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Trade Adjustments to Exchange Rate Changes by Japanese Manufacturing MNEs: Intra-firm and arm's length transactions[†]

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Abstract

This paper examines how Japanese manufacturing multinational enterprises (MNEs) adjust to exchange rate changes. Using the micro-data of Japanese manufacturing MNEs from 1994 to 2010, we find that exports tend to respond to exchange rate changes, in particular when wholly or majority-owned affiliates are dominant among their foreign affiliates and when intra-firm trade ratios are higher. Moreover, the responsiveness to exchange rate changes is higher for intra-firm exports than for total exports. The results suggest that Japanese manufacturing MNEs with greater foreign operations under their own corporate control would more fully absorb shocks of exchange rate movements by adjusting intra-firm transactions. We do not find such tendencies for imports, however. Our results also show that, among all manufacturing sectors, the exporting/importing responsiveness is lower in the electric machinery sectors and higher in the transport equipment sectors due to different types of international division of labor. Furthermore, our results show that the size of the firm does not matter in terms of the responsiveness for total exports, although it does for intra-firm exports only.

Keywords: Exchange rates, Trade elasticity, Multinational enterprises, Intra-firm trade, Production networks
JEL classification: F14, F23, F31, L23

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1. Introduction

The recent growth of globalizing corporate activities through various transaction channels has developed international networks of production and distribution within/among firms as an important phenomenon. International production networks in East Asia, for instance, involve not only dense relationships between headquarters of multinational enterprises (MNEs) and their foreign affiliates as well as among their foreign affiliates, that is, intra-firm transactions, but also a myriad of arm's length transactions with other MNEs and with indigenous firms.[1] For MNEs, issues on exchange rates can be among the most important risks.[2] As the emergence of such international production/distribution networks has been accompanied by increasingly active transactions of intermediate goods that cross national borders several times during the production, the relationship between exchange rate and trade flows/trade balances is not simple and is getting more complicated. Moreover, the cost of exchange rate movements may be more pronounced. In other words, it becomes more important to empirically analyze how MNEs adjust their trade in response to exchange rate movements.

A large volume of prior studies has examined the relationship between the volatility of exchange rates and trade; while many studies found that volatility of exchange decreases volume of trade between countries, evidence of this relationship is not conclusive.[3] Moreover, recent studies, particularly since the mid-2000s, tend to be more interested in the relationship

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[1] See, Kimura & Ando (2005), for example, for the two-dimensional fragmentation model, which is an extended conceptual framework of Jones and Kierzkowski (1990). Ando and Kimura (2005) demonstrate three features of international production/distribution networks, specifically in machinery industries in East Asia: their significance in each economy, their geographical extensiveness involving many countries at different income levels in the region, and their sophisticated intra-firm and arm's length transactions. For the fragmentation theory, see for example Jones and Kierkowzki (1990) and Arndt and Kierzkowski (2001).

[2] Kogut & Kulatilaka (1994), for example, provide the model using the "real options" concept, suggesting that firms' operations in multiple countries contribute to risk hedging against exchange rate fluctuations. They argue that, put simply, the more countries firms operate in, the more flexibly they can switch their operations across countries in response to exchange rate movements.

[3] Auboin and Ruta (2011) provide an excellent survey on the relationship between exchange rate and trade, distinguishing the early literature until the 2000s from the later literature since them, particularly since the mid 2000s. They discussed that despite progress in estimation techniques and datasets, the outcome of the empirical literature on the volatility of exchange rate and trade remains as inconclusive. In the context of production networks in East Asia, Hayakawa and Kimura (2009) conduct a gravity equation exercise and find that parts and components transactions in production networks are sensitive to exchange rate fluctuations.

between the levels of exchange rates and trade, but most of the literature investigated the impact of exchange rate changes on aggregate (sectoral) exports/imports as cross-country studies or country studies.[4] Not many studies have analyzed the relationship between exchange rates and trade at the firm level. In particular, there have been very few studies to investigate individual firms' export/import responses to exchange rate movements by incorporating heterogeneity of firms' characteristics; among few, Berman et al. (2012) provides an interesting theoretical and empirical study on heterogeneous reaction of exporters to real exchange rate movements, using French firm-level data with destination-specific export values and volumes. They analyzed how heterogeneous firms react differently to exchange rate movements in terms of prices, quantities, entry and exit and found that high-performance firms react to a depreciation by increasing significantly more their markup and by increasing less their export volume.[5] Amiti, et. al (2012) is another firm-level study on exchange rates and exports/imports, focusing on pass-through issues in line with incomplete pass-through of exchange rate shocks into international prices), using Belgian firm-product–level data. However, neither of these analyses take into account possible heterogeneity of adjustment costs for intra-firm and arm's length transactions by MNEs.[6]

Our study attempts to provide evidences on how international production networks influence individual firms' exporting/importing responsiveness to exchange rate movements. More specifically, this study examines export/import changes in response to exchange rate movements, using the micro-data of Japanese manufacturing MNEs from 1994 to 2010, incorporating heterogeneous controllability of intra-firm and arm's length trade by MNEs. Japanese manufacturing MNEs are one of important and active players in developing international production/distribution networks. In addition, our analysis is novel in the literature, in that it employs the micro-level longitudinal dataset for a 15-year window. This empirical setting enables us to trace changes over time in firm-level exports/imports, and to

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[4] As one of very recent interesting cross-country studies, Eichengreen and Gupta (2012) provide a cross-country analysis to investigate the relationship between the real exchange rate (changes in exchange rate) and export growth, with a particular interest in services sectors.

[5] See Li. et. al (2012) for the case of Chinese firms.

[6] Kiyota, et al., (2008) focus on the volatility of exchange rates and find that high exchange rate volatility facilitates firms to shift from inter-firm to intra-firm transactions. Moreover, several recent country studies address the effects of exchange rate appreciation on trade in the context of global supply chains, though they are not the firm-level analyses.

examine how a firm's characteristics influences those changes. Moreover, the context of Japan is ideal as it experienced significant exchange rate fluctuations during this time window (Figure 1). After investigating whether Japanese manufacturing MNEs increase (decrease) their exports/imports for a depreciation (appreciation) of Japanese Yen as a baseline analysis, the paper investigates firms' characteristics that would influence their responsiveness to exchange rate movements, focusing on the controllability of intra-firm and arm's length transactions by MNEs in international production/distribution networks.

== Figure 1 ==

The rest of this paper is organized as follows: the next section provides the data description of micro-data employed in this study and briefly summarizes patterns and characteristics of Japanese firms' foreign direct investment (FDI) activities. Section 3 explains the model specification and estimation methods, and Section 4 presents the results. Section 5 concludes the paper.

2. Japanese manufacturing FDI at the firm level: overview

2.1 Data description

Our analysis employs *The Basic Survey of Business Structure and Activity,* i.e., the firm-level statistics compiled by the Ministry of Economy, Trade, and Industry (METI), Government of Japan (the former name was the Ministry of International Trade and Industry (MITI)). METI first conducted the survey in 1991, and has conducted it annually since 1994. This database provides detailed information on (parent) firms located in Japan as well as on their foreign affiliates with no less than 20 percent Japanese ownership.

The samples in the survey cover firms with more than 50 workers, capital of more than 30 million yen, and establishments in mining, manufacturing, wholesale/retail trade, and restaurants. As for trade activities, which are our particular interest, the database includes not only numerical information of total exports/imports for each firm but also intra-firm exports/imports. Intra-firm exports/imports are available only for each firm's transaction with all over world: the data by country/region are not available. The database also includes the information of ownership structure of each foreign affiliate in three groups: wholly-owned, majority-owned, and 20-50 percent-owned. The database can identify the location of

foreign affiliates based on the regional basis, i.e. foreign countries as a whole, Asia, North America, and Europe.

2.2 Characteristics of Japanese manufacturing FDI and their intra-firm/arm's length transactions

This subsection provides an overall picture of Japanese FDI with an emphasis on manufacturing industries. Table 1 presents the number of 1) all sized firms and 2) small and medium enterprises (SMEs) with affiliates in East Asia/North America/Europe and the number of affiliates in these regions by industry of parent firms and by industry of affiliates.[7] In 2010, 65 percent of the Japanese MNEs that have at least one affiliate abroad are manufacturing MNEs, and their affiliates abroad consist of about 70 percent of the total Japanese affiliates abroad. In addition, 90 percent of the Japanese manufacturing MNEs have at least one affiliate in East Asia, and 68 percent of the total Japanese manufacturing affiliates are located in East Asia.

== Table 1 ==

A parent firm often conducts multiple types of foreign operations simultaneously. Japanese manufacturing (parent) firms have 71 percent of their total affiliates in East Asia in the manufacturing sector. This means that Japanese manufacturing (parent) firms also have non-manufacturing affiliates in East Asia (29 percent of total affiliates of manufacturing firms), particularly in the wholesales sector (18 percent) to establish distribution networks by internalizing wholesale trade activities. The ratio of manufacturing parent – manufacturing affiliate is higher for SMEs; 81 percent of their affiliates in East Asia are manufacturing. Such investment patterns by SMEs reflect a typical strategy for firms involved in manufacturing activities aimed at supplying intermediate goods for other firms and/or for their own affiliates and forming a critical mass of industrial clusters in the manufacturing sector.

In North America and Europe, in contrast, the share of manufacturing affiliates of manufacturing parent firms is low. Also, the share of their non-manufacturing affiliates is as high as 54 percent for the case of North America and 57 percent for Europe. These figures indicate that Japanese manufacturing investment in North America or Europe aims at selling

[7] SMEs are defined as firms with less than 300 regular workers.

their products, or producing goods to be sold there, rather than at being involved in dense vertical production chains, as is observed in East Asia.

Table 2 shows the number of manufacturing MNEs by size of parent firms and by the number of foreign affiliates in 2010. Apparently, larger firms are likely to have the greater number of foreign affiliates. Tables 3 and 4 presents export/import ratios (to total sales/purchases), intra-firm trade ratios, and ratios of wholly or majority-owned affiliates to total foreign affiliates for manufacturing MNEs that have exports/imports. These variables tend to increase over the sample period as Table 3 clearly shows. In particular, import ratios sharply increase from around 10 percent in the middle of the 1990s to 20 percent in 2010. These data suggest a substantial expansion of globalizing activities by Japanese manufacturing during that period. They also suggest that Japanese firms' imports to total purchases have rapidly increased with the development of international production networks. These ratios vary across sectors; in particular, ratios in machinery sectors tend to be larger (Table 4). Even among machinery sectors, however, export and import ratios are high in electric machinery sectors with lower intra-firm export ratios, while trade ratios are lower in transport equipment sectors than other machinery sectors but intra-firm trade ratios are high for both exports and imports.[89]

== Table 2 ==

== Table 3 ==

== Table 4 ==

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[8] Ando and Kimura (2010) verify for Japanese manufacturing firms that intra-firm transactions tend to be in long distance while arm's length transactions are prone to be in short distance in general. Because this paper deals with exports and imports of Japanese parents, transactions are basically in middle to long distance.

[9] Local transactions (both sales an purchases) by Japanese affiliates abroad also show different patterns between electric machinery sector and transport equipment sector (Table A.1 in the Appendix). Both sectors demonstrate active transactions with indigenous firms, but firms with other nationalities are much more active for electric machinery sector than other machinery sectors including transport equipment sector, particularly in Asia. It suggests the production "networks" with sophisticated combination of arm's length and intra-firm transactions, including arm's length transactions not only with Japanese firms but also with non-Japanese firms, particularly in Asia.

3. Empirical method and data

This section quantitatively analyzes the exporting/importing responsiveness of Japanese manufacturing MNEs to exchange rate changes. Our baseline concern is whether exports and imports at the firm level respond to exchange rate changes in the direction predicted by the intuition based on macroeconomic theory. Further, more importantly, the analysis investigates which types of firms more strongly respond to the changes, depending on the firms' characteristics reflecting their degree of corporate control over their foreign operations.

The equations for our annual panel data analyses in the period 1994-2009 are as follows:

$$d\ln Trade_{t,i} = \beta_0 + \beta_1 \ln RER_t + \beta_2 d\ln RER_t + \beta_3 \ln Trade_{t,i} + \beta_4 \ln SIZE_{t,i} + \beta_5 \ln KLratio_{t,i} + \beta_6 R\&Dratio_{t,i} + \beta_7 Fcapital + \varepsilon \quad \text{(I)},$$

$$d\ln Trade_{t,i} = \beta_0 + \beta_1 \ln RER_t + \beta_2 d\ln RER_t + \beta_3 d\ln RER_t \cdot D + \beta_4 \ln Trade_{t,i} + \beta_5 \ln SIZE_{t,i} + \beta_6 \ln KLratio_{t,i} + \beta_7 R\&Dratio_{t,i} + \beta_8 Fcapital + \varepsilon \quad \text{(II)},$$

where $Trade_{t,i}$ expresses trade activities of firm i in year t, and $d\ln Trade_{t,i}$ is the percent change. This study employs the following four types of variables for trade activities (*Trade*): i) exports ($EX_{t,i}$), ii) imports ($IM_{t,i}$), iii) intra-firm exports ($\text{int}raEX_{t,i}$), or iv) intra-firm imports ($\text{int}raIM_{t,i}$). Thus, dependent variable is a percent change in one of these trade activities from the year t to the year $t+1$, and the same variable in year t is included on the right-hand side in order to control the level of trade at the beginning.

$d\ln RER_t$ is a percent change in Japanese real effective exchange rates from the year t to the year $t+1$; a positive figure means an appreciation of Japanese yen and a negative figure its depreciation during the year.[10] Since several key pieces of information such as the

[10] In general, export and import orders are placed several months in advance. In other words, it would be better to consider some time lag for the adjustment of trade to exchange rate changes. In our dataset, around half of the firms report their activities including trade from April to March, around 10 percent those from January to December, and the rest those from

number of foreign affiliates, exports/imports, and intra-firm exports/imports cannot be identified by the counterpart country, as explained in section 2, this analysis employs exports (intra-firm exports) to, or imports (intra-firm exports) from, the world for each firm. Thus, Japanese real effective exchange rates are employed. A percent change in exchange rates is included as an independent variable to investigate how firms adjust their exports/imports in response to the exchange rate change. Note that the level of Japanese real effective exchange rates ($\ln RER_t$) is also included in order to control the level of currency value at the beginning. The macro economic theory in general predicts that a firm reduces exports when the Japanese Yen is appreciated. Thus, if a firm reduces exports more significantly when the Japanese Yen is appreciated more, the coefficient for $d\ln RER_t$ is expected to be negative. On the other hand, the coefficient on the import side would be positive in general.

Equation (II), in addition to a variable for exchange rate changes, involves interaction terms of exchange rate changes with binary variables representing firms' characteristics ($D_{t,i}$). This equation investigates whether responsiveness of exports/imports differ among firms, depending on the degree of corporate control over their foreign operations within the firm. First, this study examines the size of the parent firm (SIZE). The firm size might capture the degree of the firms' capability to conduct extensive foreign operations. In general, large firms tend to hold a greater number of foreign affiliates than do SMEs, which holds for Japanese manufacturing MNEs. Kogut & Kulatilaka (1994) suggest that the greater number of foreign affiliates enable firms to switch operations across country, and thus to more effectively mitigate the risk of exchange rate volatility. Furthermore, large firms often have richer financial resources than SMEs, which might help their flexible operation effectiveness.

Second, this study examines the ratio of wholly or majority-owned affiliates in each parent firm's total foreign affiliates (MOFA). The higher ownership structure confers more fully control rights on investing firms (e.g., voting rights on the board). A firm can enjo stronger operation controls over its foreign affiliate when it is a wholly owned-affiliate or majority-owned joint venture. When firms need trade adjustments to exchange rate movements, therefore, the higher degree of controllability, reflected in the ratio of wholly or

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different months. Therefore, we basically use an average of monthly exchange rate from January to December as an annual exchange rate. For the robustness check, we also use an average of monthly exchange rate from October to September. See, for instance, Auboin and Ruta (2011) for discussion and literature review on the trade balance and the J-curve debate.

majority-owned affiliates, would help them to more easily adjust intra-firm transactions and/or to switch their operations across countries.

Finally, intra-firm trade ratio (intra-firm exports share in total exports and intra-firm imports share in total imports) (INTRA) for each parent firm is included. In many cases, transactions within a firm are more controllable than are arm's length transactions. The classical notion by Coase (1937), for example, suggests that arm's length transactions often entail greater costs of contracting or transacting. If transactions are internalized within firms, they can reduce such costs, and thus more smoothly adjust their operations, responding to environment movements. Moreover, in the framework of two-dimensional fragmentation, Kimura & Ando (2005) propose that service link costs on the axis of disintegration (or controllability) are larger for arm's length transactions than for intra-firm transactions. This is because firms partially lose controllability, which incurs larger transaction costs. Consequently, firms with higher ratios of intra-firm trade would more likely enjoy smooth transaction-adjustments under exchange rate movements.

Considering that the relationship between trade adjustments and the size/ratios may not be simply linear, and that a correlation between some interaction terms, particularly the one with MOFA, and exchange rate changes is high, we create binary variables used for interaction terms as follows: as for the size of firms (SIZE), the benchmark is SMEs with fewer than 300 regular workers (SIZE0). Large firms are classified into three groups: firms with 300 to 499 regular workers (SIZE1), those with 500 to 999 workers (SIZE2), and those with 1000 or more workers (SIZE3). Three dummy variables for SIZE1, SIZE2, and SIZE3 are constructed for the groups of large firms. As for ratios of wholly or majority-owned foreign affiliates (MOFA)/ intra-firm trade ratios (INTRA), firms are categorized into five groups: firms with ratio less than 0.2 (MOFA0/INTRA0), firms with ratio from 0.2 to less than 04 (MOFA1/INTRA1), those with ratio from 0.4 to less than 0.6 (MOFA2/INTRA2), those with ratio from 0.6 to less than 0.8 (MOFA3/INTRA3), and those with ratio equal to 0.8 or more (MOFA4/INTRA4). Four dummy variables for MOFA1/INTRA1, MOFA2/INTRA2, MOFA3/INTRA3, and MOFA4/INTRA4 are constructed against the benchmark group of MOFA0/INTRA0. As we expect the size/ratios to strengthen parents firms' controllability of their operation in foreign affiliates, all interaction terms are expected to have the *negative* signs (as the lowest degree group of each size/ratio is the benchmark group (=0)). Furthermore, it is expected that, among interactions, groups with larger

size/ratio will have larger and negative coefficients, if the relationship between trade responsiveness and the size/ratios is close to linear.

Other independent variables are included as control variables for each parent firm and for the year t: the size of the firm in terms of its number of regular workers (natural log) ($SIZE_{t,i}$), capital-labor ratio in terms of tangible assets per regular workers (natural log) ($KLratio_{t,i}$), in-house research and development (R&D) expenditures ratio (in total sales) ($R\&D_{t,i}ratio$), and foreign capital ratio ($Fcapital_{t,i}$); these are all for domestic (parent) firms.[11] Capital-labor ratio and R&D activities are proxy variables of firm-specific assets. Foreign capital ratio is included to control the different behavior of firms with foreign capital if any.

Our panel dataset comprises the data from 1994 to 2009, using the data from 1994 to 2010, which are the latest and most comprehensively available years for us. The dataset is unbalanced because some manufacturing parent firms entered and exited from the export/import market during the peropd. All the data regarding Japanese manufacturing MNEs' activities are obtained from *The Basic Survey of Business Structure and Activity*. Japanese real effective exchange rates are from the Bank of Japan (2013).

All regression analyses employ the fixed effect estimation.[12][13] In addition, our analysis employs not only the full sample with all manufacturing parent firms but the sub-sample with parent firms in electric machinery/transport equipment sectors only. In general, the production in electric machinery sectors is more fragmented with active cross-border transactions involving many countries, and some firms even apply the dollar settlement. On the other hand, the production in transport equipment sectors would involve a fewer countries, and the large portion of production tends to be conducted in the countries to sell their products. In that sense, exchange rate change may affect trade more significantly for transport equipment sectors and less significantly for electric machinery sectors.

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[11] See Table A.2 for summary statistics.

[12] To decide which model should be chosen, F test, Hausman test, and Breusch and Pagan test are examined. According to the results of these tests, the paper show the results based on the fixed effect estimation.

[13] Equation (I) (and (II)) can be rewritten as the following equation:

$$\ln Trade_{t+1,i} = \beta_0 + \beta_1 \ln RER_t + \beta_2 d\ln RER_t + \beta_3 \ln Trade_{t,i} + \beta_4 \ln SIZE_{t,i} + \beta_5 \ln KLratio_{t,i} + \beta_6 R\&Dratio_{t,i} + \beta_7 Fcapital + \varepsilon .$$

As the robustness check, the fixed effect model and system GMM are applied to this equation. However, the major findings discussed in section 4 do not change.

4. Empirical results

This section presents results of the analysis examining whether Japanese manufacturing MNE adjust exports /imports respond to changes in exchange rates and which types of firms makes adjustments more strongly. Table 5 reports results for exports, focusing on Japanese manufacturing MNEs with positive exports in both year t and year $t+1$. Several interesting insights emerge from the results for exchanges rate changes and their interaction terms. First of all, changes in exchange rates are negatively associated with changes in exports with statistical significance.[14] It suggests that Japanese manufacturing MNEs tend to decrease (increase) their exports in response to the appreciation (depreciation) of Japanese Yen over foreign currencies, and a decline in exports is greater as the appreciation of Japanese yen is larger, even after controlling the initial level of currency value. These results are consistent with the general prediction of macroeconomic theory

== Table 5 ==

More interestingly, the degree of export responsiveness to exchange rate changes depends on some firm-level characteristics. Equations (2) - (4) show the results of estimation including interaction terms of exchange rate changes with three firm-level characteristics, that is, the size of firm (SIZE) in equation (2), the ratio of wholly-owned and majority-owned affiliates in total foreign affiliates (MOFA) in equation (3), and intra-firm trade ratio (INTRA) in equation (4). On the other hand, equations (5) - (7) show the results of estimation including interaction terms of exchange rate changes with binary variables of these three firm-level characteristics. As for SIZE, all the interaction terms with exchange rate changes in equation (2) and (5) are insignificant. It suggests that the size of firm at home does not matter in terms of the degree of export adjustments to exchange rate changes.

Regarding the controllability of foreign operations in terms of MOFA, the interaction term in equation (3) and interaction terms for the group of MOFA4 (firms with ratios of 0.8

[14] The coefficients for exchange rates and their interaction terms are mostly larger in absolute terms in these results with annual average of exchange rates from January to December than the results with annual average of exchange rates from October to September (See Tables A.3 and A.4 for the results with the latter exchange rates). It implies that annual average of exchanges rates from January is more appropriate in investing the trade responsiveness to exchange rate changes.

or more) and MOFA3 (0.6 to less than 0.8) in equation (6) have negative coefficients with statistical significance. It indicates that firms with high shares of wholly or majority-owned affiliates in total foreign affiliates are more likely to adjust their exports. As for another variable representing controllability of foreign operations, INTRA, the interaction term in equation (4) and interaction terms for two groups in equation (7), INTRA1 and INTRA4 have negative and significant coefficients. In particular, the absolute term of coefficient is much larger for the group of INTRA4 (firms with ratios from 0.8 or more). This implies that firms with higher ratios of intra-firm trade are likely to adjust their exports to a larger extent when the exchange rate changes. These results regarding the controllability of foreign operations suggest that Japanese manufacturing MNEs with greater foreign operations under their own corporate control, would more fully absorb shocks of exchange rate changes by adjusting intra-firm transactions.[15]

As for control variables, the coefficients for the size of firm at home, capita-labor ratio, and foreign capital ratio are positive and statistically significant in all equations, while the coefficient for R&D_ratio is positive but statistically insignificant. These findings indicate that Japanese manufacturing MNEs with a larger employment size at home, more capital intensive manufacturing MNEs, and manufacturing MNEs with more foreign capital are likely to have lager growth rates of exports.[16]

Table 6, in turn, demonstrates the results for intra-firm exports, focusing on Japanese manufacturing MNEs with positive intra-firm exports in both year t and year $t+1$. The results are mostly similar to those for exports. However, two major distinctions emerge between exports and intra-firm exports. First, the coefficients for the level of exchange rates and changes in exchange rates are negative with statistical significance, and their absolute

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[15] While the large size and controllability of foreign operations in general help the firms' exporting adjustments to exchange rate movements, this relationship is not always linear. There might be various reasons; for instance, some firms might be less likely to respond to exchange rate changes for some strategic reasons even if they could do so. Also, firms may not need to respond to exchange rate changes sensitively when they have competitiveness and thus can pass-through exchange rate changes to export/import prices. Furthermore, dollar-based operations of some firms may induce lower responsiveness in the their own groups; dollar depreciation (on the other side of yen appreciation) encourages expanding operations for a whole group of the firm, resulting in an increase in exports of parts and components from Japan to their affiliates abroad.

[16] Since the correlation between exports and the size of firm in the same year is higher, equations without the size of firm are also conducted for the robustness check. Our major results for exchange rate changes do not change.

values are larger for intra-firm exports than those for total exports. It suggests that intra-exports tend to more strongly respond to the exchange rate changes than total exports do. Second, the interaction terms of the size of firm became statistically significant with positive values, while those for total exports are insignificant, indicating that the size of firm matters in terms of the responsiveness for intra-firm trade, but it does not for total exports.

== Table 6 ==

The results for imports and intra-firm imports are displayed in Tables 7 and 8, respectively. Surprisingly, the coefficient for changes in exchange rates is negative and statistically significant. Moreover, interaction terms with changes in exchange rates are statistically insignificant in all equations unlike the case of exports, except interaction term of the size of firm for the analysis of intra-firm imports with a positive and statistically significant coefficient. In general, the exchange rate appreciation facilitates firms' imports, and thus a positive sign is expected. One potential explanation for this counter-expecting result is that most Japanese manufacturing firms in our sample import raw materials and parts and components. It may sound reasonable that, under the Yen's appreciation, firms reduce their imports (raw materials) because they need to reduce exports that they utilized imported raw materials and parts and components to produce. Another reason would be the recession of Japanese economy, which results in the reduction of imports, regardless of exchange rate movements.

== Table 7 ==

== Table 8 ==

Tables 9 and 10 present the results for firms in electric machinery sectors only and firms in transport equipment sectors only to compare them with those for firms in all manufacturing sectors. Interestingly, the absolute value of coefficients for exchange rate changes and their interaction terms are larger for firms in transport equipment sectors and smaller for firms in electric machinery sectors than firms in all manufacturing sectors. As discussed above, in general, the production in electric machinery sectors is more fragmented with active cross-border transactions involving many countries several times, and dollar-

based operations largely occupy foreign operations of Japanese MNEs. On the other hand, the production in transport equipment sectors would involve a fewer countries, and the large portion of production tends to be conducted in the countries to sell their products. In that sense, trade may be adjusted to exchange rate changes more significantly in transport equipment sectors than the average and less significantly (or trade tends to be less sensitive to exchange rate) in electric machinery sectors.

== Table 9==

== Table 10 ==

5. Conclusion

This paper attempted to shed new light on trade adjustments to changes in exchange rate by Japanese manufacturing MNEs, particularly focusing on firms' characteristics such as the size of firm and its controllability over foreign operations. The emergence of international production/distribution networks in recent decades has been accompanied by increasingly active transactions of intermediate goods that cross national borders several times during the production. Therefore, the relationship between exchange rate and trade flows is not so simple any more.

Using the micro-data of Japanese manufacturing MNEs from 1994 to 2010, we found that exports tend to respond to exchange rate changes, in particular when wholly or majority-owned affiliates are dominant in their foreign affiliates and when their intra-firm trade ratio is higher. Moreover, the responsiveness to exchange rate changes is higher for intra-firm exports than total exports. The results suggest that Japanese manufacturing MNEs with greater foreign operations under their own corporate control would more fully absorb shocks of exchange rate movements by adjusting intra-firm transactions. We do not find such tendencies for imports, however. Our results also show the exporting/importing responsiveness is lower in electric machinery sectors and higher in transport equipment sectors than in all manufacturing sectors, suggesting different types of international division of labor. Furthermore, our results show that the size of firm does not matter in terms of the responsiveness for total exports, though it does for intra-firm trade.

We can draw profound policy implication from our investigation. First, firm size does not really matter for the ability of responding to changes in exchange rates. We

sometimes presume that small and medium enterprises (SMEs) are weak and perhaps fragile against exchange rate fluctuation. However, what matters in practice is not the size of firms but the extent of globalizing corporate activities. The more globalized corporate activities, the more capable of mitigating shocks from exchange rate movements. The government may need to watch possible effects of exchange rate fluctuation not on firms with full exposure to globalization but on those that do not globalize their activities extensively yet. Policies to increase in the exposure to globalization or expand facilities to hedge risks of exchange rate fluctuation could enhance resiliency against exchange rate changes. Second, once international production networks have developed, in a sense, arm's length transactions are more stable than intra-firm transactions when exchange rates fluctuate. Evolution of the 2nd unbundling from simplistic intra-firm cross-border production sharing to production "networks" with sophisticated combination of arm's length and intra-firm transactions may nurture a sort of shock absorber or built-in stabilizer when exchange rates fluctuate. Third, at the firm level, adjustments on the export side are not symmetric to those on the import side among Japanese manufacturing MNEs; rather, the former dominates the latter in responding to exchange rate changes. This mechanism may to some extent mitigate the impact of exchange rate fluctuations on trade balance.

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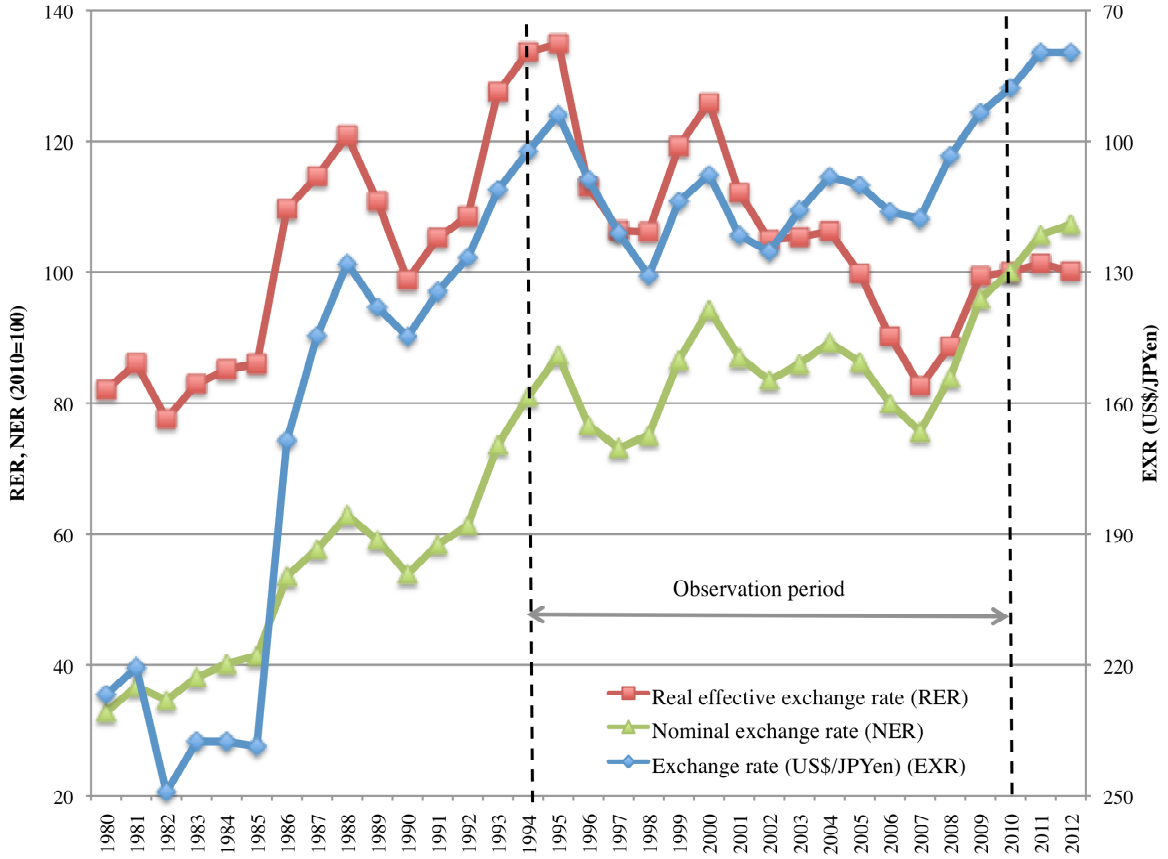
Figure 1 Japanese exchange rates



Data source: The Bank of Japan "BOJ Time-Series Data Search", available from http://www.stat-search.boj.or.jp/index.html.
Note: An upward change means an appreciation of Japanese exchange rate.

Table 1 Sectoral patterns of Japanese parent firms and their affiliates in All regions, East Asia, North America, and Europe for 2010

Industry of parent firm	Share by the industry of parernt firms		Share by the industry of affiliate				Share by the industry of parernt firms		Share by the industry of affiliate			
	Parent firms: all-sized	Affiliates	Affiliates				Parent firms: SMEs	Affiliates	Affiliates			
			Manufacturing	(machinery)	Non-manufacturing	(wholesales)			Manufacturing	(machinery)	Non-manufacturing	(wholesales)
	(a-1) All regions						(a-2) All regions					
Manufacutring	64%	69%	59%	(30%)	41%	(21%)	63%	58%	75%	(33%)	25%	(17%)
Non-manufacturing	36%	31%	21%	(6%)	79%	(38%)	37%	42%	23%	(5%)	77%	(49%)
Total	100%	100%	47%	(22%)	53%	(27%)	100%	100%	53%	(21%)	47%	(30%)
	(b-1) East Asia						(b-2) East Asia					
Manufacutring	65%	68%	71%	(36%)	29%	(18%)	64%	60%	81%	(35%)	19%	(13%)
Non-manufacturing	35%	32%	26%	(7%)	74%	(40%)	36%	40%	27%	(6%)	73%	(52%)
Total	100%	100%	57%	(27%)	43%	(25%)	100%	100%	60%	(23%)	40%	(29%)
	(c-1) North America						(c-2) North America					
Manufacutring	70%	71%	46%	(25%)	54%	(20%)	63%	61%	51%	(29%)	49%	(36%)
Non-manufacturing	30%	29%	14%	(5%)	86%	(36%)	38%	39%	9%	(4%)	91%	(48%)
Total	100%	100%	37%	(19%)	63%	(24%)	100%	100%	35%	(19%)	65%	(40%)
	(d-1) Europe						(d-2) Europe					
Manufacutring	72%	78%	43%	(20%)	57%	(32%)	61%	55%	37%	(19%)	63%	(41%)
Non-manufacturing	28%	22%	13%	(5%)	87%	(40%)	39%	45%	11%	(2%)	89%	(42%)
Total	100%	100%	36%	(16%)	64%	(33%)	100%	100%	25%	(11%)	75%	(42%)

Data source: authors' calculation, based on METI database.
Notes: The figures for (a-1, b-1, c-1, d-1) are those of all sized parent firms and figures for (a-2, b-2, c-2, d-2) are of parernt SMEs. The figures for "share" for manufacuring, machinery, non-manufacturing, and wholesales expresse the shares of manufacturing affiliates, machinery affiliates, non-manufacturing affiliates, and wholesales affiliates in total number of affiliates of all sized/SMEs firms in each sectoral category.

Table 2 The number of manufacturing parent firms by the size of parent firm and the number of foreign affiliates: 2010

	The number of foreign affiliates										
	1	2	3	4	5	6	7	8	9	10 or more	Total
SMEs	966	356	185	95	39	31	15	5	3	17	1712
(Share in total, %)	56%	21%	11%	6%	2%	2%	1%	0%	0%	1%	100%
Large firms with 300-499 workers	185	103	51	40	24	19	11	6	7	31	477
(Share in total, %)	39%	22%	11%	8%	5%	4%	2%	1%	1%	6%	100%
Large firms with 500-999 workers	121	81	71	41	35	23	31	19	17	50	489
(Share in total, %)	25%	17%	15%	8%	7%	5%	6%	4%	3%	10%	100%
Large firms with workers of 1000 or more	55	50	25	34	21	33	29	15	18	319	599
(Share in total, %)	9%	8%	4%	6%	4%	6%	5%	3%	3%	53%	100%

Data source: authors' calculation, based on METI database.

Table 3 Annual intra-firm trade ratio and wholly or majority-owned foreign affiliate ratio for manufacturing MNEs (average)

	Export ratio	Import ratio	Intra-firm export ratio	Intra-firm import ratio	Wholly/majority-owned ratio
1994	13.6%	13.9%	39.0%	45.3%	65.4%
1995	12.4%	10.3%	37.8%	46.5%	66.0%
1996	12.3%	11.5%	38.5%	49.7%	66.3%
1997	13.1%	12.5%	39.9%	49.5%	66.7%
1998	13.5%	12.1%	40.8%	50.0%	68.7%
1999	14.0%	12.2%	40.3%	50.8%	69.2%
2000	14.6%	13.6%	42.9%	51.1%	70.3%
2001	15.2%	14.4%	42.9%	52.5%	71.9%
2002	15.6%	15.2%	42.6%	51.9%	73.7%
2003	16.2%	14.8%	43.2%	52.2%	74.4%
2004	16.4%	16.1%	43.0%	50.8%	76.5%
2005	16.9%	17.4%	42.7%	50.6%	78.1%
2006	17.4%	17.7%	43.6%	52.3%	79.7%
2007	17.7%	18.0%	43.3%	52.7%	80.3%
2008	17.0%	17.9%	44.2%	53.9%	80.8%
2009	18.5%	21.2%	44.8%	54.7%	81.4%
2010	18.6%	20.1%	44.5%	53.8%	81.7%

Data source: authors' calculation, based on METI database.

Note: Export/import ratios and intra-firm ratios are for firms having exports/imports.

Table 4 By-industry intra-firm trade ratio and wholly or majority-owned foreign affiliate ratio for manufacturing MNEs: 2010 (average)

		Export ratio	Import ratio	Intra-firm export ratio	Intra-firm import ratio	Wholly/ majority-owned ratio
1	Food processing	2.5%	16.4%	46.6%	44.3%	71.1%
2	Beverages, tobacco, and animal feed	1.7%	8.6%	32.5%	29.1%	74.1%
3	Textiles and apparel	8.5%	30.1%	44.2%	45.9%	77.8%
4	Wood and wood products	2.9%	37.3%	42.8%	60.6%	82.4%
5	Furniture and fixtures	1.6%	24.4%	48.1%	61.3%	81.2%
6	Pulp, paper, and paper products	5.5%	8.7%	45.2%	47.0%	80.9%
7	Publishing and printing	11.0%	10.0%	50.5%	55.7%	86.6%
8	Chemicals	15.8%	16.8%	30.0%	37.3%	80.6%
9	Petroleum and coal products	14.1%	34.7%	25.7%	22.5%	71.6%
10	Plastic products	11.7%	13.3%	55.2%	57.9%	79.7%
11	Rubber products	13.5%	20.4%	56.5%	66.5%	80.4%
12	Leather and leather products	9.0%	63.2%	72.1%	47.7%	87.5%
13	Ceramics, clay, and stone products	19.5%	25.2%	29.6%	42.9%	74.3%
14	Iron and steel	11.5%	18.5%	33.7%	44.9%	71.3%
15	Nonferrous metal	16.5%	26.3%	48.9%	56.5%	83.1%
16	Metal products	9.9%	18.5%	45.9%	59.9%	83.4%
17	General machinery	26.1%	16.3%	36.3%	49.7%	84.8%
18	Electric machinery	25.1%	25.9%	47.3%	61.9%	86.3%
19	Transport equipment	16.4%	14.1%	60.8%	61.7%	79.1%
20	Precision machinery	29.0%	25.9%	43.8%	60.3%	87.1%
21	Other manufacturing	19.3%	28.0%	41.3%	51.1%	81.5%
	Manufacturing	18.6%	20.1%	44.5%	53.8%	81.7%

Data source: authors' calculation, based on METI database.

Note: Export/import ratios and intra-firm ratios are for firms having exports/imports.

Table 5 Results for manufacturing MNEs: export growth

Independent variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
RER^ (percent change)	-0.834 ***	-1.032 ***	-0.613 ***	-0.642 ***	-0.913 ***	-0.507 ***	-0.622 ***
	(0.055)	(0.246)	(0.126)	(0.078)	(0.083)	(0.149)	(0.081)
RER^・Firmsize		0.032					
		(0.038)					
RER^・MOFAratio			-0.287 *				
			(0.147)				
RER^・INTRAratio				-0.449 ***			
				(0.127)			
RER^・SIZE3					0.166		
					(0.124)		
RER^・SIZE2					0.171		
					(0.136)		
RER^・SIZE1					0.011		
					(0.147)		
RER^・MOFA4						-0.359 **	
						(0.159)	
RER^・MOFA3						-0.465 **	
						(0.205)	
RER^・MOFA2						-0.284	
						(0.216)	
RER^・MOFA1						-0.433	
						(0.313)	
RER^・INTRA4							-0.438 ***
							(0.124)
RER^・INTRA3							-0.257
							(0.168)
RER^・INTRA2							-0.261
							(0.169)
RER^・INTRA1							-0.372 **
							(0.165)
EX (log)	-0.480 ***	-0.480 ***	-0.480 ***	-0.480 ***	-0.480 ***	-0.480 ***	-0.480 ***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
RER (log)	-0.582 ***	-0.582 ***	-0.582 ***	-0.581 ***	-0.582 ***	-0.581 ***	-0.581 ***
	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)
Firmsize (log)	0.245 ***	0.245 ***	0.245 ***	0.245 ***	0.246 ***	0.245 ***	0.245 ***
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
KLratio (log)	0.072 ***	0.072 ***	0.071 ***	0.071 ***	0.072 ***	0.071 ***	0.071 ***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
R&Dratio	0.086	0.080	0.091	0.089	0.075	0.092	0.089
	(0.211)	(0.211)	(0.211)	(0.211)	(0.211)	(0.211)	(0.211)
Fcapital	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	4.415 ***	4.410 ***	4.410 ***	4.408 ***	4.406 ***	4.410 ***	4.409 ***
	(0.234)	(0.235)	(0.235)	(0.234)	(0.235)	(0.235)	(0.234)
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	27545	27545	27545	27545	27545	27545	27545

Data source: Authors' calculation, based on METI database.

Notes: figures in parenthesis are standard deviations. *** indicates that the results are statistically significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table 6 Results for manufacturing MNEs: intra-firm export growth

Independent variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
RER^ (percent change)	-0.952 ***	-1.632 ***	-0.550 ***	-0.485 ***	-1.054 ***	-0.457 *	-0.334 **
	(0.080)	(0.367)	(0.200)	(0.145)	(0.123)	(0.252)	(0.164)
RER^・Firmsize		0.109 *					
		(0.057)					
RER^・MOFAratio			-0.506 **				
			(0.231)				
RER^・INTRAratio				-0.802 ***			
				(0.208)			
RER^・SIZE3					0.298 *		
					(0.178)		
RER^・SIZE2					0.192 *		
					(0.189)		
RER^・SIZE1					-0.355 *		
					(0.214)		
RER^・MOFA4						-0.571 **	
						(0.264)	
RER^・MOFA3						-0.615 **	
						(0.319)	
RER^・MOFA2						-0.181	
						(0.335)	
RER^・MOFA1						-0.607	
						(0.454)	
RER^・INTRA4							-0.900 ***
							(0.199)
RER^・INTRA3							-0.567 **
							(0.242)
RER^・INTRA2							-0.672 ***
							(0.245)
RER^・INTRA1							-0.747 ***
							(0.235)
IntraEX (log)	-0.523 ***	-0.523 ***	-0.523 ***	-0.525 ***	-0.523 ***	-0.523 ***	-0.525 ***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
RER (log)	-0.605 ***	-0.604 ***	-0.603 ***	-0.604 ***	-0.603 ***	-0.602 ***	-0.605 ***
	(0.057)	(0.057)	(0.057)	(0.057)	(0.057)	(0.057)	(0.057)
Firmsize (log)	0.291 ***	0.292 ***	0.292 ***	0.293 ***	0.291 ***	0.291 ***	0.294 ***
	(0.035)	(0.068)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)
KLratio (log)	0.068 ***	0.068 ***	0.068 ***	0.067 ***	0.067 ***	0.068 ***	0.067 ***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
R&Dratio	-0.166	-0.181	-0.155	-0.174	-0.187	-0.155	-0.174
	(0.294)	(0.294)	(0.294)	(0.294)	(0.294)	(0.294)	(0.294)
Fcapital	0.003 ***	0.003 ***	0.003 ***	0.003 ***	0.003 ***	0.003 ***	0.003 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	4.151	4.137	4.140	4.150	4.141	4.138	4.147
	(0.348) ***	(0.348) ***	(0.348) ***	(0.348) ***	(0.348) ***	(0.348) ***	(0.348) ***
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	18667	18667	18667	18667	18667	18667	18667

Data source: Authors' calculation, based on METI database.

Notes: figures in parenthesis are standard deviations. *** indicates that the results are statistically significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table 7 Results for manufacturing MNEs: import growth

Independent variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
RER^ (percent change)	-1.183 ***	-1.328 ***	-0.989 ***	-1.117 ***	-1.139 ***	-1.150 ***	-1.103 ***
	(0.078)	(0.343)	(0.174)	(0.114)	(0.117)	(0.203)	(0.120)
RER^・Firmsize		0.023					
		(0.054)					
RER^・MOFAratio			-0.253				
			(0.204)				
RER^・INTRAratio				-0.128			
				(0.161)			
RER^・SIZE3					0.028		
					(0.174)		
RER^・SIZE2					-0.199		
					(0.190)		
RER^・SIZE1					-0.070		
					(0.204)		
RER^・MOFA4						-0.113	
						(0.217)	
RER^・MOFA3						0.013	
						(0.284)	
RER^・MOFA2						0.244	
						(0.300)	
RER^・MOFA1						0.487	
						(0.443)	
RER^・INTRA4							-0.094
							(0.157)
RER^・INTRA3							-0.341
							(0.267)
RER^・INTRA2							-0.345
							(0.280)
RER^・INTRA1							0.173
							(0.281)
IM (log)	-0.520 ***	-0.520 ***	-0.520 ***	-0.520 ***	-0.520 ***	-0.520 ***	-0.520 ***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
RER (log)	-0.899 ***	-0.898 ***	-0.898 ***	-0.898 ***	-0.899 ***	-0.898 ***	-0.898 ***
	(0.056)	(0.056)	(0.056)	(0.056)	(0.056)	(0.056)	(0.056)
Firmsize (log)	0.136 ***	0.136 ***	0.136 ***	0.135 ***	0.136 ***	0.136 ***	0.136 ***
	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
KLratio (log)	0.011	0.011	0.011	0.010	0.011	0.010	0.011
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
R&Dratio	-0.030	-0.034	-0.029	-0.032	-0.029	-0.033	-0.028
	(0.298)	(0.298)	(0.298)	(0.298)	(0.298)	(0.298)	(0.298)
Fcapital	0.004 ***	0.004 ***	0.004 ***	0.004 ***	0.004 ***	0.004 ***	0.004 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	6.519 ***	6.516 ***	6.511 ***	6.518 ***	6.516 ***	6.514 ***	6.513 ***
	(0.333)	(0.333)	(0.333)	(0.333)	(0.333)	(0.333)	(0.333)
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	22328	22328	22328	22328	22328	22328	22328

Data source: Authors' calculation, based on METI database.

Notes: figures in parenthesis are standard deviations. *** indicates that the results are statistically significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table 8 Results for manufacturing MNEs: intra-firm import growth

Independent variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
RER^ (percent change)	-1.325 ***	-2.154 ***	-1.155 ***	-1.500 ***	-1.478 ***	-1.065 ***	-1.715 ***
	(0.104)	(0.468)	(0.258)	(0.222)	(0.162)	(0.320)	(0.264)
RER^・Firmsize		0.132 *					
		(0.073)					
RER^・MOFAratio			-0.215				
			(0.299)				
RER^・INTRAratio				0.245			
				(0.274)			
RER^・SIZE3					0.473 **		
					(0.232)		
RER^・SIZE2					-0.145		
					(0.251)		
RER^・SIZE1					0.339		
					(0.278)		
RER^・MOFA4						-0.278	
						(0.335)	
RER^・MOFA3						-0.224	
						(0.407)	
RER^・MOFA2						-0.225	
						(0.431)	
RER^・MOFA1						-0.824	
						(0.611)	
RER^・INTRA4							0.440
							(0.287)
RER^・INTRA3							0.232
							(0.379)
RER^・INTRA2							0.250
							(0.387)
RER^・INTRA1							0.955 **
							(0.394)
IntraIM (log)	-0.516 ***	-0.517 ***	-0.516 ***	-0.516 ***	-0.517 ***	-0.516 ***	-0.516 ***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
RER (log)	-0.924 ***	-0.921 ***	-0.923 ***	-0.923 ***	-0.920 ***	-0.923 ***	-0.921 ***
	(0.076)	(0.076)	(0.076)	(0.076)	(0.076)	(0.076)	(0.076)
Firmsize (log)	0.046	0.047	0.044	0.046	0.047	0.047	0.047
	(0.044)	(0.044)	(0.046)	(0.044)	(0.044)	(0.044)	(0.044)
KLratio (log)	-0.022	-0.021	-0.021	-0.021	-0.022	-0.021	-0.020
	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)
R&Dratio	-0.524	-0.546	-0.521	-0.519	-0.542	-0.520	-0.517
	(0.412)	(0.413)	(0.412)	(0.413)	(0.413)	(0.413)	(0.412)
Fcapital	0.003 ***	0.003 ***	0.003 ***	0.003 ***	0.003 ***	0.003 ***	0.003 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	7.055 ***	7.035 ***	7.050 ***	7.045 ***	7.037 ***	7.045 ***	7.033 ***
	(0.452)	(0.452)	(0.452)	(0.453)	(0.452)	(0.453)	(0.453)
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	15033	15033	15033	15033	15033	15033	15033

Data source: Authors' calculation, based on METI database.

Notes: figures in parenthesis are standard deviations. *** indicates that the results are statistically significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table 9 Results for industry comparison: export growth and import growth

	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Independent variables	Manu	Elec	Trans	Manu	Elec	Trans	Manu	Elec	Trans	Manu	Elec	Trans
						Exports						
RER^ (percent change)	-0.834 ***	-0.519 ***	-1.078 ***	-1.032 ***	-0.452 ***	-1.082 *	-0.613 ***	-0.583 *	-1.108 ***	-0.642 ***	-0.317 *	-0.564 **
	(0.055)	(0.120)	(0.145)	(0.246)	(0.508)	(0.682)	(0.126)	(0.306)	(0.330)	(0.078)	(0.178)	(0.224)
RER^・Firmsize				0.032	-0.011	0.001						
				(0.038)	(0.078)	(0.099)						
RER^・MOFAratio							-0.287 *	0.078	0.040			
							(0.147)	(0.342)	(0.396)			
RER^・INTRAratio										-0.449 ***	-0.427	-0.948 ***
										(0.127)	(0.278)	(0.314)
RER (log)	-0.582 ***	-0.338 ***	-0.896 ***	-0.582 ***	-0.338 **	-0.896 ***	-0.582 ***	-0.338 ***	-0.897 ***	-0.581 ***	-0.335 **	-0.894 ***
	(0.039)	(0.084)	(0.109)	(0.039)	(0.084)	(0.109)	(0.039)	(0.084)	(0.109)	(0.039)	(0.084)	(0.109)
						Imports						
RER^ (percent change)	-1.183 ***	-1.021 ***	-1.438 ***	-1.328 ***	-0.468	-2.427 **	-0.989 ***	-0.830 *	-1.113 **	-1.117 ***	-1.093 ***	-0.976 ***
	(0.078)	(0.172)	(0.231)	(0.343)	(0.740)	(1.069)	(0.174)	(0.443)	(0.543)	(0.114)	(0.286)	(0.384)
RER^・Firmsize				0.023	-0.088	0.144						
				(0.054)	(0.114)	(0.152)						
RER^・MOFAratio							-0.253	-0.232	-0.436			
							(0.204)	(0.495)	(0.661)			
RER^・INTRAratio										-0.128	0.117	-0.946 *
										(0.161)	(0.373)	(0.551)
RER (log)	-0.899 ***	-0.906 ***	-1.225 ***	-0.898 ***	-0.907 ***	-1.221 ***	-0.898 ***	-0.905 ***	-1.223 ***	-0.898 ***	-0.907 ***	-1.246 ***
	(0.056)	(0.127)	(0.175)	(0.056)	(0.127)	(0.175)	(0.056)	(0.127)	(0.175)	(0.056)	(0.127)	(0.182)

Data source: Authors' calculation, based on METI database.
Notes: variables for exchange rate are shown, and others are omitted. Figures in parenthesis are standard deviations. *** indicates that the results are statistically significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table 10 Results for industry comparison: intra-firm exports and intra-firm imports

	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Independent variables	Manu	Elec	Trans	Manu	Elec	Trans	Manu	Elec	Trans	Manu	Elec	Trans
	Intra-firm exports											
RER^ (percent change)	-0.915 ***	-0.378 **	-1.266 ***	-1.657 ***	-1.034	-2.369 **	-0.471 **	0.323	-1.519 ***	-0.460 ***	-0.020	-0.368
	(0.055)	(0.172)	(0.185)	(0.361)	(0.772)	(0.921)	(0.195)	(0.484)	(0.452)	(0.141)	(0.326)	(0.404)
RER^・Firmsize				0.118 **	0.104	0.162						
				(0.056)	(0.120)	(0.133)						
RER^・MOFAratio							-0.562 *	-0.834 *	0.332			
							(0.226)	(0.538)	(0.540)			
RER^・INTRAratio										-0.786 ***	-0.595	-1.275 **
										(0.203)	(0.460)	(0.510)
RER (log)	-0.551 ***	-0.234 *	-0.941 ***	-0.551 ***	-0.233 *	-0.936 ***	-0.549 ***	-0.231 *	-0.945 ***	-0.551 ***	-0.231 **	-0.948 ***
	(0.056)	(0.123)	(0.142)	(0.056)	(0.123)	(0.142)	(0.056)	(0.123)	(0.142)	(0.056)	(0.123)	(0.142)
	Intra-firm imports											
RER^ (percent change)	-1.214 ***	-1.135 ***	-1.456 ***	-1.977 ***	0.225	-3.494 **	-0.995 ***	-1.680 ***	-1.449 *	-1.462 ***	-2.362 ***	-0.944 *
	(0.103)	(0.217)	(0.299)	(0.465)	(0.974)	(1.476)	(0.250)	(0.635)	(0.760)	(0.218)	(0.528)	(0.638)
RER^・Firmsize				0.121 *	-0.214	0.294						
				(0.072)	(0.149)	(0.209)						
RER^・MOFAratio							-0.278	0.644	-0.009			
							(0.291)	(0.707)	(0.923)			
RER^・INTRAratio										0.348	1.601 **	-0.699
										(0.270)	(0.629)	(0.769)
RER (log)	-0.799 ***	-0.893 ***	-1.009 ***	-0.797 ***	-0.897 ***	-0.997 ***	-0.798 ***	-0.892 ***	-1.009 ***	-0.798 ***	-0.895 ***	-1.006 ***
	(0.075)	(0.160)	(0.235)	(0.075)	(0.160)	(0.235)	(0.075)	(0.160)	(0.235)	(0.075)	(0.160)	(0.235)

Data source: Authors' calculation, based on METI database.

Notes: variables for exchange rate are shown, and others are omitted. Figures in parenthesis are standard deviations. *** indicates that the results are statistically significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table A.1 Transactions with Japan and at the local markets by Japanese affiliates abroad: shares of each firm group, 2010

industry	Sales to Japan: parent firms	Local sales: Japanese firms	Local sales: Indigenous firms	Local sales: firms with other nationalities	Purchaces from Japan: parent firms	Local purchases: Japanese firms	Local purchases: Indigenous firms	Local purchases: firms with other nationalities
All regions								
1	87.1	4.1	95.5	0.4	84.2	2.5	96.6	0.9
2	80.9	0.6	99.4	0.0	98.9	0.3	99.5	0.1
3	69.4	35.4	63.1	1.5	65.3	35.5	60.7	3.8
4	90.8	28.2	71.8	0.0	93.7	16.9	82.7	0.4
5	87.1	45.0	52.0	3.0	89.9	22.6	66.4	10.9
6	79.9	19.0	72.5	8.5	70.5	12.5	74.2	13.3
7	88.5	26.6	73.1	0.3	89.5	16.9	81.4	1.7
8	89.1	30.9	66.1	3.0	84.7	14.1	77.3	8.6
9	100.0	59.7	34.1	6.2	92.8	6.7	62.3	31.0
10	90.5	60.4	37.9	1.7	89.7	41.8	54.3	4.0
11	96.5	54.8	44.9	0.3	97.1	43.3	56.3	0.4
12	99.6	5.3	54.4	40.4	69.2	0.0	51.6	48.4
13	96.4	19.8	76.3	3.8	98.4	27.3	64.7	8.0
14	89.0	44.7	48.3	7.1	86.5	7.2	92.7	0.0
15	57.7	45.3	43.5	11.2	91.4	13.2	75.8	10.9
16	89.0	46.9	49.2	3.9	75.0	25.7	72.1	2.3
17	94.3	33.8	65.6	0.6	93.6	13.1	83.9	3.0
18	95.7	34.0	60.1	5.9	84.9	32.6	58.8	8.6
19	89.4	45.6	52.6	1.9	92.6	38.6	59.2	2.2
20	96.4	32.9	65.3	1.8	94.8	27.2	69.1	3.7
21	96.8	32.8	61.3	5.9	92.2	16.0	75.2	8.8
Asia								
1	84.8	1.1	98.4	0.4	71.4	4.2	95.0	0.7
2	60.7	0.3	99.7	0.0	98.3	0.0	99.8	0.2
3	72.5	47.4	50.3	2.3	58.9	45.6	50.8	3.6
4	95.1	2.6	97.4	0.0	92.7	0.3	98.1	1.6
5	87.1	45.0	52.0	3.0	89.9	22.6	66.4	10.9
6	91.5	44.1	43.4	12.5	71.6	13.1	86.3	0.6
7	78.6	37.2	62.3	0.5	81.4	23.9	73.6	2.5
8	83.0	32.2	64.8	3.0	78.4	16.2	74.2	9.7
9	100.0	62.9	32.1	4.9	100.0	8.0	52.1	39.9
10	90.6	65.8	32.2	2.0	87.8	48.2	49.9	1.9
11	96.6	76.0	24.0	0.0	96.2	63.2	36.2	0.6
12	99.8	6.9	40.5	52.6	69.2	0.0	51.6	48.4
13	96.4	22.4	73.5	4.1	98.6	17.1	75.9	6.9
14	83.3	50.6	42.2	7.3	86.5	7.0	92.9	0.0
15	45.8	49.1	44.9	6.0	91.3	16.0	83.0	1.0
16	89.0	47.4	48.6	4.0	72.9	27.3	70.8	1.9
17	94.5	41.5	57.5	1.0	91.5	17.9	77.9	4.2
18	95.7	49.6	43.4	7.0	81.6	33.6	57.4	9.0
19	90.4	38.6	59.3	2.1	88.6	30.3	67.4	2.3
20	96.5	66.5	32.5	1.0	93.5	29.3	66.9	3.8
21	96.8	58.7	31.4	9.9	90.7	14.0	73.3	12.7

(Continuc)

industry	Sales to Japan: parent firms	Local sales: Japanese firms	Local sales: Indigenous firms	Local sales: firms with other nationalities	Purchaces from Japan: parent firms	Local purchases: Japanese firms	Local purchases: Indigenous firms	Local purchases: firms with other nationalities
North America								
1	95.9	10.9	88.3	0.8	93.8	1.0	96.3	2.7
2	99.4	15.8	84.2	0.0	99.3	9.4	90.6	0.0
3	100.0	29.2	70.6	0.2	81.0	9.2	79.8	11.0
4	100.0	87.4	12.6	0.0	100.0	0.0	100.0	0.0
6	100.0	6.9	93.1	0.0	66.2	14.1	58.8	27.1
7	95.9	18.7	81.3	0.0	98.2	2.2	97.8	0.0
8	93.1	23.4	75.1	1.6	97.1	8.2	89.4	2.4
9	100.0	58.0	30.6	11.4	56.4	2.7	97.3	0.0
10	79.7	45.0	54.2	0.8	98.1	19.8	72.6	7.6
11	34.2	12.9	86.1	1.0	100.0	0.0	100.0	0.0
13	99.6	17.8	81.3	0.9	99.1	43.8	53.6	2.6
14	100.0	22.1	77.9	0.0	70.8	9.8	90.2	0.0
15	99.3	22.5	36.6	40.9	91.3	8.4	46.4	45.3
16	96.7	48.5	50.2	1.3	82.1	14.9	81.8	3.3
17	94.4	26.5	73.4	0.1	96.6	6.5	92.2	1.3
18	98.3	7.0	91.2	1.8	97.2	32.0	62.0	6.1
19	81.7	61.9	37.8	0.2	97.7	57.7	41.4	0.9
20	87.5	3.2	96.2	0.7	98.8	4.9	95.0	0.1
21	99.2	0.3	98.3	1.5	99.0	0.0	100.0	0.0
Europe								
2	82.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
3	18.8	0.0	100.0	0.0	77.6	0.0	98.9	1.1
4	94.6	28.6	71.4	0.0	100.0	0.0	100.0	0.0
7	86.2	0.6	99.4	0.0	82.5	1.0	99.0	0.0
8	98.8	27.1	59.7	13.3	97.0	4.1	84.6	11.3
9	100.0	94.3	5.7	0.0	77.3	0.0	100.0	0.0
10	68.4	30.2	69.8	0.0	99.6	8.9	63.2	27.9
11	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
13	100.0	0.3	46.3	53.4	85.9	0.0	50.5	49.5
15	67.6	49.1	50.9	0.0	96.4	1.7	98.3	0.0
16	29.2	43.0	57.0	0.0	85.9	17.5	82.5	0.0
17	83.2	6.1	93.9	0.0	96.8	0.4	99.6	0.0
18	99.0	37.6	59.3	3.1	79.8	22.9	69.9	7.2
19	94.2	52.9	42.6	4.5	94.1	50.2	45.2	4.6
20	97.4	10.5	84.5	5.0	99.0	0.0	93.9	6.1
21	90.5	4.8	95.2	0.0	99.3	66.9	33.1	0.0

Source: authors' calculation, based on METI database (Survey of Overseas Business Activities of Japaense Companies).

Notes: data for sales/purchases by firm groups are missing for some; firm groups for sales to Japan/purchases from Japan are parent firms and other Japanese firms, and those for local sales/purchases are Japanese firms, indigenous firms, and firms with other nationalities. Thus, the sum of data for these firm groups is less than the data for total sales to/purchases from Japan or local sales/purchases. The data for each firm group is aggregated at the industry level, and the ratios by the firm group are calculated as a share of the sum of data for these firm groups. See Table 4 for industry code.

Table A.2 Summary statistics for Japaense manufacturing MNEs

	Observations	Mean	Std. Dev.	Minimum	Maximum
Export growth	27547	0.05	0.71	-7.61	7.54
Import growth	22333	0.08	0.90	-9.42	8.30
EXR^	27547	-0.02	0.08	-0.18	0.12
SIZE (number of regular workers)	27547	1331	4034	50	80840
KL ratio (tangible assets per workers) (millions JPYen)	27547	13	14	0	269
R&D ratio (to total sales)	27547	0.025	0.039	0	3
foreign capital ratio	27547	3.9	11.8	0	100

Source: authors' calculation, based on METI database.

Table A.3 Robustness check for different exchange rates: export growth

Independent variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
RER^	-0.791 ***	-1.033 ***	-0.546 ***	-0.625 ***	-0.863 ***	-0.489 ***	-0.582 ***
	(0.051)	(0.226)	(0.118)	(0.071)	(0.076)	(0.140)	(0.074)
RER^・Firmsize		0.039					
		(0.035)					
RER^・MOFAratio			-0.314 **				
			(0.137)				
RER^・INTRAratio				-0.386 ***			
				(0.117)			
RER^・SIZE3					0.195 *		
					(0.114)		
RER^・SIZE2					0.145		
					(0.125)		
RER^・SIZE1					-0.035		
					(0.134)		
RER^・MOFA4						-0.348 **	
						(0.148)	
RER^・MOFA3						-0.376 *	
						(0.192)	
RER^・MOFA2						-0.212	
						(0.203)	
RER^・MOFA1						-0.344	
						(0.295)	
RER^・INTRA4							-0.387 ***
							(0.113)
RER^・INTRA3							-0.274 *
							(0.156)
RER^・INTRA2							-0.298 *
							(0.156)
RER^・INTRA1							-0.394 ***
							(0.152)
RER (log)	-0.475 ***	-0.475 ***	-0.474 ***	-0.474 ***	-0.475 ***	-0.474 ***	-0.474 ***
	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)

Data source: Authors' calculation, based on METI database.

Notes: annual average of exchange rates from October to September are used. Variables for exchange rate are shown, and others are omitted. Figures in parenthesis are standard deviations. *** indicates that the results are statistically significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table A.4 Robustness check for different exchange rates: import growth

Independent variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
RER^	-1.102 ***	-1.143 ***	-0.857 ***	-1.066 ***	-1.024 ***	-1.004 ***	-1.021 ***
	(0.071)	(0.314)	(0.163)	(0.105)	(0.106)	(0.191)	(0.111)
RER^・Firmsize		0.007					
		(0.049)					
RER^・MOFAratio			-0.316 *				
			(0.189)				
RER^・INTRAratio				-0.069			
				(0.148)			
RER^・SIZE3					-0.031		
					(0.160)		
RER^・SIZE2					-0.250		
					(0.174)		
RER^・SIZE1					-0.128		
					(0.187)		
RER^・MOFA4						-0.183	
						(0.203)	
RER^・MOFA3						-0.070	
						(0.266)	
RER^・MOFA2						0.196	
						(0.281)	
RER^・MOFA1						0.436	
						(0.416)	
RER^・INTRA4							-0.066
							(0.144)
RER^・INTRA3							-0.336
							(0.245)
RER^・INTRA2							-0.294
							(0.256)
RER^・INTRA1							-0.055
							(0.261)
RER (log)	-0.746 ***	-0.746 ***	-0.746 ***	-0.746 ***	-0.747 ***	-0.746 ***	-0.746 ***
	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)

Data source: Authors' calculation, based on METI database.

Notes: annual average of exchange rates from October to September are used. Variables for exchange rate are shown, and others are omitted. Figures in parenthesis are standard deviations. *** indicates that the results are statistically significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.