DI-only firms. Table 3 reports the average over all firms of each procurement-location category. The averages in Table 4 are after subtracting the average of each firm-size bin, exactly as defined for Figure 1. On the other hand, Table 5 results from the subtraction of three-digit industry means.[17] By comparing these three tables, we can detect how firm size or industry affects the variations in the three key variables. The following findings are noteworthy.

First, high productivity is related with offshore sourcing (outsourcing or intra-firm). FO firms and FI firms are substantially more productive than DO firms, which in turn are more productive than DI-only firms. As high productivity is supposed to be required to overcome entry costs for international operations, our finding of high productivity of firms sourcing offshore is consistent with the prediction of formal models such as Antràs and Helpman (2004). Furthermore, among firms sourcing offshore, FI firms are on average more productive than FO firms (FI more productive than FO, and DO*FI more productive than DO*FO), possibly reflecting differences in required entry costs between FDI and FO.[18] The effects of controlling for industry or firm size are quantitatively minor. Consequently, our finding is robust irrespective of the different composition of firms across size classes and industries.

Second, the firms active in intra-firm sourcing abroad tend to be substantially capital-intensive. This finding is consistent with the theoretical prediction and sector-level evidence by Antràs (2003). The gap in capital intensity is enormous in Tables 3 and 5, while it is somewhat narrower in Table 4. This implies that the high capital intensity of FI firms is partly due to their large size. However, the capital intensity differential remains sufficiently sizable even after the firm size is controlled for. The capital intensity premium of FI firms expands

14 Value-added is defined by the sales minus "the cost of goods sold," or cost of sales, which is the only cost data in the survey. Firms with no cost data (less than 2% of the surveyed) are excluded from the regressions in the next section.

15 Firms with no capital data or with capital recorded as zero (19% of the surveyed firms) are excluded from the regressions in the next section.

16 All 118,300 firms are included by replacing unobserved or non-R&D with zero R&D expenditure and by adding a negligible 10^{-8} to R&D before taking logarithm.

17 This is the most detailed industrial classification in the survey.

18 Grossman and Helpman (2004) predict a different productivity ordering in their model with monitoring efforts.

rather if compared with firms in the same industry.

Third, the firms active in intra-firm sourcing abroad tend to have substantially high R&D intensity. This firm-level finding is consistent with the theoretical prediction by Antràs and Helpman (2006) and corroborates the US. industry-level evidence reported by Yeaple (2006). The control for firm size partly narrows the differential in R&D-sales ratios, but the contrast remains visible even in Table 4. The control for industry only marginally affects the results. Since R&D-intensive firms tend to prefer internal sourcing because of intellectual property protection or because of hold-up concerns, our finding is consistent with theoretical predictions. This finding is also in line with the accumulated evidence from domestic VI, such as the classic result by Monteverde and Teece (1982) finding the positive effect of engineering design efforts on VI of automotive components.

Before closing this subsection, several notes must be added on the findings for DI-only firms. The figures in the tables indirectly show that the average DI-only firms have the productivity, capital-intensity and R&D-intensity all lowest compared with the firms in other categories. While their low productivity is exactly as expected, the finding of low capital-intensity and low R&D-intensity appears inconsistent with the theoretical prediction. One possible interpretation may be that these variables can work as a proxy for human capital or management skills necessary for contracting or global sourcing. The omission of human capital-related data in the survey may affect this finding. However, the impact of this omission on overall sourcing should be minor since these DI-only firms in our sample are generally very small in size.

4.2. Regression estimations

While the previous section disaggregates firms according to firm-size or industry, Table 6 presents the correlation between variables. The firm size is positively correlated with productivity, capital intensity, and R&D intensity, confirming our prior. Also as expected, the capital-labor ratio is correlated with labor productivity. To control for various effects simultaneously, this paper estimates the following reduced-form specification relating the procurement-location choice with the firm's characteristics and industry dummies:

$$Choice = \alpha + \beta_1 \ln\frac{VA}{L} + \beta_2 \ln\frac{K}{L} + \beta_3 \ln\frac{R\,\&\,D}{Q} + \gamma \ln Q + \delta IND + \varepsilon \,.$$

The dependent variable *Choice* denotes the firm's procurement-location choice in mutually exclusive eight categories. Included on the right-hand side of the regression are the productivity, the capital-labor ratio, the R&D-sales ratio, the firm size (sales), and the vector of industry

dummies.[19] The error term is expressed by ε. All variables other than dummies are in logarithms. As many variables are endogenous, one should not interpret this regression as showing the direction of causality.[20] Consequently, this regression should be viewed as a convenient way of summarizing statistical regularities among variables.

Table 7 reports the multinomial logit estimation results without industry dummies, while those with industry dummies are shown in Table 8.[21] Heteroskedasticity-robust standard errors are in parentheses. Noteworthy findings are as follows.

First, large firm size, high productivity, low capital-labor ratio, and low R&D-intensity are significantly related with the firm's choice of FO. The labor-intensiveness of foreign outsourcers is consistent with the theoretical prediction by Antràs (2003). The finding of low R&D-sales ratio is consistent with the make-or-buy prediction based on internalization, as theoretically formalized by Antràs and Helpman (2006). These firm-level findings on capital- and R&D-intensity are also consistent with previous results from US. aggregate intra-firm trade data by Yeaple (2006).[22] Large firm size and high labor productivity may be prerequisites for foreign business operations, though we cannot exclude the possibility that foreign outsourcing results in higher growth of firm size and productivity. While the statistical significance of capital intensity vanishes if industry effects are controlled for, other three variables remain significant in both tables.

Second, large firm-size and high R&D-sales ratio tend to be significantly related with the firm's choice of FI (sourcing internally from FDI affiliates), though the gap in R&D-sales ratio is largely due to the industry effects. The effects of productivity and capital intensity are found to be statistically insignificant on this category.

Third, the firm size is positively associated with all the three choices of two modes (DO*FO, DO*FI, and FO*FI). Among them, higher spending on R&D is significantly related with the firm's choice of sourcing from their affiliates offshore along with domestic independent suppliers (DO*FI), even after industry differences are controlled for. On the other hand, the results on productivity and capital intensity are sensitive to the inclusion of industry dummies.

Fourth, small firm size, low productivity, low capital intensity, and inactive R&D are all significantly related with the firm's choice of sourcing totally in-house or depending totally on

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19 Due to the computing capacity, this paper uses two-digit dummies in the multinomial logit.
20 It is extremely difficult to find appropriate instrumental variables in cross-section data.
21 Due to the computing capacity, we did not estimate a nested logit model (e.g. out or in-sourcing in the first stage, domestic or foreign in the second stage).
22 Yeaple (2006) further finds that the positive relation of intra-firm trade with capital intensity is especially strong for imports from least developed countries, and that with R&D-intensity is for imports from developed countries, though they are aggregated to the sector-country level.

standardized intermediates (expressed as “DI-only” in the tables), even after industry effects are controlled for. This finding is line with the descriptive statistics reported in the previous section.

Finally, large firm size and high R&D-intensity are significantly related with the firm’s choice of all the four modes simultaneously (“All”). The impacts of productivity and capital intensive are, however, found sensitive to the control for industry effects.

In sum, these regression results are generally in line with the descriptive statistics reported in the previous section.

5. Concluding remarks

This paper has compared the productivity, the capital-labor ratio, and the R&D-sales ratio across 118,300 firms sourcing from domestic and/or foreign suppliers as well as in-house, in some cases from affiliates overseas. The principal findings from our firm-level data are consistent with theoretical predictions. The productivity of firms sourcing offshore tends to be higher than that of firms sourcing only within the home country. The capital-labor ratio and R&D-sales ratio tend to be higher for firms sourcing internally from FDI affiliates compared with outsourcing firms. These results have been basically confirmed to be robust even if industry and firm size are controlled for. Consequently, the findings reported in this paper have constituted empirical evidence favourable for recent theoretical models of heterogeneous firms, such as Antràs and Helpman (2004, 2006).

While this paper has revealed impressive statistical regularities on the offshore make-or-buy decision, several issues remain unexplored in this paper. Among them, since the survey contains no data on the volume of intra-firm trade, this paper cannot evaluate the relative magnitude of in-house vs. outsourcing procurement. In future independent studies, it will be informative to link outsourcing data with intra-firm trade data derived from different firm-level sources, preferably in a longitudinal form.

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Table 1. Percentages of firms

DI only	DO	FO	FI	DO*FO	DO*FI	FO*FI	All
50.35	45.18	0.16	0.46	1.91	1.34	0.04	0.57

Notes: See text for the definition of each category.

Table 2. Percentages of firms within each industry

INDUSTRY	DI only	DO	FO	FI	DO* FO	DO* FI	FO* FI	All
12. Food manufacturing	84.90	13.59	0.10	0.50	0.34	0.48	0.01	0.09
13. Beverage, tobacco & feed	87.27	11.56	0.03	0.18	0.36	0.48	0.03	0.09
14. Textile	50.97	46.17	0.10	0.35	1.32	0.82	0.00	0.28
15. Apparel & textile products	48.39	46.86	0.30	0.33	2.28	1.12	0.11	0.61
16. Wooden products	71.48	26.82	0.23	0.09	0.87	0.37	0.07	0.07
17. Furniture & fixture	47.73	49.58	0.17	0.17	1.47	0.56	0.03	0.28
18. Paper & pulp products	54.25	42.83	0.22	0.06	1.69	0.78	0.00	0.16
19. Printing & publishing	31.06	65.81	0.06	0.13	2.25	0.41	0.00	0.28
20. Chemical products	65.72	26.84	0.16	2.56	1.20	2.99	0.03	0.49
21. Petrol. & coal products	74.31	20.17	0.00	2.49	1.10	1.66	0.00	0.28
22. Plastic products	46.59	48.13	0.10	0.40	1.40	2.74	0.08	0.56
23. Rubber products	60.13	34.94	0.38	0.38	1.92	1.25	0.04	0.96
24. Leather & fur products	58.15	37.42	0.66	0.22	2.90	0.44	0.05	0.16
25. Ceramic, stone & clay	68.21	29.56	0.10	0.45	0.86	0.61	0.05	0.17
26. Iron & steel	47.37	47.82	0.00	0.49	2.13	1.77	0.04	0.37
27. Nonferrous metals	48.02	45.93	0.00	0.73	1.67	2.92	0.05	0.68
28. Metal products	39.21	57.14	0.09	0.22	1.93	1.14	0.01	0.26
29. General machinery	25.83	67.58	0.12	0.44	3.26	1.81	0.00	0.95
30. Electric machinery	37.55	55.04	0.13	0.61	2.99	2.22	0.06	1.40
31. Transport equipment	34.75	58.48	0.12	0.53	2.24	2.67	0.07	1.14
32. Precision instruments	39.03	55.48	0.30	0.25	2.88	1.09	0.05	0.91
34. Miscl. Manufacturing	46.00	47.38	0.48	0.61	3.16	1.30	0.13	0.94

Notes: Shown are percentages in the number of firms within each industry. The ordnance industry (33) is merged into general machinery (29).

Table 3. Overall comparisons

	DO	FO	FI	DO*FO	DO*FI	FO*FI	All
VA/L	17.59	50.07	72.57	34.42	57.54	36.30	63.17
K/L	35.91	41.69	134.00	58.68	128.10	76.27	118.59
R&D/Q	155.26	224.46	741.59	406.08	793.73	391.96	848.23

Notes: Percentage logarithm difference from the average over DI-only firms is shown.

Table 4. Comparisons controlling for firm size

	DO	FO	FI	DO*FO	DO*FI	FO*FI	All
VA/L	18.83	48.89	59.18	36.00	45.32	38.38	47.54
K/L	31.17	41.25	84.02	46.43	76.31	62.46	63.77
R&D/Q	75.75	168.28	273.02	258.04	303.45	235.40	333.08

Notes: The mean of the respective firm-size bin is subtracted. There are 40 bins based on employment.

Table 5. Comparisons controlling for industry

	DO	FO	FI	DO*FO	DO*FI	FO*FI	All
VA/L	19.61	56.63	67.77	38.93	61.51	49.58	74.17
K/L	38.37	57.10	123.93	64.44	126.94	95.93	127.58
R&D/Q	148.10	223.25	657.10	388.86	747.54	389.94	813.41

Notes: The mean of respective industry is subtracted. There are 75 three-digit industries.

Table 6. Correlation between variables

	Size	*VA/L*	*K/L*	*R&D/Q*	*DO*	*FO*	*FI*
Size	1						
VA/L	0.2946	1					
K/L	0.3570	0.2188	1				
R&D/Q	0.1639	0.0281	0.0227	1			
DO	0.2212	0.0772	0.0999	0.1136	1		
FO	0.1356	0.0472	0.0456	0.0296	0.0877	1	
FI	0.2104	0.0413	0.0546	0.1024	0.0225	0.0816	1

Table 7. Multinomial logit estimation result (without industry dummies)

	Firm Size	*Productivity*	*K intensity*	*R&D intensity*
DI only	–0.2805	–0.0281	–0.0322	–0.0238
	(0.0052)	(0.0088)	(0.0049)	(0.0009)
FO	0.1324	0.3076	–0.1627	–0.1267
	(0.0192)	(0.0209)	(0.0093)	(0.0098)
FI	1.1652	0.0485	0.0420	0.0316
	(0.0607)	(0.1081)	(0.1057)	(0.0149)
DO*FO	0.2683	0.0368	0.0194	0.0059
	(0.0101)	(0.0171)	(0.0119)	(0.0015)
DO*FI	1.1823	–0.2366	–0.0985	0.0627
	(0.0385)	(0.0751)	(0.0619)	(0.0099)
FO*FI	1.3612	–0.3786	0.2015	–0.0405
	(0.2171)	(0.5481)	(0.4051)	(0.0322)
All	1.3320	–0.2323	–0.2449	0.0471
	(0.0513)	(0.0932)	(0.0737)	(0.0122)
STATISTICS	Log pseudo-likelihood = –88230.09, Pseudo R^2 = 0.0606			

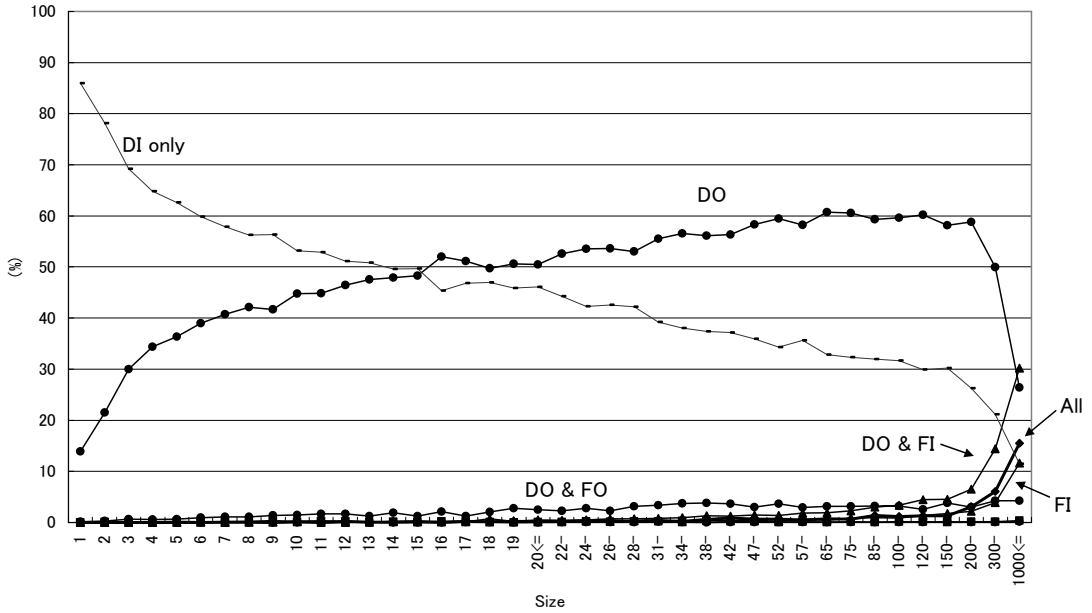
Notes: The base category is DO. 108,999 firms are covered. Heteroskedasticity-robust standard errors are in parentheses. The constant term is included.

Table 8. Multinomial logit estimation result (with industry dummies)

	Firm Size	*Productivity*	*K intensity*	*R&D intensity*
DI only	–0.3476	–0.0719	–0.0248	–0.0226
	(0.0058)	(0.0101)	(0.0059)	(0.0011)
FO	0.3903	0.3557	–0.0138	–0.1540
	(0.0240)	(0.0536)	(0.0186)	(0.0098)
FI	1.2131	–0.0516	0.2078	0.0092
	(0.0675)	(0.1277)	(0.1110)	(0.0148)
DO*FO	0.3018	–0.0271	0.0307	–0.0023
	(0.0132)	(0.0186)	(0.0133)	(0.0019)
DO*FI	1.2092	–0.1439	–0.0577	0.0486
	(0.0424)	(0.0798)	(0.0708)	(0.0104)
FO*FI	1.5322	–1.0952	–0.0578	–0.0635
	(0.3086)	(0.1919)	(0.2823)	(0.0287)
All	1.3453	–0.0209	0.0263	0.0250
	(0.0529)	(0.1176)	(0.1057)	(0.0131)
STATISTICS	Log pseudo-likelihood = –71811.12, Pseudo R^2 = 0.2354			

Notes: The dummy variables for two-digit industries are included. See notes to Table 7.

Figure 1. Percentages of firms within firm-size bins



Notes: Shown is the percentage within each firm-size bin (based on the number of workers).