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Intra-firm trade, input-output linkage, and contractual frictions: Evidence from Japanese affiliate-level data*

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Abstract

This paper examines the impact of input-output linkages on intra-firm trade based on affiliate-level data of Japanese multinationals (MNEs). We find that MNE parents tend to trade relatively more with their affiliates in vertically linked sectors if they trade goods with low contractibility, especially with affiliates located in East Asia: the major developing-country destination for Japanese MNEs. This result indicates that input-output linkage is a significant determinant of intra-firm trade when the trade is affected by contractual frictions. We also confirm that intra-firm trade is observed only in a limited fraction of affiliates.

Keywords: intra-firm trade; affiliate-level data; input-output linkage; contractual frictions
JEL Classification: F14; F23

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1. Introduction

Intra-firm trade makes up a substantial part of overall international trade. For example, nearly half of the total imports of the U.S. result from intra-firm trade.[1] The widespread use of information and communications technologies facilitates trade between parents and their offshore affiliates in remote countries. It is necessary to explore the determinants of intra-firm trade not only because of its sheer volume but also because of its crucial differences with arm's-length trade crossing firm boundaries. Intra-firm trade may differ from trade between unaffiliated firms in critical dimensions, such as responses to shocks or impacts on welfare.[2] However, Ramondo et al. (2016) report that input-output linkages have no effect on the extent of intra-firm trade despite our understanding of intra-firm trade's ties with vertical foreign direct investment (FDI). This paper re-examines whether vertical linkage is related to intra-firm trade by using contractibility based on affiliate-level data for Japanese multinational enterprises (MNEs).

As is discussed in the literature on contract theory, incomplete contracts tend to deter transactions with unrelated parties. This line of argument suggests that input-output linkage between affiliates and parents promotes intra-firm trade, especially in industries susceptible to contractual frictions. If firms depend more on differentiated inputs not traded on organized exchanges or under reference prices, or on inputs sourced from diverse sectors, firms have stronger incentives to trade inputs within firm boundaries to alleviate incomplete contract problems. This implies that input-output linkage should be significant for intra-firm trade in contract-intensive sectors and/or in countries with an inferior contracting environment. We

[1] The share of intra-firm trade is lower in total exports from the U.S. but is still around one-third of the total. Ruhl (2015) documents these trends and discusses the advantages and limitations of various U.S. statistics.

[2] Lakatos and Ohnsorge (2017) report that trade between unaffiliated firms accounts disproportionately for the global trade slowdown in the 2010s. Boehm (2018) finds that the reduction of contract enforcement costs to the U.S. levels promotes outsourcing to other firms and raises real incomes up to ten percent for many countries based on his input-output based calibration.

investigate this hypothesis by disaggregating intra-firm trade data into sectors with varying contractibility and different groups of FDI destinations.

Our work is also related to previous studies on the impact of contractual frictions on intra-firm trade. Corcos et al. (2013) use disaggregated country-product data for MNE parents in France and find that judicial institutions have a significant effect on intra-firm trade, though they did not control for affiliate attributes. Blanas and Seric (2018) investigate foreign-owned affiliates in 19 Sub-Saharan African countries and detect that a sector's contract intensity interacted with the country's judicial quality has a significant effect, though they do not control for characteristics of MNE parents. Boehm and Oberfield (2018) report that manufacturing plants in industries that are more dependent on relationship-specific inputs tend to spend less on purchases of differentiated inputs when they are located in regions with poorer contract enforcement, though this is based on the analysis of intra-Indian trade. Our research differs from previous work in our focus on vertical linkage and in our controlling for the effects of affiliate characteristics as well as those of MNEs. We find that input-output linkage is positively related to intra-firm trade share in sectors with low contractibility, especially for affiliates located in East Asia, where Japanese overseas affiliates are agglomerated and actively engaged in intra-firm trade among developing countries. In other words, MNE parents and their vertically-linked affiliates are likely to engage in intra-firm trade to mitigate contract problems, but the negative impact of incomplete contracts appears to be diluted in sectors that are not seriously vulnerable to contractual frictions and in countries with a developed contracting environment.

In addition to the above investigation of vertical linkage's impact on intra-firm trade, this paper also documents informative characteristics of intra-firm trade with Japanese offshore affiliates. Ramondo et al. (2016), Chun et al. (2017), and Blanas and Seric (2018) find that intra-firm trade is skewed toward a limited fraction of multinational firms. A substantial share of firms

does not trade within MNE boundaries at all. Although their work is not about international trade, Atalay et al. (2014) also report that transactions within multi-plant firms are limited in the U.S. We confirm that intra-firm trade is similarly concentrated in our Japanese affiliate-level data. The median offshore affiliate exports nothing to its parents and imports merely 1% of the cost of goods sold from its parents located in Japan.

The rest of the paper is organized as follows. Section 2 describes our affiliate-level data. Section 3 summarizes patterns of Japanese intra-firm trade. Section 4 reports the regression results on vertical linkage and discusses their implications. Section 5 adds some concluding comments.

2. Data Source

This section describes the firm-level data derived from the official statistics of Basic Survey on Overseas Business Activities (hereafter BSOBA, *Kaigai Jigyou Katsudou Kihon Chosa* in Japanese) conducted annually by Japan's Ministry of Economy, Trade, and Industry (METI).[3] This survey is based on questionnaires distributed to all Japanese firms with affiliates abroad and contains basic information including the sales, purchases, and employment of each offshore affiliate.[4] Chun et al. (2017) also analyzed Japanese intra-firm trade, but their data (Basic Survey of Japanese Business Structure and Activities, BSJBSA, or *Kigyo Katsudo Kihon Chosa* in Japanese) was at the MNE parent level, in contrast to our more disaggregated affiliate-level data. Corcos et al. (2013) also use MNE parent data, and this was combined with transaction-level custom trade data, albeit not linked with data on foreign affiliates, in the French case. Blanas and Seric (2018) covered 19 Sub-Saharan African countries but concentrated on 1,675 foreign-owned affiliates with no data on MNE parents except for the parent country.

[3] Access to microdata was arranged by the Research Institute of Economy, Trade, and Industry (RIETI) for our research project.
[4] For more information about BSOBA, see "Survey Form for Overseas Affiliates" and "Guide for Completing the Survey."

For the purpose of our research, BSOBA provides valuable data as the survey disaggregates sales into: (i) sales in the host country (local sales); (ii) sales to Japanese firms in the same host country; (iii) sales (exports) to Japan; and (iv) sales (exports) to the parent company in Japan. The first category includes the second category, while the fourth category is a subset of the third category. Although the second category is useful for capturing trade between Japanese firms overseas, Japanese firms in the host country are not necessarily owned by the same parent. Exports to third countries are not disaggregated either. The relevant category we use for identifying intra-firm trade is the fourth one (exports from overseas affiliates to the parent in Japan). BSOBA therefore enables us to identify trade between each affiliate and its parent, though no data on trade between affiliates are available.[5] As affiliate purchases/imports in BSOBA are broken down in exactly the same categories as sales/exports, we use each affiliate's imports from the parent in Japan as intra-firm trade on the import side. Since exports to and imports from the Japanese parent firm are available only after 2009, our sample period spans from 2009 to 2016 based on the most recent round of BSOBA at the time of this research.

We concentrate on manufacturing (where both parent and affiliates are classified as manufacturers) to avoid contamination due to irregular flows of invisible trade in service sectors. Even manufacturing firms may be involved in the trade of services, but intra-firm trade in BSOBA is defined to include trade in both goods and services, while Ramondo et al. (2016) focus on trade in goods. To uniquely determine one-to-one correspondence from each affiliate to the parent, this paper concentrates on majority-owned affiliates. We omit outliers by excluding affiliates with intra-firm trade exceeding their sales or total purchases.

[5] In the U.S. data, by contrast, Ramondo et al. (2016) include trade between affiliates. Even in BSOBA, such data were available in the surveys conducted in early years. From a different survey, we confirm that trade between affiliates is limited, especially the trade in services. See Appendix B for an overview of the results from the alternative survey.

3. Data Overview

3.1. Patterns of Japanese intra-firm trade

This subsection summarizes descriptive statistics for our affiliate-level data and documents observed patterns of intra-firm trade in the Japanese case. As we will show below, the basic pattern previously reported by Ramondo et al. (2016) in the U.S. case is confirmed in the Japanese dataset.

Table 1 shows the summary statistics on the share of intra-firm trade relative to the activities of affiliates. The upper panel of this table shows the percentage of exports (or domestic shipments) in the total sales of affiliates, while the lower panel shows the percentage of imports (or domestic procurements) in the total costs (costs of goods sold [COGS]) of affiliates. Both exports to and imports from parent firms are limited. The median offshore affiliate does not export to its parents at all and imports merely 1% of its inputs from its MNE parents. This indirectly indicates active arm's-length trade with unaffiliated parties. On the other end of the spectrum, for affiliates at the 95th percentile (p95), nearly 99% of sales and more than two-thirds of purchases take place within the same MNE. While Japanese firms are slightly more active in intra-firm trade as compared with their U.S. counterparts, the skewed concentration of intra-firm trade in such a limited portion of affiliates confirms the findings previously reported by Ramondo et al. (2016) on U.S. MNEs, Chun et al. (2017) on South Korean and Japanese MNE parents, and Blanas and Seric (2018) on foreign-owned affiliates in Africa.

In the same columns in Table 1, we can also observe many other interesting characteristics of Japanese overseas affiliates. The median affiliate sells more than half of its outputs in the local market and sources about one-quarter of its inputs from local suppliers. The share of imports from Japan, even if we include imports from unaffiliated firms, occupies merely 3%. These statistics suggest that Japanese FDI is no longer characterized by export-platform production oriented toward U.S. or European markets or by screwdriver production solely dependent on inputs

imported from Japan.

== Table 1==

Table 1 also reports the same shares for the 50th, 75th, and 90th percentiles in terms of the *employment* size distribution. The median-size affiliate exports 17% of total outputs to and imports 12% of total inputs from its parent. The share of intra-firm trade in sales gradually increases with size, but the share in COGS decreases if we compare affiliates in the 50th and 95th percentiles. The relationship between intra-firm trade and affiliate size will be further investigated in the next subsection in the regression analysis.

Table 2 breaks down the intra-firm trade shares into sectors and FDI destination regions. Intra-firm export shares tend to be high in textiles and electronics and low in transport equipment (predominantly automobiles in the Japanese case) and chemicals, while cross-industry variability is less prevalent in the shares of intra-firm imports. Intra-firm exports to Japanese parents are particularly active from affiliates located in East Asia, while intra-firm shares are not discernibly different across regions on the import side. These facts indicate that Japanese MNE parents and their often vertically-integrated affiliates are involved in dense networks of intra-firm trade within East Asia as compared with affiliates in other advanced countries, which are more characterized by horizontal FDI. Table 3, which reports intra-firm trade shares by region and year, shows that both the shares of intra-firm exports and imports are generally stable over the years in our sample period.[6]

[6] There are two other noteworthy findings. First, in Table 1, the share of intra-firm trade accounts for more than 80% of exports to and imports from Japan. This shows that the majority of MNEs' exports to and imports from the home country are intra-firm trade. Panel (A) of Appendix Table A1 presents the share of intra-firm trade in exports to or imports from Japan by industry and region. We confirm the share is greater than 80% in most industries and regions. Second, the shares of intra-firm trade for Japanese affiliates are higher than those for U.S. affiliates. For example, the shares of affiliate sales to parents and affiliate imports from parents for the U.S. in Table 1 of Ramondo et al. (2016) are 7% and 10% respectively, while those for Japan are 18% and 14% as presented in Table 1. We also provide the basic statistics for the shares of intra-firm trade by industry and region in Panel (B) of Appendix Table A1, which are comparable to Tables B1 and B2 of Ramondo et al. (2016). For both U.S. and Japanese

== Table 2 and Table 3 ==

Figure 1 displays the distribution of affiliates by the share of intra-firm exports in sales and the share of intra-firm imports in purchases across affiliates. Affiliates are sorted by these shares. The frequency of affiliates in each share bin is measured on the vertical axis. Nearly 70% of affiliates export less than 5% of their output to their parent, and almost 60% import less than 5% of their inputs from their parent. In contrast, more than 6% of affiliates export all their outputs exclusively to their parent, while affiliates that are completely dependent on imports from their parent occupy more than 1% in our sample. While this is slightly more dispersed than the U.S. case, the skewness of intra-firm trade toward a limited fraction of offshore affiliates in our Japanese sample supports the pattern discovered by Ramondo et al. (2016) and confirmed by Blanas and Seric (2018).

== Figure 1 ==

3.2. Relationship with affiliate size

This subsection examines whether the size of an affiliate is related to the affiliate's involvement in intra-firm trade. As intra-firm trade is concentrated in a limited group of affiliates, and as affiliates vary substantially in size, we investigate whether the affiliates active in intra-firm trade tend to be large-sized. To analyze this relationship, we estimate the following equation:

$$\mathrm{D}\left(X_{ijsdt}\right) = \alpha_1 \log Emp_{at} + Z_{ct}\delta_1 + \kappa_{1s} + \lambda_{1d} + \pi_{1t} + u_{1ijsdt} \qquad (1)$$

where the dependent variable, the binary dummy $D\left(X_{ijsdt}\right)$, equals one if there is positive intra-firm export from i to j at year t and equals zero otherwise. A firm with the suffix i or j=a is an overseas affiliate owned by a parent in Japan, while the suffix i or $j = p$ represents a parent owning an overseas affiliate. For instance, $D\left(X_{ap}\right) = 1$ when an affiliate exports to the parent. The size

affiliates, the share of affiliate sales to parents are relatively higher for affiliates located in neighboring regions, such as North America for U.S. affiliates and Asia for Japanese affiliates. In contrast, in the case of imports from parents, although U.S. MNEs have a higher share for affiliates located in North America, the share for Japanese affiliates amounts to 15%–17% in most regions.

of an affiliate is measured by the number of employees in logarithm (logEmp). Z_{ct} is a vector of corporate-level controls, which includes the parent's employment, the employment of the total corporate group, and the number of foreign affiliates of the multinational corporation (log$N$). We include the affiliate's sector fixed effect κ_{1s}, the FDI destination country fixed effect $\lambda_{1d,}$, and the year fixed effect π_{1t}. Sectors of affiliates and destination countries are indexed by s and d.[7] The error term is denoted by u_{1ijsdt}. We estimate the linear probability model (1) using OLS, instead of logit or probit, to control for various fixed effects.

While the regression above regards the binary decision to enter into intra-firm trade, we also estimate the following to investigate the extent of intra-firm trade:

$$\log X_{ijsdt} = \alpha_2 \log Emp_{at} + Z_{ct}\delta_2 + \kappa_{2s} + \lambda_{2d} + \pi_{2t} + u_{2ijsdt} \qquad (2)$$

The dependent variable is replaced by the logarithm of the share of intra-firm trade (log$X$), following Ramondo et al. (2016). The intra-firm trade share is defined by exports to the parent relative to the affiliate's sales or imports from the parent divided by the affiliate's costs (COGS). This regression of the continuous variable covers only firms with a positive volume of intra-firm trade. Right-hand side variables are the same as those in Equation (1). The suffix for coefficients is renumbered to 2 in Equation (2).

Equation (2) analyzes intra-firm trade in terms of share, but we also estimate the following equation to inspect the relation between affiliate size and intra-firm trade:

$$\log V_{ijsdt} = \alpha_3 \log Emp_{at} + Z_{ct}\delta_3 + \kappa_{3s} + \lambda_{3d} + \pi_{3t} + u_{3ijsdt} \qquad (3)$$

where the dependent variable is the log of the absolute size or value of intra-firm trade, not normalized by the affiliate's sales or COGS, in millions of yen (log$V$). All right-hand side variables are the same as in the preceding equations. The suffix is renumbered correspondingly. Summary statistics are shown in Appendix Table A2.

[7] Affiliate fixed effects are not included, since the affiliate-specific unique identification number is not available in BSOBA.

The estimation results of Equations (1), (2), and (3) are shown in Table 4. In even-numbered columns, we additionally control for MNE-corporate fixed effects. From Columns (I), (II), (VII), and (VIII), we see that the binary decision to conduct intra-firm trade is significantly related to affiliate size, confirming previous results from Ramondo et al. (2016) and Blanas and Seric (2018). Larger affiliates are more likely to engage in intra-firm trade. Although only a limited fraction of affiliates is involved in intra-firm trade, they are significantly larger in size.

== Table 4 ==

The results in Columns (III) and (IX) show that the intra-firm trade share is negatively related to the size of an affiliate.[8] Larger affiliates tend to trade more, but their intra-firm trade may not expand proportionally with their size. The other columns of Table 4 also show informative patterns. In Columns (V) and (XI), we observe large-sized affiliates tend to export as well as import more to/from the parents in yen. These results do not change even when we replace variables for parent firm characteristics with the MNE-corporate fixed effects in Columns (VI) and (XII).

On other variables, we obtain several insights. The number of offshore affiliates owned by the parent MNE ($\log N_c$) is negatively associated with the intra-firm trade of an affiliate in all specifications. Although parents with a larger number of affiliates are likely to be more globalized, an affiliate in that MNE group is on average less likely to be involved in intra-firm trade. We also discover that the parent's size ($\log Emp_p$) is not a significant determinant of intra-firm trade, though the size of the entire MNE corporate group ($\log Emp_c$) appears to be positively related to the share and value of intra-firm trade as indicated in Columns (III), (V),

[8] Chun et al. (2017) discover that the value and share of intra-firm trade is positively related with the parent's size based on corporate-level data. Ramondo et al. (2016) or Blanas and Seric (2018) did not estimate the impact on absolute value of trade, while reporting that both the engagement in intra-firm trade and the intra-firm trade share increase with the affiliate's size.

(IX) and (XI). In Appendix A3, as a robustness check, we confirm that our principal results remain intact even if we additionally control for the affiliate's age, the capital share of the parent firm, the parent firm's R&D sales ratio, and its capital-labor ratio.[9] Affiliates are significantly more likely to be active in intra-firm trade if the capital share of their parent is higher, in line with Blanas and Seric (2018). However, the major results remain basically unchanged.

4. Vertical Linkage and its Relationship with Contractibility

The previous section confirms that intra-firm trade is observed only in a limited fraction of overseas affiliates. This section explores the determinants of intra-firm trade. While Ramondo et al. (2016) find that vertical input-output linkages cannot explain intra-firm trade, they suggest no alternative explanation for this unexpected result, which is at odds with our conventional understanding of intra-firm trade as connected to vertical FDI. As the distinction of intra-firm trade from arm's-length trade fundamentally hinges on the issue of firm boundaries, we focus on the possible effects of incomplete contracts or contractibility.[10]

The extent of contract completeness is likely to be related to the MNE's decision to undertake intra-firm trade, as firms choose intra-firm trade over arm's-length trade when contracts are considerably incomplete. The established literature on incomplete contracts and vertical integration in the theory of the firm, contract theory, industrial organization, and international trade has repeatedly discussed this issue (e.g., Antràs on international trade [2003]). This line of theoretical argument leads us to examine the relationship between intra-firm trade and the completeness of contracts.

This paper measures the completeness of contracts using the contractibility index, or

[9] Parent firm characteristics are derived from Basic Survey of Japanese Business and Activities conducted by METI. In the process of matching these two data sets, we lost 7,575 observations.
[10] Blanas and Seric (2018) also examine the impact of contracting on intra-firm trade, but vertical linkage is outside of the scope of their analysis.

contract intensity, as proposed by previous studies. Among various measures, we use those proposed by Nunn (2007) and Levchenko (2007) and which have been repeatedly used by many other researchers.[11] Although both measures quantify the sensitivity to contractual frictions, the Nunn's (2007) index uses the share of differentiated inputs and Levchenko's (2007) uses the Herfindahl concentration of inputs. When firms depend more on differentiated inputs not traded either in organized exchanges or under reference prices, intra-firm trade may be a preferable option. Similarly, firms may prefer intra-firm trade when they need to source diverse inputs. We use the sector's continuous measure as well as the binary dummy, which is defined based on whether the sector's index exceeds the median to classify sectors into two broad groups: contract-intensive industries or non-contract-intensive industries.

Before proceeding to the econometric analysis, we compare the share of intra-firm trade by contractibility and region in Table 5. We split our sample depending on whether the industry has contractibility higher than the median value. Both the shares of exports to and imports from the parent firm are higher for more contract-intensive industries regardless of the definition of contractibility index. Looking closely at the share of intra-firm trade by region, while the share of exports to parents is not always higher for more contract-intensive industries except for affiliates located in East Asia, the share of imports from parent firms is higher regardless of region and contractibility index.

== Table 5 ==

To explore the impact of contractibility on intra-firm trade, we estimate the following equations:

[11] Blanas and Seric (2018) adopt the sector's Nunn-type index and interact it with the country's judicial quality index (the number of days required for the enforcement of a contract). Corcos et al. (2013) also use Nunn-type index to analyze intra-firm trade of French firms with microdata disaggregated to firm-product-country though without data on affiliates. Boehm and Oberfield (2018) also use a basically same classification in their study of input sourcing by Indian plants.

$$D(X_{apsdt}) = \mu_1 \log Emp_{at} + \beta_1 DR_{sr} \times Cont_s + \gamma_1 DR_{sr} + Z_{ct}\eta_1 + \rho_{1s} + \phi_{1d} + \theta_{1t} + \psi_{1c} + v_{1apsdt} \quad (4)$$

$$\log X_{apsdt} = \mu_2 \log Emp_{at} + \beta_2 \log DR_{sr} \times Cont_s + \gamma_2 \log DR_{sr} + Z_{ct}\eta_2 + \rho_{2s} + \phi_{2d} + \theta_{2t} + \psi_{2c} + v_{2apsdt} \quad (5)$$

The contractibility index discussed above is denoted by *Cont* (Nunn-type or Levchenko-type). DR_{sr} indicates the input-output linkage, namely the direct requirement coefficient (inputs from industry *s* to produce an output of industry *r*) in the input-output table, where *s* and *r* represent the industry of the affiliate and parent, respectively.[12] An analogous set of equations are also estimated for exports from parent to affiliate, X_{pa}, using DR_{rs} (the direct requirement coefficient of parent's industry *r* with the affiliate's industry *s* in the downstream position in the input-output linkage). By adding the interactive term, we inspect whether the impact of input-output linkage is evident in industries with serious contractual frictions.[13] We estimate Equation (4) either with the continuous variable *Cont* itself or the dichotomous dummy *D(Cont)* taking the value one/zero if the contractibility of the sector is greater/smaller than the median of all sectors. All other variables on the right-hand side are kept the same as in previous equations, including the fixed effects for year θ, affiliate's sector ρ, FDI destination ϕ, and corporate MNE ψ. The error term is expressed by *v*. Parameters and fixed effects are suffixed with 1 in (4) and 2 in (5).

While we examine the binary dummy of intra-firm trade *D(X)* in (4), we also estimate the same equation by replacing the dependent variable with the intra-firm trade share in (5). In this case, we replace *DR* with log*DR* following the specification in Ramondo et al. (2016), but keep all other variables the same to facilitate comparison.

Table 6 reports the estimation results with contractibility and input-output linkage variables.

[12] We use Japan's I-O Tables at the year 2011 to derive the direct requirement coefficients.
[13] Contractibility without interaction is captured by the sector fixed effect.

Most notably, the interactive term log*DR*D(Cont)* is negatively related to intra-firm trade, and especially so in the significant relationship with exports from parents to their affiliates. Results with the interaction term with the continuous measure of contractibility are presented from Columns (IX) to (XVI). Although the continuous measures of contractibility (not in binary dummies) turn out not to be statistically significant in our sample, except in Column (XVI), the input-output linkage appears related to the intra-firm trade share in contract-intensive sectors. In other words, the share of intra-firm trade tends to be significantly higher in sectors with contractibility that is lower than the average. We also confirm the previous results of Ramondo et al. (2016) in that input-output linkage *DR* or log*DR* without interaction is *not* significantly associated with intra-firm trade except in Column (VIII) and column (XVI).[14] All these results are robust regardless of the definition of contractibility (Nunn-type or Levchenko-type).[15]

== Table 6 ==

As the intra-firm trade of Japanese MNEs is geographically concentrated in East Asia, we estimate the same equation separately for each region (OECD, non-OECD, and East Asia).[16] Panels (A), (B) and (C) of Table 7 present the regression results for these regions. Significant relationships with intra-firm trade in both directions (exports to and imports from affiliates to parents) are more clearly found for affiliates located in non-OECD countries or East Asia, as indicated in Panel (B) and (C) of Table 7. The insignificance for OECD countries in Panel (A) of Table 7 is in line with our prior expectations, as it is unlikely that MNEs face serious

[14] As in Ramondo et al. (2016), we also estimate the equation without the interaction term of the contractibility index and confirm that the coefficients of input-output linkage *DR* or log*DR* are not significant. These results are presented in Appendix Table A4.

[15] In Appendix Table A5, we confirm the robustness of the results including the affiliate and parent firm characteristics.

[16] We define East Asia as the region comprised of the following countries: China (including Taiwan and Hong Kong), South Korea, and ten ASEAN members (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam).

contractual frictions in these developed countries. Hence, our results suggest that vertical intra-firm trade appears to be affected by the inferior contracting environment in developing countries, especially East Asia, in the case of Japanese MNEs. As affiliates of Japanese MNEs are heavily concentrated in East Asia, the impact of contractual frictions on Japanese intra-firm trade should not be negligible.[17]

== Table 7 ==

Our results suggest that the input-output linkage between affiliates and parents is not the key determinant of intra-firm trade in general, but significantly affects intra-firm trade when firms face serious contractual frictions. Although it is hard to pin down the exact mechanism that determines intra-firm trade within our limited dataset, our finding is consistent with the interpretation that vertically-linked affiliates and parents tend to actively trade when they face contract problems vis-à-vis arm's-length trade. In other words, the improvement of the contracting environment may facilitate input trade between firms without ownership relationships. As the extent of contractual frictions is likely to vary widely across countries, and especially between developed and developing countries, and as sectors differ substantially in terms of their susceptibility to contractual frictions, we need to distinguish FDI destinations as well as sectoral contractibility in evaluating the impact of vertical linkage between affiliates and parents on intra-firm trade. Our contribution complements the previous results by discovering that input-output linkage is positively related to intra-firm trade in contract-intensive sectors in developing countries.

5. Concluding Remarks

[17] In Appendix Table A6 Panel (a), Panel (b), and Panel (c), we also confirm the robustness of the results including the affiliate and parent firm characteristics.

This paper has examined how vertical linkages between overseas affiliates and their parents are related to intra-firm trade by considering the variation of contractibility across sectors in the case of Japanese MNEs based on affiliate-level data. Our estimations show that vertical linkages are positively related to intra-firm trade shares in sectors with low contractibility, especially for affiliates located in East Asia, but not significantly so for those in OECD countries. This result is robust regardless of the definition of contractibility. Our finding suggests that vertically-linked affiliates and parents are likely to trade actively within MNEs in contract-intensive industries. In other words, our result is consistent with the interpretation that input-output linkage has a significant impact on intra-firm trade if contractual frictions are serious. Affiliates and parents in vertically linked sectors tend to trade inputs actively within firm boundaries to alleviate contracting problems, among other reasons. Our result thus integrate the findings of previous studies that detect that contracting has a significant impact on intra-firm trade in contract-intensive sectors and in countries with inferior contract enforcement, such as Corcos et al. (2013), Blanas and Seric (2018), Boehm (2018), and Boehm and Oberfield (2018), along with the finding that vertical linkage have no overarching impact on intra-firm trade by Ramondo et al. (2016).

While our Japanese microdata study reveals the importance of vertical linkage in intra-firm trade by taking account of contractual frictions, several limitations remain in our dataset. For example, the relationship we detected with contractibility is not necessarily significant for all specifications. We also note that our intra-firm trade data derived from BSOBA contains no information on trade between affiliates owned by the same parent. Comprehensive data linkages of manufacturing censuses, custom trade data, ownership data, and surveys of overseas affiliates can contribute to the micro-level understanding of this important issue. Another issue is the

difference between trade in goods and trade in services.[18] Our data for intra-firm trade include both trades in goods and services. However, trade in services may follow a different pattern if MNEs actively exchange knowledge and production know-how between parents and affiliates. As contractual frictions are critical for theoretical investigations of firm boundaries and the organization of global production, and as well as policy discussions of development strategies, more in-depth studies of their impacts on intra-firm trade should be conducted in the future.

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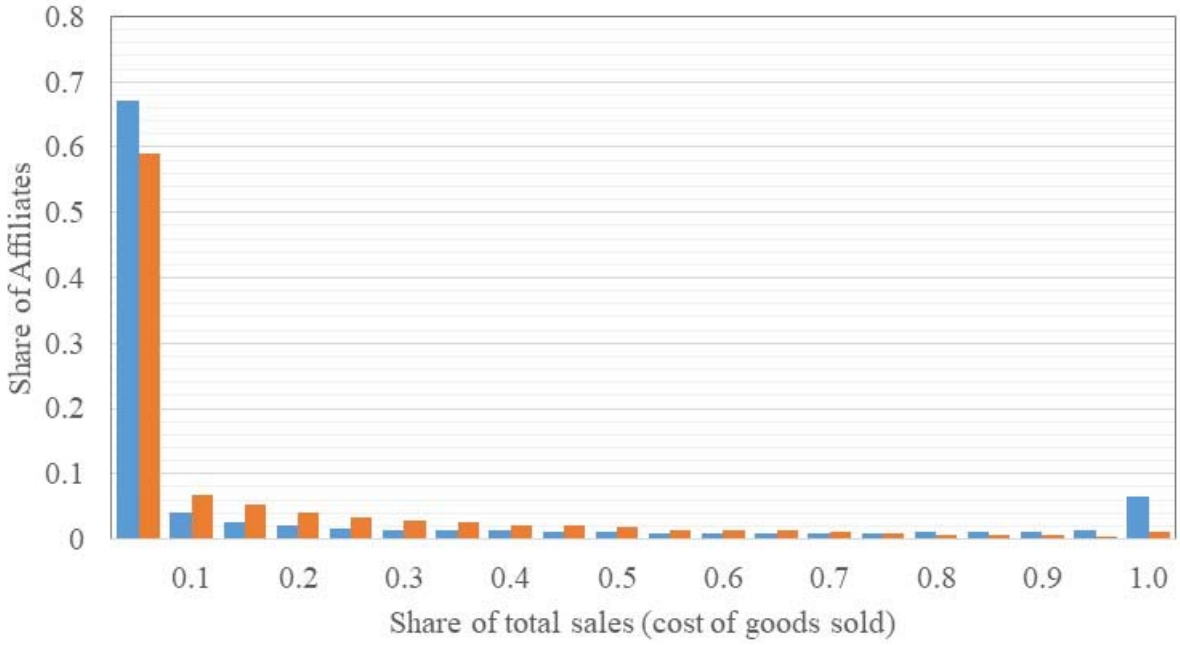
Figure 1 The distribution of affiliates by the share of intra-firm exports in sales and the share of intra-firm imports in purchases



Source: Authors' calculation based on BSOBA by METI.

Table 1. Intra-firm trade, summary

	Mean	St. Dev	p50	p75	p95	Emp>p50	Emp>p75	Emp>p95
Share in affiliate sales								
Share of local sales	52.0%	42.4%	58.8%	98.4%	100.0%	47.2%	42.9%	30.6%
Share of local sales to other Japanese firms	22.7%	36.4%	0.0%	39.0%	100.0%	21.8%	20.0%	10.3%
Share of sales to Japan	20.0%	33.1%	0.3%	26.5%	99.9%	19.7%	20.0%	22.2%
Share of sales to parent	17.5%	31.4%	0.0%	18.0%	98.6%	17.2%	17.4%	19.6%
Share in affiliate cost of goods sold (COGS)								
Share of local procurement	32.3%	32.3%	24.9%	58.9%	92.3%	31.4%	30.9%	26.5%
Share of local procurement from other Japanese firms	8.5%	19.3%	0.0%	3.2%	56.4%	9.7%	10.0%	7.2%
Share of Import from Japan	16.5%	24.3%	3.1%	25.3%	72.6%	14.3%	13.3%	12.2%
Share of Import from parent	14.1%	23.0%	1.0%	19.7%	68.3%	12.1%	11.1%	9.8%

Source: Authors' calculation based on BSOBA by METI.

Table 2. Share of intra-firm trade by industry

	Share of export to parent in total sales					Share of import from parent in cost of goods sold (COGS)				
Industry	East Asia	North America	EU	Other	Total	East Asia	North America	EU	Other	Total
Food	25.8%	7.8%	8.0%	20.0%	21.1%	4.7%	4.2%	4.5%	5.2%	4.6%
Textile	40.2%	1.3%	1.7%	8.9%	35.3%	10.0%	16.2%	10.8%	3.1%	10.0%
Chemicals	10.3%	7.0%	5.1%	1.8%	8.9%	15.9%	14.2%	12.4%	3.6%	14.7%
Glass and stone	23.8%	1.6%	1.6%	12.1%	18.7%	17.2%	17.8%	13.7%	13.7%	16.8%
Metal	19.1%	3.7%	0.2%	15.9%	16.6%	17.6%	10.9%	16.0%	6.4%	16.4%
Metal products	22.6%	1.6%	0.7%	4.1%	19.4%	11.7%	17.4%	19.5%	26.2%	13.0%
Machinery	25.6%	6.0%	4.1%	8.0%	20.0%	16.7%	19.8%	13.1%	12.2%	16.5%
Electronics	30.2%	8.1%	12.6%	8.4%	26.4%	14.8%	20.9%	13.1%	9.6%	15.1%
Electrical equipment	26.6%	4.1%	2.7%	6.6%	21.3%	15.5%	18.1%	19.5%	15.8%	16.1%
Transportation	11.0%	2.3%	3.2%	1.2%	7.6%	14.1%	12.6%	12.6%	16.4%	13.8%
Other	25.3%	4.4%	4.2%	8.0%	20.7%	12.8%	14.9%	12.0%	8.3%	12.7%
Total	22.1%	4.4%	4.8%	5.8%	17.5%	14.3%	14.8%	13.1%	11.8%	14.1%

Source: Authors' calculation based on BSOBA (METI)

Note: North America includes the USA, Canada, and Mexico. East Asia includes South Korea, China, Taiwan, Hong Kong, and 10 ASEAN members (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam).

Table 3. Share of intra-firm trade by region and year

	Share of export to parent in total sales					Share of import from parent incost of goods sold (COGS)				
year	East Asia	North America	EU	Other	Total	East Asia	North America	EU	Other	Total
2009	23.6%	5.2%	4.2%	7.4%	18.3%	16.7%	15.8%	14.7%	13.0%	16.2%
2010	21.9%	4.2%	4.4%	6.2%	17.0%	16.5%	15.3%	16.1%	12.8%	16.1%
2011	22.3%	4.5%	4.5%	5.7%	17.4%	15.8%	15.4%	14.2%	12.6%	15.4%
2012	23.1%	4.7%	5.4%	4.9%	18.4%	14.6%	16.2%	13.6%	12.9%	14.7%
2013	22.5%	4.3%	4.7%	5.0%	18.0%	13.3%	14.3%	11.7%	11.2%	13.2%
2014	21.5%	4.1%	4.8%	5.3%	17.1%	12.8%	14.4%	11.3%	11.5%	12.9%
2015	21.1%	4.2%	5.1%	6.4%	16.8%	12.2%	13.4%	11.8%	11.3%	12.3%
2016	21.4%	4.2%	5.4%	5.8%	17.0%	13.4%	14.0%	11.7%	10.1%	13.1%
Total	22.1%	4.4%	4.8%	5.8%	17.5%	14.3%	14.8%	13.1%	11.8%	14.1%

Source: Authors' calculation based on BSOBA (METI)

Note: See notes for Table 2.

Table 4. Intra-firm trade and firm size

VARIABLES	(I) $D(X_{ap})$	(II) $D(X_{ap})$	(III) $logX_{ap}$	(IV) $logX_{ap}$	(V) $logV_{ap}$	(VI) $logV_{ap}$	(VII) $D(X_{pa})$	(VIII) $D(X_{pa})$	(IX) $logX_{pa}$	(X) $logX_{pa}$	(XI) $logV_{pa}$	(XII) $logV_{pa}$
$logEmp_a$	0.0587***	0.0625***	-0.197***	-0.196***	0.582***	0.547***	0.0320***	0.0482***	-0.219***	-0.101***	0.522***	0.588***
	(0.00385)	(0.00388)	(0.0274)	(0.0387)	(0.0249)	(0.0349)	(0.00404)	(0.00365)	(0.0203)	(0.0225)	(0.0210)	(0.0251)
$logEmp_p$	-0.0116		-0.0538		-0.0403		-0.0236		-0.00655		-0.00477	
	(0.0147)		(0.0612)		(0.0698)		(0.0158)		(0.0462)		(0.0661)	
$logN_c$	-0.0441*		-0.351***		-0.490***		-0.0638**		-0.237***		-0.413***	
	(0.0237)		(0.0858)		(0.0930)		(0.0273)		(0.0704)		(0.0915)	
$logEmp_c$	-0.00333		0.117*		0.320***		0.0132		0.141***		0.380***	
	(0.0174)		(0.0631)		(0.0714)		(0.0194)		(0.0512)		(0.0725)	
Observations	56,283	55,882	26,892	26,453	26,892	26,453	56,283	55,882	27,200	26,762	27,200	26,762
R-squared	0.126	0.525	0.323	0.609	0.316	0.608	0.077	0.578	0.110	0.491	0.391	0.655
Aff ind FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Aff country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MNE FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Note: Standard errors in parentheses are clustered at the affiliate's industry-level. *,** and *** indicate statistical significance at the 10%, 5%, and 1% levels.

Table 5. Share of intra-firm trade by contractibility

Share of export to parent in total sales

	Nunn (2007) contractibility index				Levchenko (2007) contractibility index		
	Low	High	Total		Low	High	Total
Total	18.6%	15.5%	17.5%	Total	17.6%	17.3%	17.5%
East Asia	24.3%	18.7%	22.1%	East Asia	22.8%	21.0%	22.1%
EU	4.9%	4.3%	4.7%	EU	4.1%	6.1%	4.7%
North America	5.7%	2.7%	4.8%	North America	3.8%	6.9%	4.8%
Other	4.4%	6.7%	5.0%	Other	4.4%	6.0%	5.0%

Share of import from parent in cost of goods sold (COGS)

	Nunn (2007) contractibility index				Levchenko (2007) contractibility index		
	Low	High	Total		Low	High	Total
Total	15.0%	12.5%	14.1%	Total	15.4%	11.9%	14.1%
East Asia	15.2%	12.8%	14.3%	East Asia	15.5%	12.1%	14.3%
EU	16.1%	13.3%	15.2%	EU	15.8%	13.8%	15.2%
North America	14.1%	10.9%	13.1%	North America	14.3%	10.6%	13.1%
Other	12.8%	8.5%	11.7%	Other	14.2%	7.0%	11.7%

Source: Authors' calculations based on BSOBA (METI).

Table 6. I-O links, intra-firm trade, and contractibility

Discrete measure	(I)	(II)	(III)	(IV)	Discrete measure	(V)	(VI)	(VII)	(VIII)
	Nunn (2007) index		Levchenko (2007) index			Nunn (2007) index		Levchenko (2007) index	
VARIABLES	$D(X_{ap})$	$D(X_{pa})$	$D(X_{ap})$	$D(X_{pa})$	VARIABLES	$logX_{ap}$	$logX_{pa}$	$logX_{ap}$	$logX_{pa}$
DRsr	0.104		0.103		*logDRsr*	0.00819		0.0177	
	(0.0917)		(0.100)			(0.0411)		(0.0386)	
DRrs		0.0871		0.115	*logDRrs*		0.0449		0.0498*
		(0.108)		(0.0898)			(0.0320)		(0.0276)
*DRsr*D(Cont)*	-0.270		-0.156		*logDRsr*D(Cont)*	-0.0802		-0.0917**	
	(0.220)		(0.142)			(0.0495)		(0.0448)	
*DRrsd*D(Cont)*		0.0348		-0.0398	*logDRrs*D(Cont)*		-0.0869**		-0.123**
		(0.175)		(0.167)			(0.0432)		(0.0517)
Observations	55,882	55,882	55,882	55,882	Observations	24,978	25,017	24,978	25,017
R-squared	0.526	0.578	0.526	0.578	R-squared	0.620	0.502	0.620	0.502
Continuous measure	(IX)	(X)	(XIII)	(XIV)	Continuous measure	(XI)	(XII)	(XV)	(XVI)
DRsr	0.178		0.305		*logDRsr*	0.0495		0.0445	
	(0.153)		(0.186)			(0.0735)		(0.0637)	
DRrs		0.0816		0.167	*logDRrs*		0.122		0.121*
		(0.184)		(0.154)			(0.0775)		(0.0619)
*DRsr*Cont*	-0.417		-2.399		*logDRsr*Cont*	-0.161		-0.573	
	(0.390)		(1.541)			(0.125)		(0.425)	
*DRrs*Cont*		0.0460		-0.598	*logDRrs*Cont*		-0.258		-1.072*
		(0.401)		(1.292)			(0.159)		(0.567)
Observations	55,882	55,882	55,882	55,882	Observations	24,978	25,017	24,978	25,017
R-squared	0.526	0.578	0.526	0.578	R-squared	0.620	0.502	0.620	0.502

Note: Standard errors in parentheses are clustered at the affiliate's industry-level. Affiliate size in terms of the number of employees is controlled. Affiliate's industry fixed effect, FDI destination fixed effect, year fixed effect, and MNE fixed effect are included. *,** and *** indicate statistical significance at the 10%, 5%, and 1% levels.

Table 7. Variations across regions

Panel (A): OECD countries

Discrete measure	(I)	(II)	(III)	(IV)	Discrete measure	(V)	(VI)	(VII)	(VIII)
	Nunn (2007) index		Levchenko (2007) index			Nunn (2007) index		Levchenko (2007) index	
VARIABLES	$D(X_{ap})$	$D(X_{pa})$	$D(X_{ap})$	$D(X_{pa})$	VARIABLES	$logX_{ap}$	$logX_{pa}$	$logX_{ap}$	$logX_{pa}$
DRsr	0.147		0.155		*logDRsr*	-0.0171		-0.0285	
	(0.162)		(0.176)			(0.0726)		(0.0704)	
DRrs		0.0219		0.178	*logDRrs*		-0.0267		0.129**
		(0.175)		(0.173)			(0.0851)		(0.0633)
*DRsr*D(Cont)*	-0.0400		-0.0322		*logDRsr*D(Cont)*	-0.0133		0.00647	
	(0.356)		(0.230)			(0.114)		(0.0848)	
*DRrs*D(Cont)*		0.497*		0.124	*logDRrs*D(Cont)*		0.133		-0.203**
		(0.265)		(0.406)			(0.112)		(0.101)
Observations	14,062	14,062	14,062	14,062	Observations	4,663	5,587	4,663	5,587
R-squared	0.516	0.624	0.516	0.624	R-squared	0.669	0.566	0.669	0.566
Continuous measu	(IX)	(X)	(XIII)	(XIV)	Continuous measure	(XI)	(XII)	(XV)	(XVI)
DRsr	0.178		0.288		*logDRsr*	-0.0532		-0.190	
	(0.263)		(0.342)			(0.110)		(0.141)	
DRrs		-0.186		0.177	*logDRrs*		0.0534		0.240*
		(0.317)		(0.276)			(0.118)		(0.125)
*DRsr*Cont*	-0.114		-1.244		*logDRsr*Cont*	0.0538		1.126	
	(0.628)		(2.699)			(0.201)		(0.968)	
*DRrs*Cont*		0.939		0.360	*logDRrs*Cont*		-0.00228		-1.697
		(0.642)		(2.149)			(0.243)		(1.034)
Observations	14,062	14,062	14,062	14,062	Observations	4,663	5,587	4,663	5,587
R-squared	0.516	0.624	0.516	0.624	R-squared	0.669	0.565	0.669	0.566

Note: See notes for Table 6.

Panel (B): Non-OECD countries

	(I)	(II)	(III)	(IV)		(V)	(VI)	(VII)	(VIII)
	Nunn (2007) index		Levchenko (2007) index			Nunn (2007) index		Levchenko (2007) index	
VARIABLES	$D(X_{ap})$	$D(X_{pa})$	$D(X_{ap})$	$D(X_{pa})$	VARIABLES	$logX_{ap}$	$logX_{pa}$	$logX_{ap}$	$logX_{pa}$
DRsr	0.0907		0.0374		*logDRsr*	0.00542		0.0114	
	(0.116)		(0.127)			(0.0421)		(0.0393)	
DRrs		0.131		0.111	*logDRrs*		0.0541*		0.0361
		(0.132)		(0.109)			(0.0301)		(0.0287)
*DRsr*D(Cont)*	-0.347		-0.103		*logDRsr*D(Cont)*	-0.0758		-0.0839*	
	(0.251)		(0.163)			(0.0504)		(0.0459)	
*DRrs*D(Cont)*		-0.112		-0.0725	*logDRrs*D(Cont)*		-0.115***		-0.105*
		(0.211)		(0.166)			(0.0444)		(0.0548)
Observations	41,710	41,710	41,710	41,710	Observations	20,219	19,319	20,219	19,319
R-squared	0.566	0.597	0.566	0.597	R-squared	0.623	0.551	0.623	0.550
Continuous measu	(IX)	(X)	(XIII)	(XIV)	Continuous measure	(XI)	(XII)	(XV)	(XVI)
DRsr	0.193		0.256		*logDRsr*	0.0764		0.0878	
	(0.184)		(0.232)			(0.0714)		(0.0591)	
DRrs		0.154		0.152	*logDRrs*		0.158*		0.116*
		(0.217)		(0.186)			(0.0922)		(0.0686)
*DRsr*Cont*	-0.559		-2.337		*logDRsr*Cont*	-0.217*		-0.911**	
	(0.470)		(1.876)			(0.121)		(0.370)	
*DRrs*Cont*		-0.162		-0.598	*logDRrs*Cont*		-0.344*		-1.091*
		(0.461)		(1.481)			(0.191)		(0.621)
Observations	41,710	41,710	41,710	41,710	Observations	20,219	19,319	20,219	19,319
R-squared	0.566	0.597	0.566	0.597	R-squared	0.623	0.551	0.623	0.551

Note: See notes for Table 6.

Panel (C): East Asian countries

	(I)	(II)	(III)	(IV)		(V)	(VI)	(VII)	(VIII)
	Nunn (2007) index		Levchenko (2007) index			Nunn (2007) index		Levchenko (2007) index	
VARIABLES	$D(X_{ap})$	$D(X_{pa})$	$D(X_{ap})$	$D(X_{pa})$	VARIABLES	$logX_{ap}$	$logX_{pa}$	$logX_{ap}$	$logX_{pa}$
DRsr	0.0909		0.0360		*logDRsr*	0.00298		0.00431	
	(0.125)		(0.133)			(0.0419)		(0.0397)	
DRrs		0.118		0.0915	*logDRrs*		0.0598**		0.0388
		(0.133)		(0.110)			(0.0296)		(0.0286)
*DRsr*D(Cont)*	-0.385		-0.140		*logDRsr*D(Cont)*	-0.0859*		-0.0854*	
	(0.251)		(0.172)			(0.0495)		(0.0461)	
*DRrs*D(Cont)*		-0.129		-0.0778	*logDRrs*D(Cont)*		-0.112**		-0.0936*
		(0.212)		(0.171)			(0.0437)		(0.0542)
Observations	40,626	40,626	40,626	40,626	Observations	20,426	19,127	20,426	19,127
R-squared	0.564	0.600	0.564	0.600	R-squared	0.614	0.558	0.614	0.557
Continuous measu	(IX)	(X)	(XIII)	(XIV)	Continuous measure	(XI)	(XII)	(XV)	(XVI)
DRsr	0.213		0.311		*logDRsr*	0.0836		0.0684	
	(0.195)		(0.236)			(0.0708)		(0.0603)	
DRrs		0.151		0.148	*logDRrs*		0.152*		0.110*
		(0.216)		(0.184)			(0.0885)		(0.0663)
*DRsr*Cont*	-0.640		-2.941		*logDRsr*Cont*	-0.245**		-0.821**	
	(0.464)		(1.820)			(0.119)		(0.374)	
*DRrs*Cont*		-0.203		-0.745	*logDRrs*Cont*		-0.315*		-0.969
		(0.453)		(1.448)			(0.185)		(0.598)
Observations	40,626	40,626	40,626	40,626	Observations	20,426	19,127	20,426	19,127
R-squared	0.564	0.600	0.564	0.600	R-squared	0.614	0.557	0.614	0.557

Note: See notes for Table 6.

Appendix A1 Additional Descriptive statistics: Panel (A): The share of intra-firm trade in trade to/from the host country

	Share of export to parent in total sales					Share of import from parent in cost of goods sold (COGS)				
Industry	East Asia	North America	EU	Other	Total	East Asia	North America	EU	Other	Total
Food	83.4%	65.5%	83.3%	76.3%	80.1%	78.2%	85.1%	80.8%	94.6%	80.6%
Textile	80.2%	92.7%	85.7%	96.8%	81.1%	75.1%	82.0%	68.8%	43.8%	74.6%
Chemicals	74.1%	71.4%	72.7%	74.1%	73.5%	77.2%	81.1%	81.7%	71.3%	77.9%
Glass and stone	90.0%	80.9%	87.5%	91.0%	89.2%	85.2%	91.5%	89.7%	86.8%	86.2%
Metal	80.1%	86.1%	54.9%	79.5%	80.1%	78.6%	94.9%	96.2%	81.9%	80.5%
Metal products	82.5%	66.1%	81.5%	91.4%	82.0%	77.1%	79.4%	76.4%	97.5%	77.8%
Machinery	88.6%	83.6%	82.9%	86.3%	87.6%	87.0%	86.4%	91.8%	89.3%	87.4%
Electronics	83.8%	80.1%	76.8%	99.5%	83.3%	78.5%	85.1%	77.1%	64.3%	78.6%
Electrical equip	83.6%	81.4%	75.7%	80.0%	82.9%	76.7%	84.1%	89.9%	81.6%	78.2%
Transportation	87.2%	85.8%	80.9%	83.1%	86.3%	86.2%	90.2%	88.7%	85.4%	87.2%
Other	83.9%	76.5%	77.7%	75.4%	82.9%	82.9%	88.6%	90.1%	94.6%	84.3%
Total	83.9%	80.0%	78.6%	83.4%	83.2%	81.5%	87.3%	86.4%	84.9%	82.7%

Source: Authors' calculations based on BSOBA (METI).

Panel (B): Descriptive statistics of the share of intra-firm trade

Region	N	Mean	Sd	p25	p50	p75
Share of export to parent in affiliate sales						
OECD	1698	0.058	0.190	0.000	0.000	0.006
non-OECD	4319	0.236	0.349	0.000	0.011	0.400
North America	903	0.052	0.181	0.000	0.000	0.003
Latain America not Mexico	92	0.042	0.169	0.000	0.000	0.000
Europe	582	0.041	0.158	0.000	0.000	0.003
Africa	20	0.028	0.124	0.000	0.000	0.000
Asia	4410	0.232	0.348	0.000	0.009	0.388
East Asia	4371	0.231	0.348	0.000	0.007	0.382
others	62	0.149	0.310	0.000	0.000	0.068
Total	6069	0.183	0.321	0.000	0.000	0.212
Share of import from parent in cogs						
OECD	1488	0.154	0.245	0.000	0.009	0.224
non-OECD	4015	0.165	0.241	0.000	0.030	0.269
North America	796	0.158	0.245	0.000	0.011	0.245
Latain America not Mexico	84	0.107	0.187	0.000	0.000	0.140
Europe	500	0.149	0.248	0.000	0.003	0.216
Africa	14	0.135	0.253	0.000	0.017	0.098
Asia	4054	0.166	0.242	0.000	0.031	0.271
East Asia	3972	0.167	0.241	0.000	0.032	0.272
others	55	0.109	0.222	0.000	0.000	0.084
Total	5503	0.162	0.242	0.000	0.024	0.258
Panel (B) Share of intrafirm trade by industry in 2009						
Industry	N	Mean	Sd	p25	p50	p75
Share of export to parent in affiliate sales						
Food	246	0.267	0.386	0.000	0.000	0.587
Textile	239	0.370	0.413	0.000	0.085	0.828
Chemicals	679	0.095	0.235	0.000	0.000	0.032
Glass and stone	165	0.192	0.310	0.000	0.010	0.223
Metal	279	0.189	0.326	0.000	0.000	0.236
Metal products	272	0.200	0.328	0.000	0.006	0.258
Machinery	832	0.209	0.336	0.000	0.004	0.312
Electronics	810	0.260	0.367	0.000	0.015	0.490
Electrical equip	473	0.221	0.324	0.000	0.023	0.349
Transportation	1263	0.073	0.200	0.000	0.000	0.007
Other	811	0.209	0.345	0.000	0.000	0.292
Total	6069	0.183	0.321	0.000	0.000	0.212
Share of import from parent in cogs						
Food	228	0.039	0.103	0.000	0.000	0.015
Textile	229	0.117	0.200	0.000	0.013	0.158
Chemicals	642	0.154	0.253	0.000	0.001	0.225
Glass and stone	149	0.173	0.248	0.000	0.036	0.289
Metal	264	0.194	0.276	0.000	0.024	0.361
Metal products	255	0.156	0.229	0.000	0.028	0.240
Machinery	774	0.187	0.262	0.000	0.043	0.306
Electronics	739	0.180	0.264	0.000	0.014	0.301
Electrical equip	432	0.193	0.261	0.000	0.060	0.343
Transportation	1070	0.165	0.223	0.000	0.054	0.282
Other	721	0.143	0.218	0.000	0.029	0.216
Total	5503	0.162	0.242	0.000	0.024	0.258

Source: Authors' calculations based on BSOAB (METI).

Appendix A2. Summary statistics and additional estimation results

Table A1. Summary Statistics

	Mean	St. Dev	p10	p90
D(Xap)	0.478	0.500	0.000	1.000
D(Xpa)	0.500	0.500	0.000	1.000
logXap	-2.435	2.396	-6.121	-0.014
logXpa	-2.162	1.630	-4.456	-0.417
logVap	5.131	2.364	1.792	8.059
logVpa	5.246	2.215	2.303	8.025
DRsr	0.145	0.152	0.000	0.413
DRrs	0.142	0.149	0.000	0.413
logDRsr	-2.960	2.349	-5.596	-0.884
logDRrs	-2.831	2.031	-5.437	-0.884
$logEmp_a$	4.893	1.665	2.708	6.949
$logEmp_p$	6.879	1.832	4.564	9.279
$logN_c$	4.023	1.508	1.946	6.031
$logEmp_c$	10.883	3.199	6.712	15.079

Source: Authors' calculations based on BSOBA (METI).

Table A3. Intra-firm trade and firm size, controlling for affiliate and parent characteristics

VARIABLES	(I) $D(X_{ap})$	(II) $D(X_{ap})$	(III) $logX_{ap}$	(IV) $logX_{ap}$	(V) $logV_{ap}$	(VI) $logV_{ap}$	(VII) $D(X_{pa})$	(VIII) $D(X_{pa})$	(IX) $logX_{pa}$	(X) $logX_{pa}$	(XI) $logV_{pa}$	(XII) $logV_{pa}$
$logEmp_a$	0.0505***	0.0573***	-0.196***	-0.190***	0.0243***	0.0416***	-0.209***	-0.0905***	0.565***	0.542***	0.514***	0.591***
	(0.00441)	(0.00410)	(0.0303)	(0.0428)	(0.00458)	(0.00378)	(0.0237)	(0.0239)	(0.0277)	(0.0391)	(0.0247)	(0.0267)
$logEmp_p$	-0.0123		-0.0157		-0.0611***		-0.0185		-0.00701		-0.0198	
	(0.0209)		(0.0707)		(0.0205)		(0.0601)		(0.0685)		(0.0856)	
$logN_c$	-0.0463		-0.332***		-0.0901***		-0.304***		-0.480***		-0.497***	
	(0.0317)		(0.101)		(0.0335)		(0.0894)		(0.101)		(0.115)	
$logEmp_c$	-0.00246		0.126*		0.0424*		0.185***		0.310***		0.403***	
	(0.0250)		(0.0759)		(0.0252)		(0.0683)		(0.0753)		(0.0948)	
Age	0.00444***	0.00302***	-0.00853**	-0.00857*	0.00443***	0.00391***	-0.00259	-0.00446	0.00167	0.00549	0.00457	0.00526
	(0.000593)	(0.000509)	(0.00410)	(0.00471)	(0.000643)	(0.000506)	(0.00302)	(0.00329)	(0.00426)	(0.00456)	(0.00357)	(0.00371)
Control share	0.251***	0.226***	1.129***	1.177***	0.136***	0.156***	0.819***	0.954***	1.167***	1.337***	0.772***	0.968***
	(0.0343)	(0.0303)	(0.221)	(0.244)	(0.0387)	(0.0256)	(0.157)	(0.173)	(0.222)	(0.255)	(0.176)	(0.201)
$R\&D\ ratio_p$	-0.0266	0.0222	-1.791**	-0.626	-0.0816	0.0518	1.264**	0.0405	0.0356	-1.338***	2.383***	-0.345
	(0.0485)	(0.0525)	(0.793)	(0.547)	(0.0572)	(0.0650)	(0.565)	(0.234)	(0.845)	(0.477)	(0.825)	(0.357)
$logKL_p$	-0.0161	-0.00217	-0.0738	0.0515	-0.0233	-0.00848	-0.0264	-0.0118	0.0143	0.0213	0.0980**	-0.0163
	(0.0131)	(0.00885)	(0.0507)	(0.0364)	(0.0148)	(0.0101)	(0.0360)	(0.0318)	(0.0479)	(0.0393)	(0.0438)	(0.0353)
Observations	48,708	48,414	22,897	22,582	48,708	48,414	23,628	23,305	22,897	22,582	24,341	24,039
R-squared	0.142	0.525	0.327	0.601	0.098	0.584	0.120	0.485	0.320	0.600	0.387	0.644
Aff ind FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Aff country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MNE FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Note: Standard errors in parentheses are clustered at the affiliate's industry-level. Affiliate size in terms of the number of employees is controlled. *,** and *** indicate statistical significance at the 10%, 5%, and 1% levels.

Table A4. Replication of Ramondo et al. (2016)

VARIABLES	(I) $D(X_{ap})$	(II) $D(X_{pa})$	(III) $logX_{ap}$	(IV) $logX_{pa}$
DRsr	0.0228			
	(0.0783)			
DRrs		0.101		
		(0.0787)		
logDRsr			-0.0322	
			(0.0292)	
logDRrs				-8.25e-05
				(0.0232)
Observations	55,882	55,882	24,978	25,017
R-squared	0.525	0.578	0.620	0.501

Note: See notes for Table A2.

Table A5. I-O link, Intra-firm trade, and contractibility, controlling for affiliate and parent characteristics

Discrete measure	(I)	(II)	(III)	(IV)	Discrete measure	(V)	(VI)	(VII)	(VIII)
	Nunn (2007) index		Levchenko (2007) index			Nunn (2007) index		Levchenko (2007) index	
VARIABLES	$D(X_{ap})$	$D(X_{pa})$	$D(X_{ap})$	$D(X_{pa})$	VARIABLES	$logX_{ap}$	$logX_{pa}$	$logX_{ap}$	$logX_{pa}$
DRsr	0.101		0.0907		*logDRsr*	-0.0125		0.00146	
	(0.0958)		(0.105)			(0.0448)		(0.0421)	
DRrs		0.0543		0.0947	*logDRrs*		0.0522		0.0545*
		(0.107)		(0.0877)			(0.0364)		(0.0312)
*DRsr*D(Cont)*	-0.404*		-0.207		*logDRsr*D(Cont)*	-0.0750		-0.0935**	
	(0.234)		(0.151)			(0.0527)		(0.0465)	
*DRrs*D(Cont)*		0.00889		-0.111	*logDRrs*D(Cont)*		-0.0837*		-0.116**
		(0.175)		(0.174)			(0.0477)		(0.0560)
Observations	48,414	48,414	48,414	48,414	Observations	21,332	21,762	21,332	21,762
R-squared	0.526	0.584	0.525	0.584	R-squared	0.610	0.497	0.610	0.497
Continuous measure	(IX)	(X)	(XIII)	(XIV)	Continuous measure	(XI)	(XII)	(XV)	(XVI)
DRsr	0.221		0.362*		*logDRsr*	0.0269		0.0335	
	(0.160)		(0.198)			(0.0811)		(0.0730)	
DRrs		0.109		0.212	*logDRrs*		0.113		0.101
		(0.181)		(0.148)			(0.0873)		(0.0665)
*DRsr*Cont*	-0.647		-3.213*		*logDRsr*Cont*	-0.153		-0.625	
	(0.411)		(1.647)			(0.134)		(0.476)	
*DRrs*Cont*		-0.122		-1.405	*logDRrs*Cont*		-0.219		-0.824
		(0.386)		(1.229)			(0.176)		(0.598)
Observations	48,414	48,414	48,414	48,414	Observations	21,332	21,762	21,332	21,762
R-squared	0.525	0.584	0.526	0.584	R-squared	0.610	0.496	0.610	0.496

Note: Standard errors in parentheses are clustered at the affiliate's industry-level. The employment, control share, age of affiliates, R&D sales ratio, and capital-labor ratio of parent firms are controlled. Affiliate's industry fixed effect, year fixed effect, and MNE fixed effect are included. *,** and *** indicate statistical significance at the 10%, 5%, and 1% levels.

Table A6. Panel (A) I-O link, Intra-firm trade and contractibility (OECD countries), controlling for affiliate and parent characteristics

	(I)	(II)	(III)	(IV)		(V)	(VI)	(VII)	(VIII)
	Nunn (2007) index		Levchenko (2007) index			Nunn (2007) index		Levchenko (2007) index	
VARIABLES	$D(X_{ap})$	$D(X_{pa})$	$D(X_{ap})$	$D(X_{pa})$	VARIABLES	$logX_{ap}$	$logX_{pa}$	$logX_{ap}$	$logX_{pa}$
DRsr	0.172		0.192		*logDRsr*	0.0482		0.0410	
	(0.164)		(0.185)			(0.0637)		(0.0630)	
DRrs		-0.00318		0.155	*logDRrs*		-0.0390		0.102
		(0.186)		(0.180)			(0.0895)		(0.0635)
*DRsr*D(Cont)*	-0.229		-0.143		*logDRsr*D(Cont)*	-0.0543		-0.0329	
	(0.357)		(0.233)			(0.114)		(0.0822)	
*DRrs*D(Cont)*		0.353		-0.0698	*logDRrs*D(Cont)*		0.100		-0.225**
		(0.263)		(0.415)			(0.117)		(0.110)
Observations	12,822	12,822	12,822	12,822	Observations	4,284	5,110	4,284	5,110
R-squared	0.526	0.634	0.526	0.634	R-squared	0.674	0.561	0.674	0.562
Continuous measure	(IX)	(X)	(XIII)	(XIV)	Continuous measure	(XI)	(XII)	(XV)	(XVI)
DRsr	0.258		0.434		*logDRsr*	-0.00327		-0.147	
	(0.263)		(0.347)			(0.105)		(0.121)	
DRrs		-0.119		0.227	*logDRrs*		0.0365		0.209
		(0.329)		(0.280)			(0.126)		(0.134)
*DRsr*Cont*	-0.414		-2.666		*logDRsr*Cont*	0.0473		1.211	
	(0.624)		(2.710)			(0.228)		(0.946)	
*DRrs*Cont*		0.597		-0.866	*logDRrs*Cont*		-0.0348		-1.744
		(0.638)		(2.119)			(0.270)		(1.155)
Observations	12,822	12,822	12,822	12,822	Observations	4,284	5,110	4,284	5,110
R-squared	0.526	0.634	0.526	0.634	R-squared	0.674	0.561	0.675	0.562

Note: See notes for Table A5.

Table A6 Panel (B) I-O link, Intra-firm trade and contractibility (non-OECD countries), controlling for affiliate and parent characteristics

Discrete measure	(I)	(II)	(III)	(IV)	Discrete measure	(V)	(VI)	(VII)	(VIII)
	Nunn (2007) index		Levchenko (2007) index			Nunn (2007) index		Levchenko (2007) index	
VARIABLES	$D(X_{ap})$	$D(X_{pa})$	$D(X_{ap})$	$D(X_{pa})$	VARIABLES	$logX_{ap}$	$logX_{pa}$	$logX_{ap}$	$logX_{pa}$
DRsr	0.0837		0.0199		*logDRsr*	-0.0230		-0.00985	
	(0.124)		(0.136)			(0.0475)		(0.0449)	
DRrs		0.0999		0.0981	*logDRrs*		0.0572*		0.0400
		(0.125)		(0.0991)			(0.0321)		(0.0318)
*DRsr*D(Cont)*	-0.452*		-0.137		*logDRsr*D(Cont)*	-0.0546		-0.0752	
	(0.272)		(0.173)			(0.0575)		(0.0505)	
*DRrs*D(Cont)*		-0.0800		-0.0900	*logDRrs*D(Cont)*		-0.0976**		-0.0875
		(0.213)		(0.167)			(0.0474)		(0.0596)
Observations	35,493	35,493	35,493	35,493	Observations	16,957	16,553	16,957	16,553
R-squared	0.566	0.602	0.566	0.602	R-squared	0.611	0.549	0.611	0.549
Continuous measure	(IX)	(X)	(XIII)	(XIV)	Continuous measure	(XI)	(XII)	(XV)	(XVI)
DRsr	0.214		0.275		*logDRsr*	0.0384		0.0762	
	(0.200)		(0.254)			(0.0854)		(0.0708)	
DRrs		0.152		0.177	*logDRrs*		0.123		0.0813
		(0.208)		(0.174)			(0.0985)		(0.0712)
*DRsr*Cont*	-0.719		-2.806		*logDRsr*Cont*	-0.177		-0.955**	
	(0.511)		(2.055)			(0.143)		(0.420)	
*DRrs*Cont*		-0.203		-1.007	*logDRrs*Cont*		-0.245		-0.682
		(0.465)		(1.486)			(0.202)		(0.632)
Observations	35,493	35,493	35,493	35,493	Observations	16,957	16,553	16,957	16,553
R-squared	0.566	0.602	0.566	0.602	R-squared	0.611	0.549	0.612	0.549

Note: See notes to Table A5.

Table A6. Panel (C) I-O link, Intra-firm trade and contractibility (East Asian countries), controlling for affiliate and parent characteristics

	(I)	(II)	(III)	(IV)		(V)	(VI)	(VII)	(VIII)
	Nunn (2007) index		Levchenko (2007) index			Nunn (2007) index		Levchenko (2007) index	
VARIABLES	$D(X_{ap})$	$D(X_{pa})$	$D(X_{ap})$	$D(X_{pa})$	VARIABLES	$logX_{ap}$	$logX_{pa}$	$logX_{ap}$	$logX_{pa}$
DRsr	0.0909		0.0145		*logDRsr*	-0.0241		-0.0164	
	(0.136)		(0.143)			(0.0475)		(0.0453)	
DRrs		0.0959		0.0791	*logDRrs*		0.0659**		0.0442
		(0.127)		(0.100)			(0.0319)		(0.0318)
*DRsr*D(Cont)*	-0.533**		-0.181		*logDRsr*D(Cont)*	-0.0698		-0.0798	
	(0.271)		(0.185)			(0.0557)		(0.0503)	
*DRrs*D(Cont)*		-0.105		-0.0781	*logDRrs*D(Cont)*		-0.102**		-0.0828
		(0.217)		(0.171)			(0.0470)		(0.0590)
Observations	34,382	34,382	34,382	34,382	Observations	17,120	16,349	17,120	16,349
R-squared	0.566	0.605	0.565	0.605	R-squared	0.602	0.557	0.602	0.556
DRsr	0.256		0.351		*logDRsr*	0.0502		0.0557	
	(0.212)		(0.258)			(0.0842)		(0.0717)	
DRrs		0.162		0.175	*logDRrs*		0.129		0.0823
		(0.208)		(0.174)			(0.0967)		(0.0703)
*DRsr*Cont*	-0.872*		-3.638*		*logDRsr*Cont*	-0.216		-0.863**	
	(0.503)		(1.977)			(0.137)		(0.420)	
*DRrs*Cont*		-0.260		-1.113	*logDRrs*Cont*		-0.245		-0.634
		(0.460)		(1.468)			(0.199)		(0.621)
Observations	34,382	34,382	34,382	34,382	Observations	17,120	16,349	17,120	16,349
R-squared	0.566	0.606	0.566	0.606	R-squared	0.602	0.556	0.603	0.556

Note: See notes for Table A5.

Appendix B. Brief overview of RIETI survey

In addition to the BSOBA, we used a different data source for intra-firm trade. We conducted a unique survey of Japanese firms to collect information on intra-firm trade distinguishing intra-firm trade in goods, technology, and other services. This appendix summarizes the main results from the survey "Survey of Global Activities of Japanese Firms," which was conducted by RIETI for our research project (hereafter abbreviated as "RIETI survey" for short). More detailed descriptions of the survey are given in Tomiura et al. (2017) in Japanese.

We designed the sample to cover all Japanese firms owning at least one majority-owned foreign affiliate in manufacturing as well as in the wholesale and retail sectors. We selected the sample based on the comprehensive commercial dataset provided by Toyo Keizai Inc.[19] Our questionnaires were distributed to 3,291 MNE parent firms, from which we collected responses from 828 firms (25% of the contracted firms) from February to March 2016. We asked firms to report their experiences in the year 2015.

In the survey, we asked whether each firm was involved in intra-firm trade (asking about exports and imports separately). What we learned from the survey about intra-firm trade regarded extensive margins (a binary choice), not intensive margins (the value or share of intra-firm trade). One advantage of this survey over BSOBA, however, was that we asked about the firm's engagement in intra-firm trade separately in goods, technology, and other services. We also disaggregated intra-firm trade into: (i) trade between overseas affiliates and their parents in Japan; (ii) trade between overseas affiliates owned by the same parent company within the same host country; and (iii) trade between overseas affiliates owned by the same parent company located in different countries. Destinations/sources were classified into six region groups (China,

[19] The population of the RIETI survey is hence different from that of the BSOBA. Toyo Keizai constructs its database from wide number of information sources, including press coverage.

Korea/Taiwan, ASEAN, North America, Europe, and the Rest of the World), though the individual country was not identified except for China. As BSOBA merged intra-firm trade in goods with services and did not cover trade between affiliates in its recent rounds, we were able to collect previously unavailable information in our RIETI survey. We distributed our questionnaires to MNE parents and asked about intra-firm trade with affiliates owned by the parents. In contrast to affiliate-level BSOBA data, our corporate-level data from the RIETI survey did not allow us to identify which individual affiliate was involved in intra-firm trade.

The survey results displayed in Tables B1 to B6 confirm that only a small fraction of firms are active in intra-firm trade, but we further find that trade in services is especially limited. A non-negligible share of offshore affiliates trades services with unaffiliated firms within the same country, but the cross-border service trade is severely limited. The overwhelming share of intra-firm trade in technology is between affiliates and their parents.

Table B7 combines the RIETI survey results in these different categories of intra-firm trade. We find that, when a parent exports technology or other services to its affiliates, the same parent often exports goods to its affiliates as well. Although we cannot identify individual affiliates within the RIETI survey, intra-firm trade in goods and intra-firm trade in services are likely to be complementary at least at the corporate level.

We also link the RIETI survey results with firm-level data drawn from METI's The statistics in BSJBSA to explore how intra-firm trade with the parent firm is related to the parents' attributes. Here the regressions based on corporate-level data from BSJBSA focus on the characteristics of parents, while the regressions reported in the main text of this paper analyze the relationship with the characteristics of affiliates based on the affiliate-level data from BSOBA.

Tables B8, B9, and B10 report the results of the regression with intra-firm trade using trade in goods, services, and technology as the dependent variable. As indicated in Table B7, intra-firm

trade in goods tends to be related positively with the capital-labor ratio but negatively with advertising intensity, especially in the machinery industry where Japanese multinationals are most active. In Table B8, intra-firm trade in technology is related to the capital-labor ratio positively for imports from parents but negatively for exports to parents. Table B9 shows that intra-firm trade in other services is negatively related to advertising intensity but positively related to the size of parents and their number of products. While some of these findings are informative and in line with our prior expectations, we should note that these regressions based on the RIETI survey are at the MNE corporate level without controls for affiliate characteristics.

Table B1. Share of intra-firm exports of goods by destination (%)

Export destination	Location of affiliates					
	China	Korea Taiwan	ASEAN	North America	Europe	Others
Parent firm	23.57	21.15	22.50	14.00	12.94	14.62
Other affiliates in the same country	11.40	3.63	5.93	5.17	4.94	5.19
Other firms in the same country	33.90	41.09	31.85	40.67	33.65	43.40
Other affiliates in other countries	10.09	11.48	11.76	11.50	12.00	9.91
Other firms in the other countries	11.94	12.39	18.98	20.00	27.29	14.62
Other affiliates in Japan	3.39	3.63	2.96	2.83	2.82	2.83
Other firms in Japan	4.16	1.81	3.61	2.00	1.88	1.89
None	1.54	4.83	2.41	3.83	4.47	7.55
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table B2. Share of intra-firm imports of goods by origin (%)

Import origin	Location of affiliates					
	China	Korea Taiwan	ASEAN	North America	Europe	Others
Parent firm	28.45	29.34	26.81	30.06	28.64	26.41
Other affiliates in the same country	9.92	4.34	5.87	5.06	5.91	4.93
Other firms in the same country	29.61	24.23	24.85	22.77	20.68	25.35
Other affiliates in other countries	7.83	12.24	11.66	14.43	16.36	15.49
Other firms in the other countries	10.31	11.73	16.60	12.05	14.77	12.32
Other affiliates in Japan	3.88	5.61	3.74	4.46	5.00	4.23
Other firms in Japan	6.59	7.14	7.91	5.51	3.64	3.87
None	3.41	5.36	2.55	5.65	5.00	7.39
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table B3. Share of intra-firm exports of technologies by destination (%)

Destination of technology transfer	Location of affiliates					
	China	Korea Taiwan	ASEAN	North America	Europe	Others
Parent firm	7.83	4.44	7.69	6.62	5.74	3.33
Other affiliates in the same country	2.14	0.56	0.42	0.95	0.96	1.33
Other firms in the same country	2.49	1.67	2.70	2.52	2.87	4.00
Other affiliates in other countries	1.60	3.33	0.83	3.79	2.87	0.67
Other firms in the other countries	1.07	0.56	1.87	1.26	1.91	0.67
Other affiliates in Japan	0.36	0.00	0.62	1.26	0.48	0.00
Other firms in Japan	0.53	0.00	0.21	0.95	0.48	0.67
None	83.99	89.44	85.65	82.65	84.69	89.33
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table B4. Share of intra-firm imports of technologies by origin (%)

Source of technology transfer	Location of affiliates					
	China	Korea Taiwan	ASEAN	North America	Europe	Others
Parent firm	29.01	23.53	31.41	23.31	18.87	20.51
Other affiliates in the same country	1.19	0.53	0.80	0.31	0.47	0.64
Other firms in the same country	1.19	1.60	1.39	2.15	1.89	1.28
Other affiliates in other countries	1.54	0.53	1.39	1.23	0.94	0.00
Other firms in the other countries	1.02	1.07	1.39	1.84	1.42	0.64
Other affiliates in Japan	2.22	1.60	2.39	2.15	2.83	1.92
Other firms in Japan	1.19	0.53	2.19	1.53	1.42	1.92
None	62.63	70.59	59.05	67.48	72.17	73.08
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table B5. Share of intra-firm exports of other services by destination (%)

Destination of service export	Location of affiliates					
	China	Korea Taiwan	ASEAN	North America	Europe	Others
Parent firm	12.28	11.56	10.53	11.17	10.29	11.04
Other affiliates in the same country	3.99	1.01	2.26	3.15	3.29	3.07
Other firms in the same country	8.77	10.55	9.96	10.89	12.35	9.20
Other affiliates in other countries	2.39	3.52	3.57	2.87	4.53	4.29
Other firms in the other countries	2.23	2.51	3.57	4.30	6.58	3.07
Other affiliates in Japan	1.12	2.01	0.94	0.57	1.23	0.61
Other firms in Japan	0.80	0.50	0.94	0.86	1.65	1.23
None	68.42	68.34	68.23	66.19	60.08	67.48
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table B6. Share of intra-firm imports of other services by origin (%)

Source of service import	Location of affiliates					
	China	Korea Taiwan	ASEAN	North America	Europe	Others
Parent firm	16.32	16.24	16.12	19.38	16.88	14.86
Other affiliates in the same country	3.88	0.51	1.83	1.69	2.11	2.86
Other firms in the same country	16.64	19.80	17.95	22.47	21.10	21.71
Other affiliates in other countries	0.97	1.02	2.38	1.69	3.38	3.43
Other firms in the other countries	0.81	1.02	2.56	2.25	3.80	2.29
Other affiliates in Japan	0.97	1.52	1.47	0.84	0.84	1.14
Other firms in Japan	1.45	2.03	2.38	1.97	2.53	2.86
None	58.97	57.87	55.31	49.72	49.37	50.86
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table B7. Relationship between trade in goods, services, and technologies

Relationship between trade in goods and trade in services

Panel A		Manufacturing			Wholesale and Retail		
		Service export to parent firm			Service export to parent firm		
		No	Yes	Total	No	Yes	Total
Export of goods to parent firm	No	503	74	577	163	33	196
	Yes	376	76	452	135	29	164
	Total	879	150	1,029	298	62	360

Panel B		Manufacturing			Wholesale and Retail		
		Service import from parent firm			Service import from parent firm		
		No	Yes	Total	No	Yes	Total
Import of goods from parent firm	No	258	35	293	111	14	125
	Yes	553	178	731	170	69	239
	Total	811	213	1,024	281	83	364

Relationship between trade in goods and trade in technology

Panel C		Manufacturing			Wholesale and Retail		
		Technology import from parent firm			Technology import from parent firm		
		No	Yes	Total	No	Yes	Total
Export of goods to parent firm	No	395	179	574	174	22	196
	Yes	239	213	452	147	19	166
	Total	634	392	1,026	321	41	362

Panel D		Manufacturing			Wholesale and Retail		
		Technology import from parent firm			Technology import from parent firm		
		No	Yes	Total	No	Yes	Total
Import of goods from parent firm	No	235	58	293	117	7	124
	Yes	398	334	732	206	34	240
	Total	633	392	1,025	323	41	364

Panel E		Manufacturing			Wholesale and Retail		
		Technology export to parent firm			Technology export to parent firm		
		No	Yes	Total	No	Yes	Total
Export of goods to parent firm	No	539	32	571	191	3	194
	Yes	393	57	450	149	14	163
	Total	932	89	1,021	340	17	357

Panel F		Manufacturing			Wholesale and Retail		
		Technology export to parent firm			Technology export to parent firm		
		No	Yes	Total	No	Yes	Total
Import of goods from parent firm	No	279	16	295	120	4	124
	Yes	653	74	727	222	13	235
	Total	932	90	1,022	342	17	359

Table B8. Intra-firm trade and parent firm characteristics: Trade in goods

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	Export of goods				Export of goods				Import of goods				Import of goods			
Sub-sample	Manufacturing				Machinery industry				Manufacturing				Machinery industry			
ln(N of employee)	0.0254	0.0213	0.0245	-0.0157	0.0252	0.0244	0.0234	-0.0129	0.0243	0.0244	0.0235	0.0136	0.0457	0.0379	0.0460	0.0451
	(0.0282)	(0.0230)	(0.0283)	(0.0282)	(0.0417)	(0.0401)	(0.0467)	(0.0446)	(0.0289)	(0.0257)	(0.0290)	(0.0258)	(0.0461)	(0.0417)	(0.0450)	(0.0375)
R&D / Sales	-0.323		-0.319	0.177	-0.0210		0.106	0.519	0.161		0.0964	-0.00293	-0.828**		-0.854***	-0.922*
	(0.648)		(0.648)	(0.605)	(0.845)		(0.956)	(0.954)	(0.550)		(0.520)	(0.579)	(0.344)		(0.321)	(0.490)
Advertising expenses / Sales		-0.754**	-0.751**	-0.569*		-26.39***	-26.50***	-20.12***		3.818	3.741	3.822		5.206	5.939	5.501
		(0.341)	(0.347)	(0.302)		(2.069)	(2.336)	(1.727)		(2.691)	(2.521)	(2.637)		(6.981)	(6.709)	(7.484)
ln(Capital / Labor)	-0.00755	-0.00952	-0.00674	-0.0141	-0.0482	-0.0414	-0.0424	-0.0488	0.0439	0.0432	0.0426	0.0397	0.0763***	0.0676**	0.0753**	0.0751**
	(0.0382)	(0.0415)	(0.0383)	(0.0442)	(0.0421)	(0.0481)	(0.0394)	(0.0505)	(0.0279)	(0.0277)	(0.0278)	(0.0288)	(0.0270)	(0.0334)	(0.0295)	(0.0293)
N of products	0.0229	0.0258	0.0255	0.0245*	0.0255	0.0250*	0.0253**	0.0217***	0.0476**	0.0455*	0.0455*	0.0392*	0.00505	0.00812	0.00530	0.00419
	(0.0148)	(0.0165)	(0.0162)	(0.0131)	(0.0178)	(0.0143)	(0.0117)	(0.00536)	(0.0241)	(0.0242)	(0.0240)	(0.0222)	(0.0115)	(0.0121)	(0.0124)	(0.0155)
N of affiliate firms for production				0.0948***				0.0991**				0.00481				-0.00299
				(0.0196)				(0.0395)				(0.0118)				(0.00394)
N of affiliate firms for wholesale				-0.0278*				-0.0253				0.0292				0.00754
				(0.0159)				(0.0269)				(0.0278)				(0.0209)
Observations	996	996	996	996	548	548	548	548	1,014	1,014	1,014	1,014	549	549	549	549

Note: Standard errors in parentheses are clustered at the industry-level. Industry and region fixed effects are included. *,** and *** indicate statistical significance at the 10%, 5%, and 1% levels.

Table B9. Intra-firm trade and parent firm characteristics: Trade in technology

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	Technology export				Technology export				Technology import				Technology import			
Sub-sample	Manufacturing				Machinery industry				Manufacturing				Machinery industry			
ln(N of employee)	0.0188	0.0158	0.0187	0.00203	0.0140	0.0121	0.0139	-0.00815	0.0550*	0.0543**	0.0547*	0.0144	0.0506	0.0539	0.0496	0.0250
	(0.0197)	(0.0175)	(0.0196)	(0.0145)	(0.0270)	(0.0255)	(0.0268)	(0.0107)	(0.0321)	(0.0257)	(0.0316)	(0.0310)	(0.0554)	(0.0438)	(0.0535)	(0.0510)
R&D / Sales	-0.309		-0.307	-0.247	-0.209		-0.194	-0.0737	-0.0704		-0.0354	0.140	0.370		0.418	0.455
	(0.323)		(0.323)	(0.328)	(0.135)		(0.123)	(0.285)	(0.747)		(0.742)	(0.638)	(0.974)		(0.955)	(0.900)
Advertising expenses / Sales		-0.229	-0.221	-0.145		-2.155	-1.933	-0.763		-2.355	-2.343	-2.096		-8.273	-8.722	-7.202
		(0.233)	(0.234)	(0.224)		(6.663)	(6.599)	(4.802)		(1.945)	(2.079)	(1.668)		(6.295)	(6.770)	(7.278)
ln(Capital / Labor)	-0.0306***	-0.0329***	-0.0304***	-0.0345***	-0.0238**	-0.0250***	-0.0232***	-0.0307*	0.0294	0.0293	0.0296	0.0187	0.0774**	0.0827*	0.0789**	0.0723*
	(0.00673)	(0.00569)	(0.00662)	(0.00776)	(0.0101)	(0.00864)	(0.00873)	(0.0162)	(0.0280)	(0.0321)	(0.0282)	(0.0282)	(0.0354)	(0.0432)	(0.0376)	(0.0436)
N of products	0.000282	0.000818	0.000904	-0.00237	0.0110	0.0115	0.0110	0.00914	-0.00852	-0.00515	-0.00519	-0.0117	-0.0336*	-0.0343**	-0.0331*	-0.0391***
	(0.0125)	(0.0129)	(0.0127)	(0.0134)	(0.0153)	(0.0153)	(0.0151)	(0.0137)	(0.0177)	(0.0177)	(0.0180)	(0.0173)	(0.0193)	(0.0164)	(0.0183)	(0.00804)
N of affiliate firms for production				0.0275***				0.0400***				0.0803**				0.0559
				(0.00717)				(0.00543)				(0.0350)				(0.0616)
N of affiliate firms for wholesale				-0.000541				-0.00642				0.0105				0.00414
				(0.00603)				(0.00463)				(0.0167)				(0.0258)
Observations	934	934	934	934	549	549	549	549	1,027	1,027	1,027	1,027	546	546	546	546

Note: See notes for Table B8.

Table B10. Intra-firm trade and parent firm characteristics: Trade in other services

	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)
VARIABLES	Export of service				Export of service				Import of service				Import of service			
Sub-sample	Manufacturing				Machinery industry				Manufacturing				Machinery industry			
ln(N of employee)	0.0740***	0.0739***	0.0741***	0.0692***	0.0925***	0.0837***	0.0916***	0.0884***	0.0647**	0.0634**	0.0644**	0.0375	0.0518	0.0503	0.0522	0.0321
	(0.0145)	(0.0100)	(0.0142)	(0.0175)	(0.0185)	(0.0155)	(0.0199)	(0.0277)	(0.0275)	(0.0271)	(0.0274)	(0.0237)	(0.0442)	(0.0456)	(0.0452)	(0.0382)
R&D / Sales	-0.0253		-0.0184	-0.133	-0.745***		-0.707***	-1.045**	-0.195		-0.104	-0.264	-0.187***		-0.196***	-0.494
	(0.417)		(0.422)	(0.479)	(0.103)		(0.0914)	(0.466)	(0.338)		(0.282)	(0.260)	(0.0310)		(0.0353)	(0.364)
Advertising expenses / Sales		-0.687	-0.684	-0.592		-7.534***	-6.500**	-8.288***		-5.227*	-5.048*	-4.400**		1.209	1.392	0.385
		(0.665)	(0.686)	(0.523)		(2.604)	(3.316)	(1.566)		(3.173)	(2.707)	(1.949)		(3.418)	(3.599)	(2.907)
ln(Capital / Labor)	-0.0194	-0.0195	-0.0193	-0.0216	0.00117	-0.00655	0.00347	0.00624	-0.0109	-0.0107	-0.00975	-0.0177	0.00355	0.00113	0.00320	-0.00142
	(0.0189)	(0.0153)	(0.0192)	(0.0207)	(0.0102)	(0.00925)	(0.0114)	(0.0108)	(0.0192)	(0.0173)	(0.0178)	(0.0175)	(0.0244)	(0.0240)	(0.0237)	(0.0245)
N of products	0.0113**	0.0116**	0.0115**	0.00851*	0.00716	0.00835	0.00711	0.00545	0.0302***	0.0304***	0.0304***	0.0248**	0.0199	0.0203	0.0199	0.0145
	(0.00560)	(0.00544)	(0.00574)	(0.00496)	(0.00472)	(0.00516)	(0.00580)	(0.00574)	(0.0113)	(0.0111)	(0.0112)	(0.0121)	(0.0186)	(0.0188)	(0.0189)	(0.0208)
N of affiliate firms for production				-0.00402				-0.0208				0.0245**				0.0166*
				(0.00924)				(0.0164)				(0.0119)				(0.00982)
N of affiliate firms for wholesale				0.0137				0.0206				0.0257*				0.0227
				(0.0116)				(0.0254)				(0.0143)				(0.0224)
Observations	977	977	977	977	551	551	551	551	976	976	976	976	547	547	547	547

Note: See notes for Table B8.