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

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Abstract

This paper revisits how vertical linkages between overseas affiliates and their parents are related to intrafirm trade by shedding light on variations in contractibility across sectors in the case of Japanese multinational enterprises (MNEs) based on affiliate-level data. We confirm that intrafirm trade is observed only in a limited fraction of affiliates. To include a large number of affiliates with zero intrafirm trade into our regressions, we estimate our model by Poisson Pseudo Maximum Likelihood. We find that Japanese multinational affiliates tend to export relatively more to their parents in vertically linked sectors especially if they trade goods with low contractibility. This relationship is evident for affiliates located in developing countries. This result indicates that input–output linkage is a significant determinant of intrafirm trade when the trade is affected by contractual frictions. We also confirm the robustness of the results regardless of the definition of contractibility indices by previous studies.

Keywords: Intrafirm trade; Affiliate-level data; Input–output linkage; Contractual frictions

JEL Classification: F14; F23

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1. Introduction

Intrafirm trade makes up a substantial part of overall international trade. For example, nearly half of the total imports of the U.S. result from intrafirm trade.[1] In examining U.S. firm-level data, Ramondo et al. (2016) report that only a limited fraction of overseas affiliates are involved in intrafirm trade despite our understanding of intrafirm trade linked with vertical foreign direct investment (FDI). The incompleteness of contracts should be among the determinants for trade to cross beyond firm boundaries. This paper reexamines whether vertical linkage is related to intrafirm trade by considering contractual frictions based on affiliate-level data of Japanese multinational enterprises (MNEs).

As is discussed in the literature on contract theory (e.g., Antràs, 2003, in the international trade context), an incomplete contract environment tends to deter transactions with unrelated parties. This argument suggests that affiliates and parents are actively engaged in intrafirm trade especially in industries susceptible to contractual frictions. If firms depend more on differentiated inputs that are neither traded on organized exchanges nor under reference prices (Nunn, 2007), or on inputs sourced from diverse sectors (Levchenko, 2007), firms have stronger incentives to trade inputs within firm boundaries to alleviate incomplete contract problems. We investigate this hypothesis by disaggregating intrafirm trade data into sectors with varying contractibility. The two measures used in this paper for sector-specific contractibility

[1] The share of intrafirm 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.

are (i) Nunn-type measure, which subtracts from the value one the weighted average of the proportion of inputs that are neither sold on an organized exchange nor reference priced, and (ii) Levchenko-type measure of sectoral concentration, which is the Herfindahl index of input use.

Our work is related to previous studies of the impact of contractual frictions on intrafirm trade. Bernard et al. (2010) find that intrafirm trade is negatively correlated with product contractibility, for which they use the share of wholesale employment in each firm as a proxy of intermediation based on U.S. firm-level data. Corcos et al. (2013) use disaggregated country–product data for MNE parents in France and find that intrafirm trade tends to be active for products that are neither sold on an organized exchange nor reference priced, but they did not control for affiliate attributes. Blanas and Seric (2018) investigate foreign-owned affiliates in 19 Sub-Saharan African countries and found that a sector's contract intensity interacted with the country's judicial quality has a significant effect on intrafirm trade intensity, but they do not control for characteristics of MNE parents. Compared with previous work, our research focuses on vertical linkage and controls for the effects of affiliate characteristics as well as those of MNEs.[2] We estimate our model by Poisson Pseudo Maximum Likelihood (PPML). The inclusion of affiliates with zero intrafirm trade into our regressions is important because an overwhelming majority of affiliates are not involved in any intrafirm trade at all as repeatedly confirmed.

[2] As a rare example of detailed firm-level data, Berlingieri et al. (2021) find that intrafirm trade share tends to rise with the cost share of the product in French firms, suggesting the importance of production technology as consistent with the transaction cost theory.

This paper is also related to previous studies of vertical FDI with production stage fragmentation. Alfaro and Charlton (2009) emphasize the prevalence of vertical FDI in "close" industries by reporting that nearly a quarter of offshore affiliates operate in the same two-digit industry, not four-digit, as their parents in their global ownership database, but industrial classifications may not be informative for examining closeness or linkages of industries.[3] Antràs and Chor (2013) conclude that under incomplete contracts, intrafirm trade share increase with the upstreamness of firms in sequential production stages, and they provide supportive evidence from U.S. aggregated sector-level data. Although they do not directly examine intrafirm trade, Alfaro et al. (2019) report that integrated inputs (produced in industries within firm boundaries) tend to be positioned more upstream than outsourced inputs (sourced from other industries) in worldwide establishment-level data. We introduce sectoral contractibility interacted with input–output linkages between parents and offshore affiliates in countries with a different contracting environment.

To preview our principal results, we find that input–output linkages are positively related to intrafirm trade share especially for affiliates' exports to their parents in sectors with low contractibility, and for affiliates located in East Asia, where Japanese overseas affiliates are agglomerated. No such relationship is detected for affiliated in developed countries: member countries of Organisation for Economic Cooperation and Development (OECD). In other words, MNE parents and their vertically linked affiliates are likely to

[3] From global ownership database, Del Prete and Rungi (2017) also report that parents tend to integrate affiliates when they are proximate along the supply chains because of technological complementarities in adjacent industries.

engage in intrafirm 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.

The rest of the paper is organized as follows. Section 2 describes our affiliate-level data. Section 3 summarizes patterns of Japanese intrafirm trade. After the explanation of our empirical framework in Section 4, the regression results are presented in Section 5. Section 6 reports robustness check results. Section 7 adds some concluding comments.

2. Data Sources

This section describes the firm-level data derived from the official statistics of the 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).[4] The BSOBA 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.[5]

For the purpose of our research, the BSOBA provides valuable data as the survey disaggregates the

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[4] Access to microdata was arranged by the Research Institute of Economy, Trade, and Industry (RIETI) for our research project. This dataset is frequently used in previous published research. Examples includes Ito and Wakasugi (2007), Hayakawa and Matsuura (2015), and Spinelli et al. (2020).

[5] Chun et al. (2017) also analyzed Japanese intrafirm 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. Thus, they do not take into account the differences in the contracting environment across industries, and they do not distinguish the location of MNE affiliates. 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.

affiliate's 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, (iv) sales (exports) to the parent company in Japan, and (v) sales (exports) to the rest of the world. The first category includes the second category while the fourth category is a subset of the third category. Exports to the rest of the world are not disaggregated into intrafirm trade and arm's-length trade. The relevant category we use for identifying intrafirm trade is the fourth one (exports from overseas affiliates to the parent company in Japan).[6] The BSOBA therefore enables us to identify trade between each affiliate and its parent though no data on trade between affiliates are available.[7] As affiliate purchases/imports in the BSOBA are broken down in exactly the same categories as sales/exports, respectively, we use each affiliate's imports from the parent in Japan as intrafirm trade on the import side. Because data on 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 the BSOBA at the time of this research.[8]

We concentrate on manufacturing sectors (where both parent and affiliates are classified as manufacturers) to focus on the export of goods and service produced by the firm or the import of intermediate input for further processing. Note that intrafirm trade in the BSOBA is defined to include trade

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6 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.

7 In the U.S. data, Ramondo et al. (2016) include trade between affiliates.

8 Because our sample period covers both the global financial crisis and the East Japan earthquake in 2011, one may concern our estimates may suffer from some biases from these events. However, we confirm that both the average shares of intrafirm exports and imports are generally stable over the years in our sample period. For more details, see Appendix Table A1.

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.[9] We omit outliers by excluding affiliates with intrafirm trade exceeding their sales or total purchases.

3. Patterns of Japanese intrafirm trade

This section summarizes descriptive statistics for our affiliate-level data and documents observed patterns of intrafirm trade in the Japanese case. As we will show below, the skewed concentration of intrafirm trade in a limited portion of firms, which is also 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 intrafirm 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) of affiliates. Both exports to and imports from parent firms are limited. The median offshore affiliate does not export to its MNE parent at all and imports merely 1% of its inputs from its parent. 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 intrafirm trade

[9] We confirm the robustness of our main results by including a dummy variable for wholly-owned affiliates and its interaction term with other covariates. See Section 5.1.

as compared with their U.S. counterparts, the skewed concentration of intrafirm 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.[10] 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%.

== Table 1==

Figure 1 displays the distribution of affiliates by the share of intrafirm exports in sales and the share of intrafirm 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, intrafirm trade skewing 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). By applying PPML in Section 4, we will remedy the econometric problem associated with this high percentage of affiliates with zero intrafirm trade in our regressions.

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10 In support of this finding, Alfaro et al. (2019) report that integrated production stages are sparse in their worldwide establishment-level data.

== Figure 1 ==

Table 2 breaks down the intrafirm trade shares into sectors and FDI destination regions. Intrafirm 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-sectoral variability is less prevalent in the shares of intrafirm imports. Intrafirm exports to Japanese parents are particularly active from affiliates located in East Asia, while intrafirm import shares are not discernibly different across all regions. These facts indicate that Japanese MNE parents and their often vertically integrated affiliates in East Asia are involved in dense networks of intrafirm trade as compared with affiliates in advanced countries, which are often established by horizontal FDI.[11]

== Table 2 ==

4. Empirical Framework

The previous section confirms that intrafirm trade is observed only in a limited fraction of overseas affiliates. This section explores the determinants of intrafirm trade.[12] As the distinction of intrafirm trade from arm's-length trade fundamentally hinges on the issue of firm boundaries, we focus on the possible effects of

[11] Previous studies have confirmed that FDI in Asia is strongly characterized by vertical FDI. For instance, Fukao et al. (2003) find a significant vertical intra-industry trade in East Asia associated with FDI from Japan. Hanson et al. (2005) report active intrafirm trade with affiliates in East Asia in the case of U.S. multinationals. Petri (2012) emphasizes the difference of intra-Asia FDI from other regions by referring to active FDI flows between countries with different technology levels.

[12] While Ramondo et al. (2016) find that vertical input–output linkages cannot explain intrafirm trade, they suggest no alternative explanation for this unexpected result. Milliou and Sandonis (2019) present a theoretical explanation for this empirical observation.

incomplete contracts or contractibility.[13]

The extent of contract completeness is likely to be factored into the MNE's decision to undertake intrafirm trade as firms choose intrafirm trade over arm's-length trade when contracts are seriously 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, 2003 on international trade). This line of theoretical argument leads us to examine the relationship between intrafirm trade and the completeness of contracts.

This paper measures the completeness of contracts using the contractibility index as proposed by previous studies. Among various measures, we use those proposed by Nunn (2007) and Levchenko (2007), which have been frequently used.[14] We use the sector's continuous measure as well as the binary dummy, which is defined based on the sector's classification (contract-intensive industry or other industry) that depends on whether the sector's index exceeds the median.

Of the two measures, Nunn's index tries to "identify which inputs require relation-specific investments" (Nunn, 2007, p. 575). He classifies products based on Rauch (1999): whether the product is sold on an organized exchange and whether it is reference priced in trade publications. If the product falls

[13] Blanas and Seric (2018) also examine the impact of contracting on intrafirm trade, but vertical linkage is outside of the scope of their analysis.

[14] Blanas and Seric (2018) adopt the sector's Nunn-type index and link 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 the Nunn-type index to analyze intrafirm trade of French firms with microdata disaggregated to firm–product–country though without data on affiliates. Boehm and Oberfield (2020) also use basically the same classification in their study of input sourcing by Indian plants.

into one of these two categories, the market for the product should be thick. This limits the possibility for hold-up. However, when firms depend more on differentiated inputs that are neither traded in organized exchanges nor under reference prices, intrafirm trade may be a preferable option to avoid the hold-up problem due to incomplete contracts. With the value share of inputs in the industry's total inputs as the weight, Nunn's contract intensity measure is defined as the weighted average of the proportion of inputs that are neither sold on an organized exchange nor reference priced. This paper uses the Nunn-type measure constructed and provided by Antràs (2016), which subtracts the Nunn's original index from value one to make our contractibility index high when firms can contract easily with independent suppliers in sourcing inputs in comparison with selling their own outputs

On the other hand, Levchenko (2007) focuses on cross-sectoral dispersion of inputs. Technological features of production processes in some industries prohibit firms from relying on spot markets for input procurement but require "establishing complex relationships between factors" (Levchenko, 2007, p. 791). Levchenko (2007) measures the extent of industry's institutional dependence with "the Herfindahl index of intermediate input use" (p. 809). While Levchenko (2017) multiplied the index by −1, our measure of Levchenko type index, which is provided by Antràs (2016), is the one without multiplication. If our contractibility index is low, firms in this industry need to produce their outputs from inputs sourced from wide range of industries and hence to establish relationships with diverse suppliers. We use this Levchenko-type index as firms may prefer intrafirm trade when they source many different inputs across sectoral boundaries to mitigate contractual frictions.

Before proceeding to the econometric analysis, we compare the share of intrafirm trade by industry-level contractibility and region (OECD, non-OECD, East Asia) in Table 3.[15] 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 industries with lower contractibility regardless of the definition of contractibility index. Looking at regional variation, the share of affiliates' export to their parents are high in non-OECD countries or East Asia, where MNEs may face serious contract frictions.

== Table 3 ==

To explore the impact of contractibility on intrafirm trade, we estimate the following equation:

$$X_{apsdt} = \exp\left(\alpha \log Emp_{at} + \beta \log DR_{sr} \times Cont_s + \gamma \log DR_{sr} + \kappa_s + \lambda_d + \pi_t + \theta_c\right) u_{apsdt} \qquad (1)$$

The dependent variable in Equation (1) is the share of intrafirm trade (X). Previous studies, including Ramondo et al. (2016), estimate this type of model after taking logarithms of both sides of the equation. The subscripts indicate the export from the affiliate a to the parent p in sector s, FDI destination d, and at year t. We also estimate the corresponding equation for imports of affiliates from their parents (X_{pa}). The intrafirm 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 (cost of goods sold). We include the affiliate's sector fixed effect κ_s,

[15] Hereafter, South Korea is excluded from East Asia because the country is a member of OECD with its relatively developed contracting environment. We have confirmed the robustness of our main findings, however, even if we include South Korea in East Asia. We also note that 94% of affiliates in non-OECD countries are located in East Asia in our samples.

the FDI destination country fixed effect λ_d, the year fixed effect π_t, and the MNE corporate fixed effect θ_c. Sectors of affiliates and destination countries are indexed by s and d, respectively.[16] The size of an affiliate is controlled by the number of employees in logarithm (log*Emp*). We will additionally control for research and development (R&D) intensity of affiliates as a robustness check. The error term is expressed by u.

DR_{sr} indicates the input–output linkages, 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.[17] We take logarithm of DR, following the specification in Ramondo et al. (2016). An analogous equation is also estimated for imports 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 linkages).

To investigate the impact of contractual frictions, we introduce the contractibility index discussed above by *Cont* (Nunn-type or Levchenko-type). By adding the interactive term, we inspect whether the impact of input–output linkages is evident in industries with serious contractual frictions.[18] We estimate Equation (1) either with the continuous variable *Cont* itself or with the dichotomous dummy *D(Cont)* taking the value 1/0 if the contractibility of the sector is greater/smaller than the median of all sectors, respectively.

[16] Affiliate fixed effects are not included, because the affiliate-specific unique identification number is not available in the BSOBA.
[17] We use Japan's I-O Tables at the year 2011 (Ministry of Internal Affairs and Communications) to derive the direct requirement coefficients.
[18] Contractibility without interaction is captured by the sector fixed effect.

Previous studies estimate the Equation (1) by ordinary least squares after taking logarithms.[19] However, as the dependent variable often takes 0, they have to restrict the samples to affiliates with strictly positive intrafirm trade, which may lead to biased estimates. To address this problem, we estimate the Equation (1) without taking logarithms by PPML, which is a remedy for heteroskedasticity and has become popular for a wide range of applications, including estimations of the gravity model in international trade.[20] The non-linear estimation enables us to cover all affiliates even without any intrafirm trade.

5. Estimation Results

This section reports our main estimation results and discusses their implications. Table 4 shows the PPML estimation results with contractibility and input–output linkages variables.[21] Columns (I) to (IV) present the estimation results with the continuous measure of contractibility (*Cont*) while those with the dichotomous index of contractibility (*D*(*Cont*)) are shown in Columns (V) to (VIII). The contractibility index in the odd-numbered columns is Nunn-type while the Levchenko-type index is used in the columns with even numbers. Although the relationship with imports of affiliates are often weak in our sample, the interactive terms both for the continuous and dichotomous index of contractibility, log*DR*Cont* and

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19 Previous studies, including Ramondo et al. (2016), analyze the binary intrafirm trade decision of all affiliates in addition to trade shares of affiliates with positive trade. While they estimate two equations separately, our PPML integrates all affiliates into a single regression. Some of them, such as Corcos et al. (2013), consider selectivity by Heckman's procedure in estimating the two equations.

20 Silva and Tenreyrou (2006) is the pioneering paper for applying PPML to estimate the gravity equation in international trade. Tobit is another estimation method for samples including zero observations but imposes a strong assumption of normality, which is obviously violated in our sample of skewed distribution. Heckman's two-step estimation procedure is another option for handling zero observations, but the assumption of independence of two disturbance terms is unlikely to be met in our case.

21 Basic statistics of variables used for the regressions are presented in Appendix Table A2.

log*DR*D(Cont)*, respectively, are significantly negatively related to intrafirm trade for affiliates' exports to parents. These results imply that the input–output linkages appear to be related to the intrafirm trade share in sectors with lower contractibility.[22] We also note that input–output linkages log*DR* without interaction is significant in some of the cases, especially in affiliates' exports to parents, but our PPML result is not directly comparable with previous studies dependent on log-linear specification. All these results are generally robust regardless of the definition of contractibility (Nunn-type or Levchenko-type).[23]

The significant relationship with contract intensity appears to be often detected in the exports from overseas affiliates to parents in Japan rather than in the imports of affiliates from their parents. Cross-regional and cross-sectoral variations of affiliates' exports, rather than of imports, in the Japanese case reported in Table 2 might be behind this finding. While we cannot exactly determine the underlying reasons for the asymmetry within our limited dataset, MNE parents' exports to their affiliates, namely affiliates' import from parents, include headquarters services, which cannot be easily replaced by inputs sourced outside the MNE boundaries. In contrast, affiliates export more to their MNE parents if the affiliates' exports are inputs for producing the parents' outputs and if contractibility is lower. In relation to this finding,

[22] As contractual frictions are likely to be more serious in transactions of services than of goods, intrafirm trade should be more active in trade in services. Although the BSOBA does not distinguish goods and services in intrafirm trade, a related observation in line with this conjecture is found from a different survey. Overseas affiliates of Japanese MNEs tend to import technologies almost exclusively from their parents in Japan. Cross-border trade in services is limited, as some types of services are non-tradable. See Appendix B.

[23] As a robustness check, we include parent firm characteristics, such as the parent's employment, parent's R&D–sales ratio and logged capital–labor ratio (log(KL)), which are derived from the Basic Survey of Japanese Business Structure and Activities prepared by METI. Although we lost around 6,000 observations in the process of matching these two datasets. Results are presented in Appendix Table A3, and we confirmed that our major findings remain unchanged..

Co (2010) detects a significant difference between intrafirm versus inter-firm trade in exports from abroad to the U.S., and not in exports from the U.S., though she focuses on country-level variables.

== Table 4 ==

As the intrafirm trade of Japanese MNEs is geographically concentrated in East Asia, we estimate the same equation separately for each region. Table 5 presents the regression results for affiliates' exports to and imports from parents in Panels (A) and (B), respectively. Significant relationships with intrafirm trade, especially exports from affiliates to parents, are more clearly found for affiliates located in non-OECD countries or East Asia. The insignificance for OECD countries is in line with our prior expectations, as it is unlikely that MNEs face serious contractual frictions in these developed countries. From U.S. data, Co (2010) also finds that the difference between intrafirm and inter-firm trade tends to be weak for the OECD sample. Hence, our results suggest that vertical intrafirm trade appears to be affected by the weak contracting environment in developing countries, especially East Asia in the case of Japanese MNEs.[24] As affiliates of Japanese MNEs are heavily concentrated in East Asia, the impact of contractual frictions on Japanese intrafirm trade should not be negligible.

== Table 5 ==

To examine the effect of the weak contracting environment, we split our sample according to the

[24] We have checked whether this contrast between East Asia versus OECD is driven by the geographic proximity to parents in Japan by including the interaction term of log geographical distance (obtained from CEPII gravity database) with the input-coefficient. The results are presented in Appendix A4, and we confirmed that the interaction term is not significant and including it does not affect our main results.

level of the rule of law index, which is obtained from the World Wide Governance Indicators. This measure has been frequently used in previous studies and constructed based on a weighted average of various indicators of the effectiveness and predictability of the courts in each country. We average the annual index over 2009–2016 and divide our sample according on whether the measure is greater/smaller than the median of all countries.[25] Table 6 presents the estimation results. Similar to Table 5, we found a significant relationship between the share of exports to parents and the input–output linkages in countries with inferior judicial quality.

== Table 6 ==

Although it is hard to pin down the exact mechanism that determines intrafirm 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. As the extent of contractual frictions is likely to vary widely across countries, 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 linkages between affiliates and parents on intrafirm trade. Our PPML estimation incorporating a large number of affiliates with no intrafirm trade complements the previous results by discovering that input–

[25] Among East Asian countries, China, Indonesia, Philippines, Vietnam, Cambodia, Laos, and Myanmar are categorized as countries with low "Rule of Law." Affiliates in these countries account for 93% of affiliates in countries with below median "Rule of Law."

output linkages are positively related to intrafirm trade particularly in contract-intensive sectors in developing countries.

6. Robustness Checks

6.1. Wholly-owned affiliates

We have examined majority-owned affiliates, but wholly-owned affiliates may differ in various dimensions including intrafirm trade. For example, sharing of intangible assets and knowledge transfers tend to be easier in wholly-owned affiliates than in joint ventures (Mansfield and Romeo, 1980; Desai et al., 2004). Table 7 reports the results including a dummy variable for affiliates with 100% ownership (WO) and the interaction term with other covariates. Wholly owned dummies have a positive and significant coefficient in all specifications, implying ownership structure systematically correlates with intrafirm trade. However, the coefficients of its interaction term with other covariates are all insignificant. This result is consistent with Desai et al. (2004) as they confirm that intrafirm trade tends to be active not only in wholly owned but also in majority-owned affiliates compared with minority owned affiliates. We hence conclude that the inclusion of a dummy variable for wholly-owned affiliates does not affect our main findings.

== Table 7 ==

6.2. Heterogeneity of affiliates in East Asia

While we have focused on East Asia among FDI destinations, this subsection reports another robustness check related with East Asia. While affiliates in East Asia with different levels of wages and technologies are often involved in vertical production fragmentations, they may differ in technological intensities of their products. For example, if their products do not embody technological knowledge or know-how, MNEs do not have to rely on intrafirm trade and can easily procure their intermediate goods from local suppliers. To examine this issue, we add the affiliate's R&D–sales ratio to our baseline regressions because R&D-intensive affiliates tend to produce products that embody technological knowledge or know-how, and MNEs have incentives to trade these products within firm boundaries. Although we have controlled for affiliates' size in terms of employment, the additional control of this affiliate-specific attribute will also alleviate a potential omitted-variable bias.

Table 8 reports the PPML results with the R&D variables. While R&D intensity interacted with input–output linkage is not significant, the coefficient of R&D without interaction turns out to be positive and significant for exports from affiliates to parents. This finding is robust irrespective of the definition of contractibility index (Nunn or Levchenko, continuous or dichotomous). The statistical significance for affiliates' exports, not parents' exports, is in line with our previous finding on the contractibility interacted with input–output linkage in the baseline case.

== Table 8 ==

7. Concluding Remarks

This paper has examined how vertical linkages between overseas affiliates and their parents are related to intrafirm trade by considering the variations in contractibility across sectors in the case of Japanese MNEs based on affiliate-level data. We integrate a large number of affiliates with no intrafirm trade into our regressions by estimating the model by PPML. Our estimations show that vertical linkages are positively related to intrafirm trade shares especially in sectors with low contractibility, 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 tend to export a high share of outputs to their parents within MNEs particularly in contract-intensive industries. In other words, our result is consistent with the interpretation that input–output linkages have a significant impact on intrafirm trade especially if contractual frictions are serious. Affiliates and parents in vertically linked sectors tend to trade inputs actively within firm boundaries to alleviate contracting problems although we cannot strictly exclude alternative explanations within our dataset. Our result is in line with the findings of previous studies by Corcos et al. (2013), Blanas and Seric (2018), Boehm (2020), and Boehm and Oberfield (2020) in which contracting has a significant impact on intrafirm trade in contract-intensive sectors and in countries with weak contract enforcement. Our result is also in line with Ramondo et al.'s (2016) finding that only a limited share of affiliates are involved in intrafirm trade.

While our Japanese microdata study reveals the importance of vertical linkage in intrafirm 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 intrafirm trade data derived from the 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. As contractual frictions are critical for theoretical investigations of firm boundaries and the organization of global production, and as well as for policy discussions of development strategies, more in-depth studies of their impacts on intrafirm trade should be conducted in the future.

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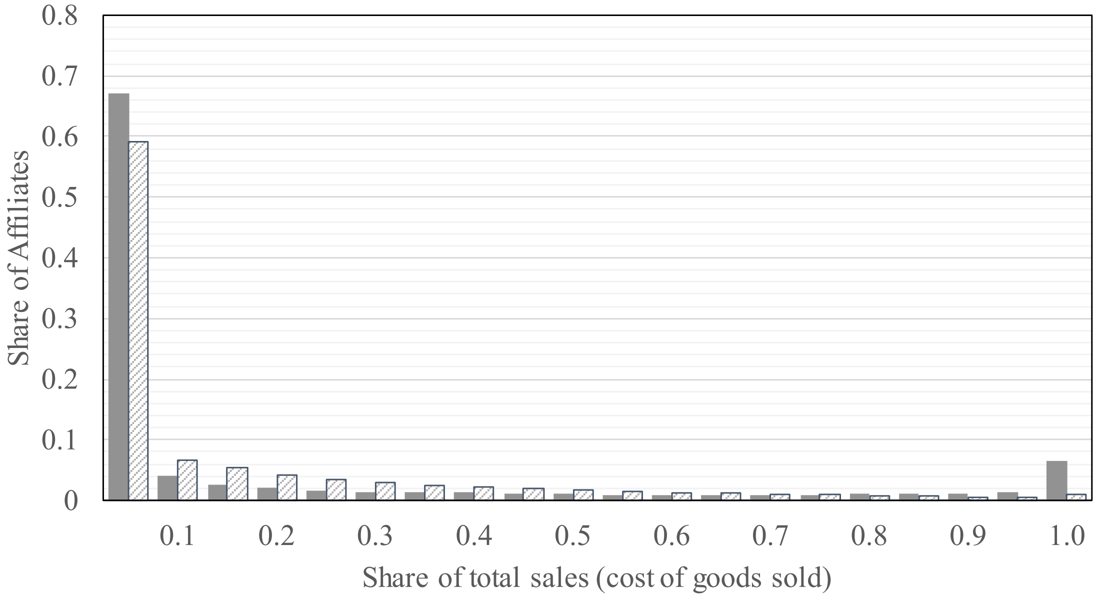
Fig. 1 The distribution of affiliates by the share of intrafirm exports in sales and the share of intrafirm imports in cost of goods sold



Source: Authors' calculation based on Basic Survey on Overseas Business Activities by the Ministry of Economy, Trade and Industry

Table 1. Intrafirm trade, summary

	Mean	St. Dev	p50	p75	p95
Share in affiliate sales					
Share of local sales	52.0%	42.4%	58.8%	98.4%	100.0%
Share of local sales to other Japanese firms	22.7%	36.4%	0.0%	39.0%	100.0%
Share of exports to Japan	20.0%	33.1%	0.3%	26.5%	99.9%
Share of exports to parents	17.5%	31.4%	0.0%	18.0%	98.6%
Share in affiliate cost of goods sold (COGS)					
Share of local procurement	32.3%	32.3%	24.9%	58.9%	92.3%
Share of local procurement from other Japanese firms	8.5%	19.3%	0.0%	3.2%	56.4%
Share of imports from Japan	16.5%	24.3%	3.1%	25.3%	72.6%
Share of imports from parents	14.1%	23.0%	1.0%	19.7%	68.3%

Source: Authors' calculation based on Basic Survey on Overseas Business Activities (BSOBA).

Table 2. Share of intrafirm trade by industry and region

	Share of exports to parents in total sales	Share of imports from parents in cost of goods sold (COGS)
Industry		
Food	21.1%	4.6%
Textile	35.3%	10.0%
Chemicals	8.9%	14.7%
Glass and stone	18.7%	16.8%
Metal	16.6%	16.4%
Metal products	19.4%	13.0%
Machinery	20.0%	16.5%
Electronics	26.4%	15.1%
Electrical equipme	21.3%	16.1%
Transportation	7.6%	13.8%
Other	20.7%	12.7%
East Asia	22.1%	14.3%
North America	4.4%	14.8%
EU	4.8%	13.1%
Other	5.8%	11.8%
Total	17.5%	14.1%

Source: Authors' calculation based on BSOBA.

Note: North America includes the U.S., 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 intrafirm trade disaggregated by regions and sectors

	Industry-level contractibility			
	Nunn-type		Levchenko-type	
	Low	High	Low	High
Share of exports to parents in total sales				
Total	18.4%	15.0%	17.2%	16.9%
OECD	5.9%	4.8%	4.6%	7.1%
non-OECD	22.8%	17.9%	21.5%	19.9%
East Asia	24.3%	18.5%	22.7%	20.9%
Share of imports from parents in cost of goods sold (COGS)				
Total	13.3%	11.6%	13.7%	10.9%
OECD	12.8%	11.5%	13.0%	11.1%
non-OECD	13.4%	11.7%	13.9%	10.9%
East Asia	13.6%	11.8%	13.9%	11.2%

Source: Authors' calculation based on the BSOBA.

Table 4. I-O links, intrafirm trade, and contractibility

1) Continuous measure of contractibility (Cont)

	Exports to parents			Imports from parents	
	(I)	(II)		(III)	(IV)
	Nunn-type	Levchenko -type		Nunn-type	Levchenko -type
logDRsr	0.0990**	0.0833**	*logDRrs*	0.0125	0.0706*
	(0.0504)	(0.0401)		(0.0522)	(0.0384)
*logDRsr*Cont*	-0.182**	-0.577**	*logDRrs*Cont*	0.0568	-0.267
	(0.0838)	(0.230)		(0.100)	(0.309)
Observations	41,825	41,825	Observations	38,844	38,844
Pseudo-R2	0.280	0.280	Pseudo-R2	0.160	0.160

2) Dichotomous measure of contractibility D(Cont)

	(V)	(VI)		(VII)	(VIII)
logDRsr	0.0378	0.0430*	*logDRsr*	0.0344	0.0605***
	(0.0267)	(0.0253)		(0.0275)	(0.0217)
*logDRsr*D(Cont)*	-0.0579*	-0.0659**	*logDRsr*D(Cont)*	0.00994	-0.0510
	(0.0303)	(0.0295)		(0.0353)	(0.0358)
Observations	41,825	41,825	Observations	38,844	38,844
Pseudo-R2	0.280	0.280	Pseudo-R2	0.160	0.160

Note: The dependent variable is intrafirm trade share. 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, respectively.

Table 5. Variations across regions

Panel (A) Exports to parents

1) Continuous measure of contractibility (Cont)

	(I)	(II)	(III)	(IV)	(V)	(VI)
	Nunn-type			Levchenko-type		
Regions	*OECD*	*non-OECD*	*East Asia*	*OECD*	*non-OECD*	*East Asia*
logDRsr	0.308*	0.109***	0.111***	0.165	0.0785**	0.0796*
	(0.170)	(0.0395)	(0.0420)	(0.177)	(0.0378)	(0.0406)
*logDRsr*Cont*	-0.343	-0.206***	-0.210***	-0.235	-0.553**	-0.560**
	(0.264)	(0.0635)	(0.0661)	(1.161)	(0.221)	(0.233)
Observations	9,007	31,588	29,860	9,007	31,588	29,860
Pseudo-R2	0.371	0.259	0.247	0.371	0.259	0.247

2) Dichotomous measure of contractibility D(Cont)

	(VII)	(VIII)	(IX)	(X)	(XI)	(XII)
logDRsr	0.0872	0.0366	0.0369	0.0734	0.0327	0.0324
	(0.0992)	(0.0240)	(0.0254)	(0.104)	(0.0234)	(0.0248)
*logDRsr*D(Cont)*	0.0945	-0.0588**	-0.0598**	0.122	-0.0489*	-0.0484*
	(0.121)	(0.0270)	(0.0278)	(0.110)	(0.0265)	(0.0273)
Observations	9,007	31,588	29,860	9,007	31,588	29,860
Pseudo-R2	0.371	0.259	0.247	0.371	0.259	0.247

Panel (B) Imports from parents

1) Continuous measure of contractibility (Cont)

	(I)	(II)	(III)	(IV)	(V)	(VI)
	Nunn-type			Levchenko-type		
Regions	*OECD*	*non-OECD*	*East Asia*	*OECD*	*non-OECD*	*East Asia*
logDRrs	-0.111	0.0229	0.0254	0.0995	0.0464	0.0441
	(0.126)	(0.0599)	(0.0598)	(0.0937)	(0.0436)	(0.0435)
*logDRrs*Cont*	0.282	0.0415	0.0431	-0.628	-0.0331	0.0157
	(0.227)	(0.126)	(0.125)	(0.685)	(0.371)	(0.369)
Observations	8,851	29,212	27,536	8,851	29,212	27,536
Pseudo-R2	0.195	0.165	0.166	0.195	0.165	0.166

2) Dichotomous measure of contractibility D(Cont)

	(VII)	(VIII)	(IX)	(X)	(XI)	(XII)
logDRrs	-0.105	0.0483*	0.0510**	0.0231	0.0485**	0.0499**
	(0.0681)	(0.0253)	(0.0253)	(0.0522)	(0.0238)	(0.0238)
*logDRrs*D(Cont)*	0.202***	-0.0112	-0.00987	0.0103	-0.0149	-0.0101
	(0.0746)	(0.0362)	(0.0361)	(0.0735)	(0.0382)	(0.0382)
Observations	8,851	29,212	27,536	8,851	29,212	27,536
Pseudo-R2	0.195	0.165	0.166	0.195	0.165	0.166

Note: See notes for Table 4.

Table 6. Variations across countries with different levels of rule of law

Panel (A) Exports to parents

1) Continuous measure of contractibility (Cont)

	(I)	(II)	(III)	(IV)
	Nunn-type		Levchenko-type	
Rule of Law	*High*	*Low*	*High*	*Low*
logDRsr	-0.0285	0.182***	0.0229	0.109**
	(0.0777)	(0.0565)	(0.0755)	(0.0469)
*logDRsr*Cont*	0.0608	-0.333***	-0.176	-0.763***
	(0.143)	(0.0885)	(0.486)	(0.277)
Observations	18,956	21,371	18,956	21,371
Pseudo-R2	0.321	0.257	0.321	0.257

2) Dichotomous measure of contractibility D(Cont)

	(VII)	(VIII)	(IX)	(X)
logDRsr	-0.00410	0.0520*	0.00703	0.0455
	(0.0454)	(0.0312)	(0.0489)	(0.0285)
*logDRsr*D(Cont)*	0.00964	-0.0702**	-0.0135	-0.0635**
	(0.0608)	(0.0328)	(0.0722)	(0.0315)
Observations	18,956	21,371	18,956	21,371
Pseudo-R2	0.321	0.257	0.321	0.257

Panel (B) Imports from parents

1) Continuous measure of contractibility (Cont)

	(I)	(II)	(III)	(IV)
	Nunn-type		Levchenko-type	
Rule of Law	*High*	*Low*	*High*	*Low*
logDRrs	0.0315	0.0228	0.134**	0.00916
	(0.0870)	(0.0681)	(0.0670)	(0.0496)
*logDRrs*Cont*	0.0733	0.0110	-0.554	0.173
	(0.149)	(0.147)	(0.491)	(0.453)
Observations	18,393	19,286	18,393	19,286
Pseudo-R2	0.177	0.167	0.177	0.167

2) Dichotomous measure of contractibility D(Cont)

	(VII)	(VIII)	(IX)	(X)
logDRrs	0.0662	0.0376	0.112***	0.0260
	(0.0555)	(0.0303)	(0.0374)	(0.0265)
*logDRrs*D(Cont)*	0.00233	-0.0199	-0.110*	0.00505
	(0.0615)	(0.0441)	(0.0606)	(0.0476)
Observations	18,393	19,286	18,393	19,286
Pseudo-R2	0.177	0.167	0.177	0.167

Note: See notes for Table 4.

Table 7. Separating wholly-owned affiliates

1) Continuous measure of contractibility (Cont)

	Exports to parents			Imports from parents	
	(I)	(II)		(III)	(IV)
	Nunn-type	Levchenko -type		Nunn-type	Levchenko -type
logDRsr	0.114**	0.0752*	*logDRrs*	-0.0168	0.0389
	(0.0482)	(0.0416)		(0.0587)	(0.0452)
*logDRsr*Cont*	-0.250***	-0.643**	*logDRrs*Cont*	0.125	0.0240
	(0.0915)	(0.289)		(0.114)	(0.373)
WO	0.335***	0.346***	*WO*	0.234***	0.238***
	(0.0805)	(0.0817)		(0.0589)	(0.0592)
*logDRsr*WO*	-0.0250	0.00615	*logDRrs*WO*	0.0274	0.0338
	(0.0356)	(0.0380)		(0.0340)	(0.0290)
*logDRsr*Cont*WO*	0.0950	0.109	*logDRrs*Cont*WO*	-0.0681	-0.310
	(0.0625)	(0.243)		(0.0681)	(0.229)
Observations	41,825	41,825	Observations	41,825	41,825
Pseudo-R2	0.281	0.281	Pseudo-R2	0.281	0.281

2) Dichotomous measure of contractibility D(Cont)

	(V)	(VI)		(VII)	(VIII)
logDRsr	0.0323	0.0293	*logDRrs*	0.0302	0.0549**
	(0.0246)	(0.0257)		(0.0320)	(0.0263)
*logDRsr*D(Cont)*	-0.0818***	-0.0714**	*logDRrs*D(Cont)*	0.0154	-0.0430
	(0.0313)	(0.0316)		(0.0386)	(0.0416)
WO	0.339***	0.351***	*WO*	0.235***	0.239***
	(0.0814)	(0.0842)		(0.0594)	(0.0596)
*logDRsr*WO*	0.00427	0.0176	*logDRrs*WO*	0.00139	0.00461
	(0.0236)	(0.0276)		(0.0201)	(0.0194)
*logDRsr*D(Cont)*WO*	0.0345	0.00552	*logDRrs*D(Cont)*WO*	-0.00294	-0.00741
	(0.0247)	(0.0271)		(0.0251)	(0.0249)
Observations	38,844	38,844	Observations	38,844	38,844
Pseudo-R2	0.161	0.161	Pseudo-R2	0.161	0.161

Note: See notes for Table 4.

Table 8. Controlling for affiliates' R&D–sales ratio

1) Continuous measure of contractibility (Cont)					
	Exports to parents			Imports from parents	
	(I)	(II)		(III)	(IV)
	Nunn-type	Levchenko -type		Nunn-type	Levchenko -type
logDRsr	0.109***	0.0819**	*logDRrs*	0.0432	0.0560
	(0.0423)	(0.0404)		(0.0596)	(0.0437)
*logDRsr*Cont*	-0.207***	-0.577**	*logDRrs*Cont*	0.0216	-0.0227
	(0.0670)	(0.233)		(0.124)	(0.363)
R&D	1.168**	0.907	*R&D*	-2.355	-2.208
	(0.488)	(0.564)		(1.475)	(1.426)
*logDRsr*R&D*	0.166	0.114**	*logDRrs*R&D*	0.617	0.844
	(0.299)	(0.0574)		(0.745)	(0.823)
*logDRsr*Cont*R&D*	-0.330	-1.514	*logDRrs*Cont*R&D*	-0.754	-4.431
	(0.870)	(1.245)		(1.285)	(4.179)
Observations	29,115	29,115	Observations	26,890	26,890
Pseudo-R2	0.247	0.247	Pseudo-R2	0.168	0.168
2) Dichotomous measure of contractibility D(Cont)					
	(V)	(VI)		(VII)	(VIII)
logDRsr	0.0364	0.0328	*logDRrs*	0.0608**	0.0599**
	(0.0252)	(0.0250)		(0.0255)	(0.0240)
*logDRsr*D(Cont)*	-0.0589**	-0.0498*	*logDRrs*D(Cont)*	-0.0143	-0.0165
	(0.0277)	(0.0279)		(0.0362)	(0.0381)
R&D	1.127**	1.051**	*R&D*	-2.369	-2.413
	(0.462)	(0.531)		(1.486)	(1.526)
*logDRsr*R&D*	0.0573	0.0520	*logDRrs*R&D*	0.361	0.303
	(0.0696)	(0.0747)		(0.625)	(0.713)
*logDRsr*D(Cont)*R&D*	-0.0856	-0.0556	*logDRrs*D(Cont)*R&D*	-0.208	-0.0135
	(0.229)	(0.0744)		(0.655)	(0.627)
Observations	29,115	29,115	Observations	26,890	26,890
Pseudo-R2	0.247	0.247	Pseudo-R2	0.168	0.168

Note: See notes for Table 4.

Appendix Table A1 Intrafirm trade intensity by region and year

	Share of exports to parents in total sales					Share of imports from parents in cost 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 Survey of Overseas Business Activities (Ministry of Economy, Trade, and Industry)

North America includes USA, Canada and Mexico. East Asia includes South Korea, China, Taiwan, Hong Kong, ASEAN countries.

Appendix Table A2. Descriptive Statistics

		Mean	SD	Correlation matrix [1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
[1]	*Xap*	0.213	0.336	1.000												
[2]	*Xpa*	0.144	0.228	0.055	1.000											
[3]	*logDRsr*	-2.948	2.253	-0.057	0.029	1.000										
[4]	*logDRrs*	-2.726	1.977	-0.070	0.059	0.578	1.000									
[5]	$logDRsr*Cont_{Nunn}$	-1.307	1.409	-0.014	0.031	0.864	0.407	1.000								
[6]	$logDRsr*Cont_{Levchenko}$	-0.352	0.414	-0.030	0.042	0.805	0.377	0.907	1.000							
[7]	$logDRrs*Cont_{Nunn}$	-1.181	1.104	-0.019	0.067	0.454	0.848	0.486	0.414	1.000						
[8]	$logDRrs*Cont_{Levchenko}$	-0.320	0.315	-0.047	0.092	0.449	0.813	0.417	0.443	0.891	1.000					
[9]	$logDRsr*D(Cont_{Nunn})$	-1.198	2.199	0.023	0.021	0.631	0.230	0.866	0.752	0.408	0.304	1.000				
[10]	$logDRsr*D(Cont_{Levchenko})$	-1.311	2.290	-0.014	0.042	0.672	0.313	0.749	0.851	0.333	0.418	0.664	1.000			
[11]	$logDRrs*D(Cont_{Nunn})$	-1.146	1.947	0.036	0.054	0.253	0.516	0.398	0.314	0.798	0.682	0.504	0.260	1.000		
[12]	$logDRrs*D(Cont_{Levchenko})$	-1.212	1.974	-0.008	0.086	0.344	0.528	0.311	0.391	0.612	0.813	0.238	0.526	0.528	1.000	
[13]	*R&D*	0.011	0.260	0.036	-0.017	-0.005	-0.004	0.001	0.000	0.003	0.003	0.011	-0.005	0.015	-0.005	1.000

Appendix Table A3. Including Parents' firm characteristics

1) Continuous measure of contractibility (Cont)

	Exports to parents			Imports from parents	
	(I)	(II)		(III)	(IV)
	Nunn-type	Levchenko type		Nunn-type	Levchenko -type
logDRsr	0.0898	0.0785*	*logDRrs*	0.0134	0.0764*
	(0.0592)	(0.0465)		(0.0553)	(0.0414)
*logDRsr*Cont*	-0.179*	-0.603**	*logDRrs*Cont*	0.0665	-0.265
	(0.0983)	(0.267)		(0.106)	(0.333)
$logEmp_{affiliate}$	0.0632***	0.0632***	$logEmp_{affiliate}$	0.0133	0.0131
	(0.0192)	(0.0191)		(0.0140)	(0.0140)
$logEmp_{parent}$	0.0571*	0.0574*	$logEmp_{parent}$	-0.00358	-0.00341
	(0.0346)	(0.0346)		(0.0461)	(0.0461)
Parent's R&D intensity	-0.0603	-0.0465	*Parent's R&D intensity*	-0.0917	-0.0907
	(0.382)	(0.383)		(0.251)	(0.251)
Parent's logK-L ratio	0.0473**	0.0473**	*Parent's logK-L ratio*	-0.00270	-0.00263
	(0.0202)	(0.0202)		(0.0219)	(0.0219)
Observations	36147	36147	Observations	36147	36147
Pseudo-R2	0.279	0.279	Pseudo-R2	0.157	0.157

2) Dichotomous measure of contractibility D(Cont)

	(V)	(VI)		(VII)	(VIII)
logDRsr	0.0322	0.0386	*logDRsr*	0.0438	0.0698***
	(0.0311)	(0.0294)		(0.0296)	(0.0236)
*logDRsr*D(Cont)*	-0.0618*	-0.0703**	*logDRsr*D(Cont)*	0.00310	-0.0588
	(0.0348)	(0.0333)		(0.0378)	(0.0392)
$logEmp_{affiliate}$	0.0636***	0.0636***	$logEmp_{affiliate}$	0.0133	0.0127
	(0.0192)	(0.0191)		(0.0140)	(0.0140)
$logEmp_{parent}$	0.0569*	0.0570*	$logEmp_{parent}$	-0.00349	-0.00353
	(0.0346)	(0.0346)		(0.0461)	(0.0460)
Parent's R&D intensity	-0.0590	-0.0474	*Parent's R&D intensity*	-0.0914	-0.0902
	(0.383)	(0.385)		(0.251)	(0.251)
Parent's logK-L ratio	0.0474**	0.0480**	*Parent's logK-L ratio*	-0.00262	-0.00275
	(0.0203)	(0.0203)		(0.0219)	(0.0219)
Observations	33453	33453	Observations	33453	33453
Pseudo-R2	0.279	0.279	Pseudo-R2	0.157	0.157

Note: See notes for Table 5.

Appendix Table A4. Including geographical distance

1) Continuous measure of contractibility (Cont)					
	Exports to parents			Imports from parents	
	(I)	(II)		(III)	(IV)
	Nunn-type	Levchenko -type		Nunn-type	Levchenko -type
logDRsr	-0.0763	-0.0925	*logDRsr*	0.0902	0.154
	(0.140)	(0.148)		(0.116)	(0.114)
*logDRsr*Cont*	-0.188**	-0.600**	*logDRsr*Cont*	0.0568	-0.274
	(0.0912)	(0.241)		(0.100)	(0.311)
*logDRsr*logDist*	0.0224	0.0224	*logDRsr*logDist*	-0.00941	-0.00994
	(0.0187)	(0.0182)		(0.0125)	(0.0126)
Observations	41,799	41,799	Observations	38,821	38,821
R-squared	0.280	0.280	R-squared	0.161	0.161
2) Dichotomous measure of contractibility D(Cont)					
	(V)	(VI)		(VII)	(VIII)
logDRsr	-0.132	-0.132	*logDRsr*	0.113	0.145
	(0.144)	(0.144)		(0.106)	(0.108)
*logDRsr*Cont*	-0.0590*	-0.0683**	*logDRsr*Cont*	0.0103	-0.0520
	(0.0316)	(0.0305)		(0.0353)	(0.0359)
*logDRsr*logDist*	0.0214	0.0221	*logDRsr*logDist*	-0.00959	-0.0102
	(0.0184)	(0.0178)		(0.0125)	(0.0126)
Observations	41,799	41,799	Observations	38,821	38,821
R-squared	0.280	0.280	R-squared	0.161	0.161

Note: See notes for Table 5.

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.[26] 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,

[26] 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 official 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.