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FDI-Trade Nexus: New Evidence from Product-Level Data

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Abstract

The difficulty in finding the substitution effects on exports of foreign direct investment has posed challenges to empirical analysts. In analysing newly-constructed product-level data that enable endogeneity and aggregation bias to be addressed simultaneously, this study finds that auto part exports from Japan are positively correlated with overseas operations by Japanese automakers but negatively correlated with overseas operations by Japanese suppliers. However, the evidence on the latter is rather weak consistent with the fact that Japanese suppliers predominantly sell their products to Japanese automakers at the initial stage but that they are expanding their business with non-Japanese firms in host countries over time.

Keywords:

Foreign direct investments, trade, automobile, Japan

JEL Classification:

F14, F23

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1. INTRODUCTION

The difficulty in finding the substitution relationship between foreign direct investment (FDI) and exports has been a puzzle that remains unsettled in empirical research. Since the seminal work by Mundell (1957), the nexus between FDI and trade has been theoretically and empirically explored by a large number of economists. One stylized fact is that although the theoretical literature postulates the possibility of both substitution and complementarity between FDI and exports from the home country, depending on assumptions, empirical research has consistently found a complementary relationship at firm-, industry-, and country-levels across countries (Blomstrom et al 1988, Yamawaki 1991, Chedor et al 2002).

Previous research has addressed two statistical concerns. One has been possible endogeneity bias resulting from omitted variables that simultaneously determine FDI and exports. Previous studies attempt to reduce omitted variable bias by controlling for observable variables at the country-, industry- and firm-levels and by employing an estimation technique such as instrumental variable estimation. However, they have not found the substitution effect of FDI on exports.

The other statistical concern has been aggregation bias emanating from the nature of the conventional data such as firm-, industry- and country-level trade data. Given that firm-level data, for example, does not provide information on trade by products, it is difficult to identify a substitution effect to the extent that the firm is multiproduct [1](discussed in detail in Section 2). In order to address this issue, Blonigen (2001) analyses product-level data and finds overseas operations by Japanese automakers are positively correlated with auto parts exports from Japan but negatively associated with overseas operations by Japanese parts suppliers. Head et al (2004) find the similar evidence in the case of the US.

The objective of this study is to contribute to the literature by analysing a broader and more up-to-date product-level data on auto parts exports from Japan covering 79 products and 36 countries over the period 1993 to 2008. The advantage of this dataset allows both endogeneity and aggregation bias to be addressed simultaneously. The key focus of this study is to search for the substitution effects of overseas operations by Japanese parts suppliers on auto parts exports from Japan, controlling for the complementary effects emanating from overseas operations by Japanese automakers (vertical networks).

The findings of my empirical analyses are broadly consistent with those of Blonigen (2001). However, there are two notable differences. First, the degree of substitution between overseas operations by Japanese suppliers and auto parts exports from Japan is found to be much weaker. This is consistent with the fact that Japanese suppliers predominantly sell their products to Japanese automakers at the initial stage but that they are expanding their business with non-Japanese firms in host countries over time. Second the product-by-product analysis in this study points to the relevance of bulkiness in deterring the nature of procurement practices of Japanese overseas automakers. There is a tendency for domestic procurement of bulky components (such as engine, chassis, body and seats) while procuring high value-to-weight components from Japan. This implies that Japanese parts suppliers' overseas operations are largely confined to the production of the former types of components.

The relationship between FDI and exports has been an issue of policy interest in home countries of multinational enterprises (MNEs). It is widely held in policy circles in Japan and other home countries that the growing overseas activity of MNEs could replace exports from a home country thereby depriving the locals of job opportunities (Navaretti and Falzoni 2004). However, the empirical evidence of this study casts doubt on this pessimistic view. The expansion of overseas operations of MNEs could in fact strengthen trade relations between home and host countries.

While existing studies have addressed either endogeneity or aggregation bias, to the best of my knowledge, this study is the first attempt to address them simultaneously. The novelty of this study is that this has been done not only by constructing broader product-level panel datasets but also in some original ways. In order to minimise aggregation bias, this study examines the case of Toyota and its parts suppliers, enabling the matching of the level of data aggregation by identifying specific suppliers for *each* auto part. For the same purpose, this study undertakes product-by-product analyses following aggregated analyses.

The rest of this paper is structured as follows. Section 2 discusses endogeneity and aggregation bias relating to the empirical analyses of the nexus between FDI and exports in more detail. Section 3 presents the empirical model, data and measurement of variables and discusses the estimation methods. Section 4 reports the estimation results. Section 5 discusses the key results obtained in Section 4. Section 6 concludes.

2. FDI-TRADE NEXUS: EMPIRICAL ISSUES

One stylized fact is that although the theoretical literature postulates the possibility of both substitution and complementarity between FDI and exports from the home country, empirical research has consistently found a complementary relationship between these two variables (Table 1).[2] A positive relationship can be explained by at least two factors (Head and Ries 2004). First, the expansion of a firm's product in a given foreign market could lead to an increase in demand for the firm's other products. This is called "statistical complementarity". Second, investment abroad by a downstream firm (e.g. automaker) could create demand for parts and components, leading to an increase in export demand for upstream firms (e.g. parts suppliers) in a home country. This is called "economic complementarity".

-Table 1 here-

The difficulty in finding the substitution relationship between FDI and exports has been an empirical issue yet to be settled over the past decades. In order to address this issue, previous research has explored two statistical concerns. One has been possible endogeneity bias resulting from omitted variables that simultaneously determine FDI and exports. It might be argued that unobservable variables related to policy in a host country could be a cause of the complementarity between FDI and exports. For example, liberalisation policy favourable to trade and FDI in a host country might encourage home country's MNEs to increase both exports from the home country and the activities of their overseas affiliates in the same host country. The other concern is that firm- and industry-heterogeneity might cause the upward bias. Helpman et al (2004) suggest that firm-heterogeneity in terms of productivity and size matters as determinants of firms' exports and FDI: the more productive the firm, the more the firm exports and invests overseas.

Previous research attempts to reduce the omitted variable bias in two ways. The first is to control for observable variables at the country-, industry- and firm-levels. Many previous studies employ a gravity equation as an analytical framework (Table 1). This is because the gravity equation could capture observable country-specific factors such as trade costs, market size and income level. Within the gravity model, Lipsey and Weiss (1981) and Kim (2000) additionally put a dummy variable for membership in the EEC (European Economic Community) into the equation to control for the downward bias derived from a free-trade area. Yamawaki (1991) employs industry-level data and attempts to control for observable industry-specific variables such as the size of industry, and the industry's capital-intensity. Lipsey and Weiss (1984) employ firm-level data and control for the size of the parent firm. Chedor et al (2002) and Head and Ries (2001) attempt to control for a wider variety of time-varying firm characteristics such as size, capital intensity, productivity, and expenditure on R&D.

The second way to enable an escape from the endogeneity problem is to employ an estimation method such as instrumental variable (IV) estimation (Blomstrom et al 1988, Grubert and Mutti 1991, Clausing 2000). However, Head and Ries (2001) claim that IV approaches are not appropriate because of the difficulties in finding an instrument that is correlated with MNEs overseas activity, does not determine exports from the home country, and is excludable from the equation. The alternative method is to use a least squares dummy variables (LSDV) model, allowing controls for time-invariant unobservable factors among countries, industries and firms. However, previous studies have not found a substitution relationship between FDI and exports overall notwithstanding the efforts to reduce possible endogeneity bias.

The other statistical concern is aggregation bias emanating from the nature of the conventional data such as firm-, industry- and country-level trade data. Given that firm-level data, for example, does not provide information on trade by products, it is difficult to identify a substitution effect to the extent that the firm is multiproduct. For example, if a firm produces two products (A and B) and only product A is produced abroad, it would be possible that overseas production of product A increases demand for product B due to statistical complementarity. To the extent that the statistical complementarity for product B offsets the substitution effects arising from the decrease in exports of product A, the relationship between FDI and exports would be complementary.

Another example is an economic complementarity. If a firm produces both an intermediate and a final good, it would be possible that overseas production of a final product is associated with exports of intermediate goods from the home country. To the extent that the economic complementarity for the intermediate products offsets the substitution effects arising from the decrease in final products, the relationship between FDI and exports would be complementary.

Economic complementarity also occurs when vertical networks between upstream and downstream firms play an important role. Suppose that an intermediate product is produced by an upstream firm A and a final product is produced by a downstream firm B. If only firm B produces a final product in the host country, it would be possible that overseas production of a final product is associated with exports of intermediate goods from an upstream firm A in the home country.

Product-level data enables the aggregation biases to be addressed by separating the substitute effects from the complementary effects emanating from the nature of the vertical networks between upstream and downstream firms (Blonigen 2001). Suppose that an intermediate product is produced by two upstream firms (A and B) and is sold to a downstream firm. Only firm A produces abroad to supply its product to the downstream firm directly in the host country. Controlling for the economic complementarity for exports from firm B at home, it would be possible to identify the substitution effects emanating from the replacement of exports with overseas production by firm A.

Despite the potential importance of product-level data, the empirical evidence is still limited. Constructing time-series data for 10 products over 1978 to 1991 between Japan and the US, Blonigen (2001) undertakes product-by-product analyses. The analyses find auto parts exports from Japan are positively correlated with overseas production by Japanese automakers but negatively correlated with overseas production by Japanese suppliers. Constructing three-dimensional panel data covering 53 products and 26 countries over 1989-1994, Head et al (2004) examine the case of the US and find similar results.

This study relates closely to Blonigen (2001) extending it in several ways.[3] First, I analyse broader product-level data covering 79 auto parts and 36 countries over the period 1993 to 2008 in the case of exports from Japan. The superiority of using a wider coverage of data is the opportunity to address endogeneity and aggregation bias simultaneously. The endonegeity issue is addressed by controlling for unobserved country-, product- and year-effects whereas the aggregation bias is tackled in various ways. The latter is discussed in detail in the next section. The estimation efficiency is also enhanced due to the increased number of observations. In addition to these econometric reasons, an extension of data coverage is prompted by the rapid expansion of global production networks by Japanese automakers and parts suppliers over the past two decades: Asia, and particularly China, is emerging as a centre of global production networks whereas the importance of North America, and particularly the US, is declining.[4] In line with this compositional change in overseas operations, the destination of auto parts exports from Japan has shifted toward Asia: in 2008 the share of Asia was 40%, followed by North America (31%) and Europe (20%). Thus, the extension of country coverage is more informative.

Second, this study undertakes not only product-by-product analyses (as done by Blonigen) but also three-dimensional panel data analyses by combining 79 products into the same dataset following Head et al (2004). The panel data analyses are extended to an in-depth case study of Toyota and its parts suppliers. The details of these analyses are discussed in the next section.

3. ESTIMATION STRATEGY AND DATA

This study examines broader product-level data covering 79 auto parts and 36 countries over the period 1993 to 2008 and undertakes not only product-by-product analyses but also three-dimensional panel data analyses. This section discusses the estimation model followed by a discussion of the variable construction and estimation method.

Following the conventional way, I estimate an augmented version of the gravity equation,

$$\ln EX_{i,j,t} = \alpha + \beta_1 \ln FDI\_M_{j,t} + \beta_2 \ln FDI\_S_{j,t} + \beta_3 \ln GDP_{j,t} + \beta_4 \ln PGDP_{j,t} + \beta_5 \ln DIS_j + \beta_6 \ln NER_{j,t} + \gamma C + \delta P + \omega T + u_{i,j,t} \quad (1)$$

where subscripts i stands for i th auto parts: i =1,…,79, j stands for the j th country: j =1,…,36 and t stands for the year: t = 1993,1996,1999,2002,2005 and 2008. The auto parts and countries are listed in Appendix 1 and 2, respectively. The variables are listed and defined below with expected sign of the coefficient for independent variables in parentheses:

EX	Export value of auto parts i from Japan to country j in Japanese yen
FDI_M	Scale of overseas operations by Japanese automakers in country j (+)
FDI_S	Scale of overseas operations by Japanese suppliers in country j (+or-)
GDP	Gross domestic product (GDP) in country j (+)
PGDP	GDP per capita in country j (+)
DIS	Distance between Japan and a capital of country j (-)

NER	Nominal exchange rate index in country *j*	(+)
C	A set of country dummy variables	
P	A set of part dummy variables	
T	A set of time dummy variables	
α	A constant term	
u	An error term	

The scale of overseas operation by Japanese automakers (*FDI_M*) is a measure of outward FDI by Japanese automakers into the host country. It is expected that FDI by automakers increases auto parts exports from Japan because of economic complementarities (Head and Ries 2004). The scale of overseas operations by Japanese parts suppliers (*FDI_S*) is used as a measure of outward FDI by Japanese suppliers into the host country. The sign of the coefficient is of primary interest in this study.

The destination GDP (*GDP*) and distance (*DIS*) are included as measures of market size and trade costs, respectively. The GDP per capita (*PGDP*) is added as a measure of the development level of the destination country. Controlling for the development level matters because richer countries tend to have better ports, infrastructure, and communication systems that facilitate trade and FDI. In addition, more advanced countries tend to have more developed supporting industries that induce FDI but replace exports from home with local procurement. In addition to these gravity variables, the control for the exchange rate (*NER*) matters because changes in exchange rate cause changes in the relative price between home and host country, affecting firms' decisions on exporting and FDI. Finally, I control for unobservable factors to eliminate the possibility of endogeneity bias by including country-, part-, and time-dummy variables.[5]

Japan's disaggregated trade data classified according to the harmonised system (HS) are from the Trade Statistics of Japan compiled by the Ministry of Finance. These data enable identification of auto parts at the 9 digit-level. However, careful attention has to be paid to the classification of auto parts. While parts and components for motor vehicles are mainly classified into HS code 87, a large number of auto parts come under a different heading: tyres and rubber products (40), glass (70), electronic products (84, 85), seats (94), and so on. I classify auto parts based on the Japan Auto Parts Industries Association (JAPIA), which provides information on the comprehensive coverage of auto parts based on the HS code at the 9 digit level (Appendix 1). The monetary unit of export value is measured in Japanese yen.

The scale of overseas operations by Japanese suppliers (*FDI_S*) is measured by the number of employees at Japanese suppliers' overseas affiliates in each destination country. The data are extracted from *Nihon no jidoshabuhin kogyo* [Japanese Automotive Parts Industry] compiled by the Japan Auto Parts Industries Association (JAPIA) for various issues. The scale of overseas operations by Japanese automakers (*FDI_M*) is measured by the number of employees at the overseas affiliates of Japanese automakers in each destination country.[6] The data are from *Kaigai kigyo shinshutsu soran* [List of Japanese overseas affiliates] compiled by Toyo Keizai for various issues. Among possible alternatives the number of employees is a better measure of overseas operations by firms for three reasons. First, the number of employees at overseas affiliates is closely correlated with the scale of production. Second, data on the number of employees at overseas subsidiaries are available for both automakers and suppliers. Third, data on the number of employees at overseas subsidiaries are available for a longer period.

Nominal gross domestic product (*GDP*) and GDP per capita (*PGDP*) measured in $US are from the World Development Indicators. Distance (*DIS*) is obtained from the CEPII database. Distance is measured using the geographical coordinates of the capital cities. The nominal exchange rate index (*NER*) is constructed based on the formula,

$$NER_{jt} = \frac{Japaneses\ Yen\ per\ \$US_t}{Local\ Currency\ per\ \$US_{jt}} = \frac{Japanese\ Yen_t}{Local\ currency_{jt}}$$

where *j* and *t* represent destination country and year, respectively. An increase in the index indicates depreciation of the Japanese yen, which should lead to an expansion of auto parts from Japan. The information for constructing the official exchange rate is obtained from the World

Development Indicators. I report the summary statistics for variables and correlation matrix in Tables 2 and 3, respectively.

-Table 2 about here-

-Table 3 about here-

To allow a robustness check of the OLS estimates, the model is estimated not only by ordinary least squares (OLS) but also by the poisson pseudo-maximum-likelihood (PPML) technique. It is claimed that estimating the constant-elasticity model (i.e. the log-log model) by OLS might result in inconsistency estimates for two reasons (Silva and Tenreyro 2006). First is the strong assumption that the expected value of the error term is independent from any values of explanatory variables. Violation of this assumption leads to inconsistency of the OLS estimator. Second, the parameters estimated by OLS might be biased under heterosckedasticity. In order to tackle these problems, Silva and Tenreyro (2006) propose a PPML technique as an alternative, using a multiplicative form of the constant-elasticity model and demonstrate that PPML estimates are less susceptible to a bias. One of the useful properties of the PPML estimator is a wide range of applicability including panel data analysis (Wooldridge 1999).

The empirical analyses are carried out in three steps. First, panel dataset covering 36 countries over the period 1993 to 2008 is examined. Subsequently, I analyse three-dimensional panel data by disaggregating the dependent variable (i.e. auto parts exports from Japan) into 79 products following Head et al (2004). This treatment not only enhances the efficiency of estimation due to the increase in the number of observations but also allows controlling for parts-specific characteristics as already discussed.

Next I apply the previous panel data analyses to the in-depth analysis of Toyota and its suppliers for two reasons. First, matching the level of data aggregation is important to reduce the possibility of aggregation bias (Blonigen 2001). The variable of overseas operations by Japanese suppliers in the previous analyses is not calculated by product (but only by country). On the other hand, this case study enables identification of specific suppliers for *each* auto part and calculation of the total number of employees of suppliers' overseas affiliates by product (and by country). Second, Toyota's supplier relationship is the most intimate among Japanese automakers, leading to higher degree of the following-leader investments by its suppliers. Therefore, it is more likely that a substitute relationship between overseas operations by Toyota's suppliers and auto parts exports will be found.

The third step is go one stage further by undertaking product-by-product analyses. I estimate the model (1) for 79 products and 37 product groups. This analysis is motivated by two reasons. The first is to address the possible aggregation bias that makes it difficult to identify the substitution effects (Blonigen 2001). Second is to compare the estimation result with previous studies, particularly Blonigen (2001), which undertakes product-by-product analyses for 10 auto parts in the case of auto parts exports from Japan.

4. RESULTS

Panel Data Analysis

Table 4 reports estimates of model (1) with panel data. The first three columns show OLS estimates whereas the last three columns present PPML estimates. The overall goodness-of-fit of both OLS and PPML regressions are sufficient to conduct an econometric analysis. Some gravity variables such as distance and GDP per capita perform in accordance with expectations whereas other variables such as GDP and nominal exchange rate do not.

-Table 4 about here-

The first column shows the specification where only overseas operations by automakers is added. The coefficient of overseas operations by automakers (*FDI_M*) is positive and statistically significant at the 1% level, predicting that, overall, a 10% expansion of overseas production by Japanese automakers leads to a 2.1% increase in auto parts exports from Japan. Likewise, the second column reveals the existence of a complementary relationship between overseas operations by suppliers and exports from Japan. When overseas production by both automakers and suppliers are added to the model (third column), the coefficient of overseas production by automakers is still positive and significant whereas the counterpart of overseas production by suppliers is positive but no longer statistically significant. The results of the PPML estimation are given in the fourth to sixth columns in Table 4. They are generally consistent with the results obtained by OLS.

Table 5 reports estimates with three-dimensional panel data that disaggregates the dependent variable (i.e. auto parts exports from Japan) into 79 products and combines them into the same dataset. The data disaggregation increases the numbers of observations dramatically, leading to the improvement in the efficiency of estimation. The overall goodness-of-fit of both OLS and PPML regressions are still reasonably high to conduct an econometric analysis. As shown in Table 5, the result with the three-dimensional data is quite similar to that with the panel data presented in Table 4. To sum up, there is no evidence that overseas operations by Japanese suppliers and auto part exports from Japan are substitutes. On the other hand, there is strong evidence that auto parts exports are positively associated with overseas operations by automakers.

-Table 5 about here-

The Case of Toyota and its Suppliers

Following the previous analyses, I estimate an augmented version of the gravity equation:

$$\ln EX_{i,j,t} = \alpha + \beta_1 \ln FDI\_T_{j,t} + \beta_2 \ln FDI\_S_{i,j,t} + \beta_3 \ln GDP_{j,t} + \beta_4 \ln PGDP_{j,t} + \beta_5 \ln DIS_j + \beta_6 \ln NER_{j,t} + \gamma C + \delta P + \omega T + u_{i,j,t} \quad (2)$$

where subscripts *i* stands for the *i* th auto part: *i* =1,…,44, *j* stands for the *j* th country: *j* =1,…,32 and *t* stands for the year: *t* = 1993,1996,1999,2002,2005, and 2008. Since the firm-level data is not available, the dependent variable is extracted from the records of ports in the Aichi prefecture, the transport hub of the Toyota-centred auto cluster in Japan.[7] The 12 main plants of Toyota Motors and 173 of its *keiretsu* suppliers, out of a total 218, are located in the Aichi prefecture. More importantly, all key *keiretsu* suppliers of Toyota are located in this area.[8] The scale of overseas operations by Toyota Motors (*FDI_T*) is a measure of outward FDI by Toyota Motors into a host country. The scale of overseas operations by Toyota's suppliers (*FDI_S*) is used as a measure of investment by Toyota's suppliers into a host country. The other variables are identical to those used in the previous section.

Table 6 reports the estimation result at the aggregate level. The key finding is that, on average, overseas operations by Toyota Motors is positively correlated with auto parts exports, predicting that 10% increases in overseas operations by Toyota leads to 3% increases in auto parts exports from ports in Aichi (Third column). Another finding is that there is no evidence that overseas operations by suppliers substitutes auto parts exports. As can be seen, both OLS and PPML estimations show positive coefficients even though the significance levels vary. These results are consistent with those presented in the previous analysis (Table 4).

-Table 6 about here-

Table 7 shows the results obtained by re-estimating the model after disaggregating auto parts exports and overseas operations by suppliers at the product level. The results are mixed. The OLS estimates show quite similar results whereas the PPML estimates imply that overseas operations by both Toyota and suppliers are insignificant predictors in explaining the flow of auto parts exports. To sum up, the in-depth analyses of Toyota and its parts suppliers indicate that a complementary relationship between overseas operations by Toyota Motors and auto parts exports seems to exist. On the other hand, the relationship between overseas operations by suppliers and auto parts exports is ambiguous. However, there is no evidence that overseas operations by suppliers substitutes auto parts exports.

-Table 7 about here-

Product-by-Product Analyses

I estimate the model (1) by 79 products *separately* and calculate the numbers of coefficients of overseas operations by both automakers and suppliers according to its sign and significance level. Table 8 presents the summary of the result. As can be seen, 53 OLS estimates of overseas operations by Japanese automakers are positive and significant with at least a 10% significance level whereas the counterpart of PPML is 46. More importantly, the export value of 53 products (in the case of OLS regression) has accounted for nearly 80% of the total value of auto parts exports from Japan during the period 1993 to 2008. This indicates the complementary effect of overseas operations by Japanese automakers is quite prevailing across products.

On the other hand, as expected, the complementary effect of overseas operations by suppliers seems more limited comparing with that by automakers. There are only 22 OLS coefficients and 31 PPML coefficients, which are positive and statistically significant with at least a 10% significance level. However, the important finding is that there are some products that have the substitute relationship between overseas operations by suppliers and auto parts exports although the number of products is quite limited: with 2 OLS estimates and 7 PPML estimates, respectively.

-Table 8 about here-

In order to compare the estimation results with those in Blonigen (2001) in a more comparable manner, I classify 79 products into 37 groups and estimate the model (1) for *each* product group.[9] As expected, a wide range of product groups presents complementarities: 21 product groups show positive and significant coefficients of overseas operations by automakers for both OLS and PPML estimations (Table 9). However, the interesting finding lies in the product group that does not present a significant coefficient of overseas operations by automakers. In particular, the insignificant coefficients of engine, chassis and body and seat are consistent with the idea that bulky components tend to be produced locally rather than exported from Japan due to high transportation costs.

-Table 9 about here-

The number of positive and significant coefficients of suppliers' overseas operations is more limited: only 10 product groups have positive coefficients which are significant at least at the 10% level. The interesting finding is the positive coefficients for product groups that are likely to have sub-components of auto parts including engine parts, components of electric engine parts, components of lighting/signaling equipment, parts of body, and other parts of motor vehicles. This might suggest the vertical linkage between suppliers (e.g. first and second tier suppliers) also facilitates auto parts exports from the home country. On the other hand, there is no product that shows a substitute relationship between overseas operations by suppliers and auto parts exports from Japan in OLS estimation whereas PPML shows two products (Air conditioners and Bumpers) with the substitution relationship (Table 9).

5. DISCUSSIONS

Through product-by-product analyses, Blonigen (2001) finds that auto parts exports from Japan are positively correlated with overseas operations by Japanese automakers but negatively correlated with overseas operations by Japanese suppliers. The empirical analyses in this study support these findings (Tables 8 and 9) however the evidence on the latter is much weaker. The panel data analyses suggest that there is no statistical association concerning the latter but strongly support the former. The interesting questions here are: *Why have the empirical analyses in this study found much weaker evidence on the relationship between overseas operations by Japanese suppliers and auto parts exports from Japan? Why is the complementary relationship between overseas operations by Japanese automakers and auto parts exports from Japan robust even after controlling for Japanese suppliers' overseas operations?* This section explores these two questions.

Why Is the Substitution Relationship between Overseas Operations by Suppliers and Exports Weak?

The substitute relationship between overseas operations by Japanese parts suppliers and auto parts exports from Japan is consistent with the 'following-leader' pattern of overseas investments by Japanese suppliers – parts suppliers' investment following their customers' (automakers') investments abroad (Head et al 1995, 1999, Banerji and Sambharya 1996, Blonigen et al 2005). When Japanese automakers build production plants abroad, they attempt to transplant the efficient supplier relationships forged locally to the host country to achieve competitive advantages such as a just-in-time inventory system and quality control. The recent development of modularity has also encouraged parts suppliers to follow their customers' overseas investments. The modularity results in large modules (e.g. Cockpit Module, Chassis Module, Axle Module, Front/Rear End Module, Door Module), which are more difficult and expensive to ship over long distances and are more likely to be coordinated tightly with the final assembly process, leading to the co-location of automaker and parts suppliers (Sturgeon et al 2008). Thus, the following-leader pattern of overseas investment by auto parts suppliers seems to reduce auto parts exports from Japan.

Nevertheless, the empirical analyses in this study have found only limited evidence of substitution between overseas operations by suppliers and exports of components from Japan. How does this result compare with the finding of Blonigen (2001)? I argue that it is the result of the growing market penetration of Japanese parts suppliers in host counties over time, leading to an increase in total demand for the firms' products (statistical complementarity). In the beginning Japanese suppliers follow the overseas investments of Japanese automakers, predominantly selling their products to automakers. Their customers are limited because they are not yet recognised in the host country market. At this stage, it is expected that the substitution effects of overseas operations by Japanese suppliers on auto parts exports from Japan is strong as found in Blonigen (2001). The time period covered by the empirical analyses of Blonigen (2001) is 1978-1991 suggesting that these were the formative period of overseas operations by Japanese auto parts suppliers. In recent years, Japanese auto parts suppliers such as Denso have been expanding their overseas operations to meet expanding demand from both Japanese and non-Japanese automakers (IRC 2009).[10] This growing market penetration of Japanese parts suppliers tends to increase demand for some parts and components produced in Japan. The time period covered in this study (1993-2008) is representative of these new developments.

Another explanation could be that Japanese MNEs have followed a mixed strategy of combining exports and overseas production over time, leading to weakening substitution effects. Japanese suppliers have attempted to establish production networks in order to position themselves in a better position to face perpetual external shocks such as a rapid appreciation of Japanese yen, economic fluctuations in host country and unforeseen events such as natural disasters, political riot and strike.

Why Are Overseas Operations of Automakers and Exports Complementary?

Japanese automakers have gradually expanded their local procurements in host countries. In the case of Toyota local procurements in North America and Europe had reached 80% to 90% by 2008 (IRC 2009). The increasing overseas operations of Japanese parts suppliers and the existence of competitive suppliers enables such a high local procurement in these regions. On the other hand, the local procurement in developing countries is still limited. In China, the local procurement for Land Cruiser is still less than 40% while in India, the local procurements for Innova and Altis are 55% and 35%, respectively (IRC 2009). This low local procurement is mainly due to the absence of competitive suppliers in these countries although components suppliers have begun to follow the automakers in setting up plants there. Thus, many components are imported from Japan. One of the underlying factors that could cause complementary effects of overseas operations by Japanese automakers on auto parts exports from Japan is that developing countries, particularly in Asia, have been emerging as a centre of global production networks for Japanese automakers over the past two decades.

The strong vertical linkages between Japanese automakers and their suppliers can be another factor of the complementary relationship between overseas operations by Japanese automakers and auto parts exports from Japan. The vertical linkages within production networks between Japanese automakers and their suppliers is characterised by a long-standing and stable hierarchical structure of division of labour (Nishiguchi 1994). It is well documented that the nature of the strong vertical network limits the degree of substitutability between local procurement within host countries and auto parts exports from Japan (Swenson 1997, Hackett and Srinivasan 1998). At the same time, the strong vertical network could reduce the complementarity by facilitating the following-leader investment of suppliers that could substitute for local procurement of auto parts exports from Japan. In fact, the estimation results show that the magnitudes of the positive coefficients of overseas operations by Japanese automakers on Japan's auto parts exports are smaller when overseas operations by suppliers are included in the model (Tables 4 and 5).

However, the positive coefficient of overseas operations by Japanese automakers remains statistically significant indicating that the export-creating effect of the vertical linkage is large enough to offset the export-reducing effects. In addition, the coefficients of overseas operations by Toyota are mostly higher than those of overseas operations by Japanese automakers (Compare Table 6 with Table 4), affirming the role of *keiretsu* in creating the complementary relationship between overseas operations and exports.

6. CONCLUSION

This study has analysed broader product-level data that enable endogeneity and aggregation bias to be addressed simultaneously. The empirical analyses confirm that auto parts exports from Japan is positively associated with overseas operations by Japanese automakers but negatively correlated with overseas operations by Japanese suppliers. However, the evidence on the latter is rather weaker than that of previous studies, probably involving the existence of statistical complementarity. The robust evidence on the former suggests the existence of economic complementarity. This study concludes that, despite the discovery of substitution effects highlighting the role of aggregation bias, the empirical results suggest that overall the relationship between FDI and exports seems to be more complementary rather than substitution.

It should be noted that product-level data employed in this study allows for separation of economic complementarity emanating from vertical networks between upstream and downstream firms but not that of statistical complementarity emanating from the increase in total demand for the firms' products. As discussed, the statistical complementarity could be an important factor that makes it difficult to find the substitution relationship between FDI and exports. Thus, the search for substitution effects by separating statistical complementarity would be a future work.

Table 1: Summary of Previous Research[1]

Author	*Period[2]*	*Dependent Variable[3]*	*Measurement of MNEs' Overseas Activities[4]*	*Results[5]*	*Data[6]*	*Control Variables[7]*	*Method[8]*
Lipsey and Weiss (1981)	1970	US Exports, industry-level	Net sales of US affiliates including manufacturing and non-manufacturing	Complement	Cross-section (44 destinations)	GDP, Distance, Dummy for membership in EEC	OLS
Lipsey and Weiss (1984)	1970	Exports of US Parent Firms	Sales of manufacturing affiliates minus their imports from the US	Complement	Cross-section (1090 firms, 5 areas)	Scale of parent's firm, GDP, Sales by non-manufacturing affiliates	OLS
Blomstrom, Lipsey and Kulchycky (1988)	1982	US Exports, industry-level	Net sales of US affiliates in industry	Mixed	Cross-section (countries)	GDP, Per capita GDP	OLS, 2SLS
Blomstrom, Lipsey and Kulchycky (1988)	1978	Swedish Exports, industry-level	Net local sales	Complement	Cross-section (countries)	GDP, Per capita GDP	OLS, 2SLS
Chedor, Mucchielli and Soubaya (2002)	1993	Intra-Firm Exports of French Firms	Number of employees at French overseas affiliates	Complement	Cross-section (firm, 21 destinations)	Firm's characteristics (size, capital intensity, R&D), GDP and Distance	OLS
Kim (2000)	1994	South Korea's Exports, industry-level	Value of outward FDI	Complement	Cross-section (9 industries and 57 countries)	GDP, PGDP, Dummy for membership in EEC	OLS
Yamawaki (1991)	1986	Total Japanese Exports to US markets, industry-level	Total employment of Japanese distribution affiliates in US	Complement	Cross-section (44 industries)	Total industry employment in US, Total industry employment in Japan, etc	OLS
Lipsey, Ramstetter and Blomstrom (2000)	1986-1992	Exports of Japanese parent firms	Number of employees in parent's affiliates	Complement	Cross-section (firms, regions)	GDP, Per capita GDP, Distance, Total sales of parent	OLS

Lipsey and Ramstetter (2003)	1986-1995	Japan's Exports, industry-level	Number of employment in Japanese affiliates	Complement	Cross-section (96-98 countries)	GDP, Per capita GDP, Distance	OLS
Head and Ries (2001)	1966-1991	Japanese automaker's exports to world	Number of new manufacturing investment by automakers	Substitute	Panel data (932 firms, 25 years)	Time-varying firm characteristics (Size, Capital Intensity, Labour Productivity, Wage)	OLS
		Japanese supplier's exports to world	Number of new manufacturing investment by suppliers/by automakers	Complement/ Complement	Panel data (932 firms, 25 years)	Time-varying firm characteristics (Size, Capital Intensity, Labour Productivity, Wage)	OLS
Blonigen (2001)	1978-1991	Japan's auto parts exports to US, product-level	Number of employees of Japanese suppliers' plants in US/ Number of vehicles produced by Japanese automakers in US	Substitute/ Complement	Time series (14 years)	Price, capital, US automobile production	OLS, SUR
Head, Ries and Spencer (2004)	1989-1994	US auto parts exports, product-level	Number of employees of US affiliates related to automobile industry/ Number of vehicles produced by Big 3	Substitute/ Complement	Panel data (53 products, 26 countries, 5 years)	Distance, Per capita GDP, Dummy for Mexico and Canada, Dummy for language, and communist	OLS

Notes:

[1] A large number of studies relevant to the relationship between FDI and exports from home country are not listed here due to the space limitation. Since this study examines the case of Japanese automobile industry, I focus only on literature related to developed countries including the United States, France, Sweden, Japan and South Korea. Also, this study has been interested in the analysis at disaggregated level therefore I focus only on industry-, firm- and product-level analyses.

[2] The period of analysis.

[3] The dependent variables relating to exports from home country measured by various definitions according to the authors.

[4] The key variables related to MNE’s overseas activities.

[5] The relationships between FDI and exports from home country derived from the regression analysis.

[6] The datasets employed in each study.

[7] The control variables. EEC represents European Economic Community.

[8] The estimation methods. SUR represents seemingly unrelated regression.2SLS represents of two stage least squares.

Table 2: Summary Statistics

Variables	Obs.	Mean	Standard Deviation	Min	Max
Log Auto Parts Exports, Japanese Yen	18,495	10.73	2.82	5.30	19.72
Log Overseas Operations by Suppliers	13,525	7.96	2.42	0	12.62
Log Overseas Operations by Automakers	8,913	8.08	1.65	1.61	11.36
Log GDP, $US	18,497	25.87	1.50	19.09	30.09
Log GDP Per Capita, $US	18,497	8.67	1.42	5.55	10.65
Log Distance, km	18,100	8.96	0.58	7.05	9.83
Log Nominal Exchange Rate Index	17,774	2.78	2.65	-5.06	9.22

Table 3: Correlation Matrix

	FDI_S	*FDI_M*	*GDP*	*PGDP*	*DIS*	*NER*
Log Overseas Operations by Suppliers (*FDI_S*)	1					
Log Overseas Operations by Automakers (*FDI_M*)	0.60	1				
Log GDP (*GDP*)	0.44	0.36	1			
Log GDP Per Capita (*PGDP*)	-0.03	0.16	0.57	1		
Log Distance (*DIS*)	-0.34	-0.13	0.26	0.60	1	
Log Nominal Exchange Rate Index (*NER*)	-0.09	0.01	0.53	0.74	0.43	1

Table 4: Regression Results, Panel Data[1]

Estimator:	OLS[2]			PPML[3]		
Dependent Variable: Auto Parts Exports from Japan	Log (*EXjt*)			*EXjt*		
Log Overseas Operations by Japanese Automakers (*FDI_Mjt*)	0.21***		0.16***	0.11**		0.09**
	(0.04)		(0.04)	(0.05)		(0.05)
Log Overseas Operations by Japanese Suppliers (*FDI_Sjt*)		0.21***	0.07		0.09***	0.04*
		(0.07)	(0.05)		(0.03)	(0.03)
Log Distance from Japan (*DISj*)	-4.77***	-2.7***	-2.47***	-21.3***	-7.71***	-27.04***
	(1.8)	(0.98)	(0.94)	(5.7)	(2.13)	(4.75)
Log GDP in the Host Country (*GDPjt*)	-3.34*	-2.33**	-1.29	-1.67**	-1.88***	-2.42***
	(1.78)	(1.1)	(0.97)	(0.7)	(0.65)	(0.62)
Log GDP Per Capita in the Host Country (*PGDPjt*)	4.8***	4.05***	3.06***	3.79***	3.85***	4.35***
	(1.81)	(1.32)	(1.12)	(0.77)	(0.67)	(0.79)
Log Nominal Exchange Rate (*NERjt*)	-0.22***	-0.23*	-0.27***	-0.21***	-0.18**	-0.17*
	(0.08)	(0.13)	(0.08)	(0.06)	(0.09)	(0.09)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummy	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared/Pseudo R-Squared	0.96	0.96	0.97	0.99	0.98	0.99
Observation	141	227	126	141	227	126

Notes:

[1] *j* represents the destination including 36 countries and *t* represents the year covering 1993, 1996, 1999, 2002, 2005, and 2008. The number shown in the parenthesis is heteroscedasticity-consistent standard errors.

***p-value < 0.01, ** p-value < 0.05, * p-value < 0.1.

[2] OLS is ordinary least squares.

[3] PPML is poisson pseudo-maximum-likelihood.

Table 5: Regression Results, Three-Dimensional Panel Data[1]

Estimator:	OLS[2]			PPML[3]		
Dependent Variable: Auto Parts Exports from Japan	Log (*EXijt*)			*EXijt*		
Log Overseas Operations by Japanese Automakers (*FDI_Mjt*)	0.11***		0.08**	0.12***		0.08**
	(0.03)		(0.04)	(0.05)		(0.04)
Log Overseas Operations by Japanese Suppliers (*FDI_Sjt*)		0.1***	0.03		0.08**	0.03
		(0.02)	(0.04)		(0.03)	(0.04)
Log Distance from Japan (*DISj*)	-3.85***	-2.35***	-2.78***	-3.26***	-7.24***	-2.78***
	(0.76)	(0.5)	(0.71)	(1.16)	(2.39)	(1.4)
Log GDP in the Host Country (*GDPjt*)	-1.75**	-0.53	-1.27	-2.48	-1.94***	-2.1
	(0.7)	(0.5)	(0.79)	(1.02)	(0.74)	(0.82)
Log GDP Per Capita in the Host Country (*PGDPjt*)	3.65***	1.98***	3.47***	3.71***	3.9***	4.85***
	(0.72)	(0.6)	(0.83)	(1.05)	(0.78)	(0.9)
Log Nominal Exchange Rate (*NERjt*)	-0.28***	-0.37***	-0.44***	-2.64***	-0.17**	-0.23**
	(0.05)	(0.06)	(0.06)	(0.06)	(0.07)	(0.08)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Part Dummy	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared/Pseudo R-Squared	0.66	0.64	0.66	0.87	0.86	0.89
Observation	8,489	12,893	7,722	8,489	12,893	7,722

Notes:

[1] *i* represents auto parts including 79 products, *j* represents the destinations including 36 countries and *t* represents the year covering 1993, 1996, 1999, 2002, 2005 and 2008. The dependent variable is disaggregated but not the independent variables. The number shown in the parenthesis is clustered heteroscedasticity-consistent standard errors.

*** p-value<0.01, ** p-value<0.05, * p-value<0.1.

[2] OLS is ordinary least squares.

[3] PPML is poisson pseudo-maximum-likelihood.

Table 6: Regression Results for Toyota Motors, Panel Data[1]

Estimator:	OLS[2]			PPML[3]		
Dependent Variable: Auto Parts Exports from Ports in Aichi (EX_{jt})	Log (EX_{jt})			EX_{jt}		
Log Overseas Operations by Toyota Motors (FDI_T_{jt})	0.29***		0.30***	0.16**		0.16**
	(0.09)		(0.08)	(0.1)		(0.1)
Log Overseas Operations by Suppliers (FDI_S_{jt})		0.14	0.09		0.14**	0.12**
		(0.09)	(0.07)		(0.07)	(0.06)
Log Distance from Japan (DIS_j)	-8.55***	-5.85**	-7.22***	-23.91***	-23.17***	-24.89***
	(2.78)	(2.29)	(1.96)	(4.69)	(4.70)	(4.68)
Log GDP in the Host Country (GDP_{jt})	-4.61*	-4.20*	-6.14***	-5.86***	-5.79***	-6.38***
	(2.37)	(2.47)	(2.12)	(1.51)	(1.56)	(1.52)
Log GDP Per Capita in the Host Country ($PGDP_{jt}$)	7.67***	7.64***	9.41***	8.46***	8.19***	8.78***
	(2.54)	(2.70)	(2.40)	(1.53)	(1.51)	(1.53)
Log Nominal Exchange Rate (NER_{jt})	-0.59***	-0.62***	-0.63***	-0.41***	-0.41***	-0.45***
	(0.11)	(0.11)	(0.12)	(0.11)	(0.11)	(0.11)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared/Pseudo R-Squared	0.92	0.92	0.93	0.98	0.98	0.98
Observations	106	102	102	106	102	102

Notes:
[1] *j* represents the destination including 32 countries and *t* represents the year covering 1993, 1996, 1999, 2002, 2005, and 2008. The number shown in the parenthesis is heteroscedasticity-consistent standard errors.
***p-value < 0.01, ** p-value < 0.05, * p-value < 0.1.
[2] OLS is ordinary least squares.
[3] PPML is poisson pseudo-maximum-likelihood.

Table 7: Regression Results for Toyota Motors, Three-Dimensional Panel Data[1]

Estimator:	OLS[2]			PPML[3]		
Dependent Variable: Auto Parts Exports from Ports in Aichi (EX_{ijt})	Log (EX_{ijt})			EX_{ijt}		
Log Overseas Operations by Toyota Motors (FDI_T_{jt})	0.21**		0.46**	0.03		0.03
	(0.09)		(0.21)	(0.09)		(0.17)
Log Overseas Operations by Suppliers (FDI_S_{ijt})		0.08***	-0.03		0.14***	-0.01
		(0.03)	(0.10)		(0.04)	(0.07)
Log Distance from Japan (DIS_j)	-4.66*	-0.48	-10.34**	17.74***	-1.98**	18.33***
	(2.61)	(0.82)	(4.53)	(3.45)	(0.79)	(5.03)
Log GDP in the Host Country (GDP_{jt})	-1.46	-7.11***	-9.18*	-6.82***	-6.74***	-4.87
	(2.52)	(1.34)	(5.05)	(2.58)	(1.84)	(3.99)
Log GDP Per Capita in the Host Country ($PGDP_{jt}$)	3.77	8.79***	13.65***	9.61***	8.47***	8.89**
	(2.57)	(1.39)	(5.05)	(2.48)	(1.85)	(3.82)
Log Nominal Exchange Rate (NER_{jt})	-0.28**	-0.56***	-1.33***	-0.20	-0.40***	0.14
	(0.12)	(0.08)	(0.24)	(0.18)	(0.11)	(0.25)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Part dummy	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared/Pseudo R-Squared	0.66	0.63	0.83	0.92	0.87	0.96
Observations	863	2,779	202	1,059	3402	230

Notes:
[1] *j* represents the destination including 32 countries and *t* represents the year covering 1993, 1996, 1999, 2002, 2005, and 2008. The number shown in the parenthesis is clustered heteroscedasticity-consistent standard errors.
*** p-value < 0.01, ** p-value < 0.05, * p-value < 0.1.
[2] OLS is ordinary least squares.
[3] PPML is poisson pseudo-maximum-likelihood.

Table 8: Number of Coefficients of 79 Products According to Sign and Significance Level[1]

Dependent Variable: Auto Parts Exports from Japan Year: 1993-2008	Overseas Operations by Automakers (*FDI_M*)[2]		Overseas Operations by Suppliers (*FDI_S*)[3]	
	OLS	PPML	OLS	PPML
(a) Positive Coefficients	71	67	56	51
Significant	53	46	22	31
p-value < 0.01	36	30	8	24
0.01 < p-value < 0.05	13	11	7	5
0.05 < p-value < 0.1	4	5	7	2
Insignificant	18	21	34	20
(b) Negative Coefficients	8	12	23	28
Significant	3	6	2	7
p-value < 0.01	0	5	1	2
0.01 < p-value < 0.05	2	0	0	4
0.05 < p-value < 0.1	1	1	1	1
Insignificant	5	6	21	21
Total ((a)+(b))	79	79	79	79

Notes:
[1] I estimate the model (1) by running the regression for 79 products. OLS is ordinary least squares and PPML is poisson pseudo-maximum-likelihood.
[2] The first and second columns show the numbers of OLS and PPML coefficients relating to overseas operations by automakers (*FDI_M*).
[3] Third and fourth columns show the numbers of OLS and PPML coefficients relating to overseas operations by suppliers (*FDI_S*).

Table 9: Regression Results by Product Groups[1]

Dependent Variable: Auto Parts Exports from Japan Year: 1993-2008		Overseas Operations by Automakers (*FDI_M*)[2]		Overseas Operations by Suppliers (*FDI_S*)[3]	
		OLS	PPML	OLS	PPML
1	Tyre	0.250**	0.169	0.046	0.161*
2	Glass	0.482***	0.604***	-0.143	-0.166
3	Leaf springs	0.449*	0.567	0.278	0.526
4	Mountings	0.607***	0.587***	0.243	0.474***
5	Engine	0.041	-0.257	-0.058	-0.474
6	Engine parts	0.414***	0.318***	0.246**	0.461***
7	Air Conditioners	0.240	0.175***	0.032	-0.453***
8	Filters	0.510***	0.497***	-0.008	0.019
9	Jacks/hoists	0.405***	0.039	0.110	0.791***
10	Shafts and cranks	0.276***	0.252***	0.184*	0.532***
11	Gaskets	0.292***	0.330***	0.097	0.329***
12	Electric engine parts	0.207**	-0.043	-0.014	0.411
13	Component of electric engine parts	0.138	0.019	0.470***	0.948***
14	Lighting and signaling equipment	0.519***	0.609***	0.032	-0.053
15	Component of lighting/signaling equipment	0.378***	0.252**	0.282**	0.502***
16	Speakers	0.426	0.845***	-0.048	-0.077
17	Car audio and radio	0.169	0.173	0.299	0.515
18	Lamps	1.114**	0.735**	-0.481	0.092
19	Wire harness	0.365***	0.190	0.140*	0.324***
20	Chassis and body	-0.055	-0.241	0.385	0.337**
21	Bumpers	0.496***	0.517***	-0.139	-0.219**
22	Seat belts	0.503**	0.898***	0.262*	0.420***
23	Parts of bodies	0.475***	0.532***	0.179*	0.170*
24	Brake system	0.797**	0.825***	-0.190	0.322**
25	Transmission	0.475***	0.629***	0.261**	0.140
26	Axles	0.736***	0.784***	0.183	0.393***
27	Wheels	0.265***	0.188**	0.208*	0.325***
28	Shock absorbers	0.498***	0.165	-0.013	0.383***
29	Radiators	0.361***	0.386**	0.091	0.099
30	Mufflers and exhaust pipes	0.263**	0.300***	0.028	0.083
31	Clutches	0.534***	0.441***	0.156	0.378***
32	Steering wheels	0.456***	0.248**	0.092	0.067
33	Airbags	-0.241	-0.365***	0.937***	1.139***
34	Other parts of motor vehicle	0.424***	0.399***	0.286***	0.484***
35	Motorcycle parts	0.066	0.477*	0.034	-0.140
36	Clocks	0.193	0.602	0.055	0.647**
37	Seats	0.052	-0.152	0.351**	-0.386

Notes:
[1] I estimate the model (1) by running the regression for 37 product groups. Due to the space limitation, standard errors are not reported.
[2] Second and third columns show the coefficients of overseas operations by Japanese automakers measured by the number of employees at automakers' overseas affiliates.
[3] Fourth and fifth columns show the coefficients of overseas operations by Japanese suppliers measured by the number of employees at suppliers' overseas affiliates.
*** p-value<0.01, ** p-value<0.05 and * p-value<0.1.

Appendix 1: List of Products

	HS Code	*Name of Products*
1	401110000	New pneumatic tyres, of rubber, of a kind used on motor cars (incl. station wagons & racing cars)
2	401120000	New pneumatic tyres, of rubber, of a kind used on buses/lorries
3	401140000	New pneumatic tyres, of rubber, of a kind used on motorcycles
4	401211000	Retreaded pneumatic tyres of rubber, of a kind used on motor cars (incl. station wagons & racing cars)
5	401212000	Retreaded pneumatic tyres of rubber, of a kind used on buses/lorries
6	401220000	Used pneumatic tyres of rubber
7	401310000	Inner tubes, of rubber, of a kind used on motor cars (incl. station wagons & racing cars), buses/lorries
8	700711000	Safety glass (tempered) for vehicles, aircraft, etc
9	700721000	Safety glass (laminated) for vehicles, aircraft, etc
10	700910000	Rear-view mirrors for vehicles
11	732010100	Leaf springs/leaves thereof, iron or steel for motor vehicles
12	830230000	Motor vehicle mountings, fittings, of base metal, nes
13	840731000	Engines, spark-ignition reciprocating, <50 cc
14	840732100	Engines, spark-ignition reciprocating for motorcycle, 50-250 cc
15	840732900	Engines, spark-ignition reciprocating for others, 50-250 cc
16	840733100	Engines, spark-ignition reciprocating for motorcycle, 250-1000 cc
17	840733900	Engines, spark-ignition reciprocating for others, 250-1000 cc
18	840734100	Engines, spark-ignition reciprocating for motorcycle , over 1000 cc
19	840734900	Engines, spark-ignition reciprocating for others, over 1000 cc
20	840820000	Engines, diesel, for motor vehicles
21	840991100	Parts for spark-ignition engines for motor vehicle
22	840999100	Parts for diesel and semi-diesel engines for motor vehicle
23	841430100	Compressors for refrigerating equipment for motor vehicle
24	841520000	Air cond used in vehicle
25	842123000	Oil/petrol filters for internal combustion engines
26	842131000	Intake air filters for internal combustion engines
27	842542000	Hydraulic jacks/hoists except for garages
28	848310000	Transmission shafts and cranks, cam and crank shafts
29	848340100	Gearing, ball screws, speed changers, torque converter
30	848350000	Flywheels and pulleys including pulley blocks
31	848410000	Gaskets of metal sheeting, including sandwich type
32	848420000	Mechanical seals
33	850211000	Generating sets, diesel, output < 75 kVA
34	850212000	Generating sets, diesel, output 75-375 kVA
35	850710000	Lead-acid electric accumulators (vehicle)

36	851110000	Spark plugs
37	851120000	Ignition magnetos, magneto-generators and flywheels
38	851130100	Distributors and ignition coils for motor vehicle
39	851140100	Starter motors for motor vehicle
40	851150000	Generators and alternators
41	851180100	Glow plugs & other ignition or starting equipment nes for motor vehicle
42	851190100	Parts of electrical ignition or starting equipment for motor vehicle
43	851220000	Lighting/visual signalling equipment nes
44	851230000	Sound signalling equipment
45	851240000	Windscreen wipers/defrosters/demisters
46	851290000	Parts of cycle & vehicle light, signal, etc equipment
47	851821100	Single loudspeakers, mounted in enclosure for motor vehicle
48	851829100	Loudspeakers, nes for motor vehicle
49	851840200	Audio-frequency electric amplifiers for motor vehicle
50	852719990	Radio receivers, portable, non-recording for motor vehicle
51	852721000	Radio receivers, external power, sound reproduce/record
52	852729000	Radio receivers, external power, not sound reproducer
53	853910000	Sealed beam lamp units
54	853921000	Filament lamps, tungsten halogen
55	853929100	Filament lamps, except ultraviolet or infra-red, nes for motor vehicle
56	854430000	Ignition/other wiring sets for vehicles/aircraft/ship
57	870600100	Motor vehicle chassis fitted with engine for buses
58	870600200	Motor vehicle chassis fitted with engine for trucks
59	870600900	Motor vehicle chassis fitted with engine for others
60	870710000	Bodies for passenger carrying vehicles
61	870790000	Bodies for tractors, buses, trucks etc
62	870810000	Bumpers and parts thereof for motor vehicles
63	870821000	Safety seat belts for motor vehicles
64	870829000	Parts and accessories of bodies nes for motor vehicles
65	870830000	Brake system and its parts
66	870840000	Transmissions for motor vehicles
67	870850000	Drive axles with differential for motor vehicles
68	870870000	Wheels including parts/accessories for motor vehicles
69	870880000	Shock absorbers for motor vehicles
70	870891000	Radiators for motor vehicles
71	870892000	Mufflers and exhaust pipes for motor vehicles
72	870893000	Clutches and parts thereof for motor vehicles
73	870894000	Steering wheels, columns & boxes for motor vehicles

74	870895000	Airbags and its parts
75	870899900	Motor vehicle parts nes for others
76	871411000	Motorcycle saddles
77	871419000	Motorcycle parts except saddles
78	910400000	Instrument panel clocks etc for vehicles/aircraft etc
79	940120000	Seats, motor vehicles

Source: *Nihon Jidosha Buhin Kogyo Kai* [Japan Auto Parts Industries Associations (JAPIA)].

Appendix 2: List of Countries

1	Argentina	16	Malaysia	31	Thailand
2	Australia	17	Mexico	32	Turkey
3	Austria	18	Netherlands	33	United Kingdom
4	Belgium	19	Norway	34	United States of America
5	Brazil	20	Pakistan	35	Venezuela
6	Canada	21	Philippines	36	Viet Nam
7	China	22	Poland		
8	Czech Republic	23	Portugal		
9	France	24	Republic of Korea		
10	Germany	25	Romania		
11	Hungary	26	Russia		
12	India	27	Slovakia		
13	Indonesia	28	South Africa		
14	Ireland	29	Spain		
15	Italy	30	Taiwan		

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NOTES

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[1] The multiproduct nature is a common feature of contemporary multinational enterprises. For example, automakers produce a wide variety of products, ranging from commercial cars (trucks and buses) and passenger cars to intermediate products such as engines, engine parts and transmission. In addition, it is common that auto parts suppliers involve several type s of products.

[2] See Mundell (1957) and Markusen (1995) for theoretical studies.

[3] It is important to note that the differences between this study and Blonigen (2001) are not only the dataset used but also model specification. This study examines determinants of auto parts exports from Japan by estimating a gravity equation whereas Blonigen (2001) estimates a demand function.

[4] Regarding overseas production (in volume) by Japanese automakers, the share of North America dropped from 42% in 1988 to 31% in 2008 whereas the share of Asia rose from 26% to 42% during the same period. In particular, the sharp contrast between these two regions reflects in the rise of China and the fall of the US. Regarding overseas operations by Japanese parts suppliers, their overseas subsidiaries are most concentrated in Asia: Out of 1,203 subsidiaries in 2008, 659 were located in Asia, followed by North America (290), and Europe (186).

[5] I have already discussed the country dummy variables (*C*). The part dummy variables (*P*) are included to control for part-specific characteristics such as bulkiness, engineering and designing costs, and asset specificity that could influence FDI and exports, simultaneously (Head et al 2004). For example, auto parts with higher asset specificity and engineering costs (e.g. catalytic converters, variable valve lift systems) are probably exported from headquarters' plants in a home country due to the avoidance of a breach of technology and information. On the other hand, bulky parts such as body and chassis components are expected to be directly supplied in a host country rather than exported from a home country because of higher transportation costs. The time dummy variables (*T*) are included to control for time-varying factors relating to auto parts such as technological change, and price changes.

[6] I exclude non-manufacturing affiliates such as those involved in R&D, distribution, insurance and other non-manufacturing services.

[7] There are 9 main custom ports in Japan: Tokyo, Yokohama, Kobe, Osaka, Nagoya, Moji, Nagasaki, Hakodate, and Okinawa. Nagoya customs cover ports in the Aichi prefecture. Calculating by "Google map", the distances between the headquarter of Toyota Motors (address: 1 Toyota-cho, Toyota city, Aichi prefecture) and each custom are: Nagoya custom is 25.91 km, Hakodate is 813.49 km, Tokyo is 247.17 km, Yokohama is 228.56 km, Kobe is 183.36 km, Osaka is 162.78 km, Moji is 580.98, Nagasaki is 715.92 km, and Okinawa is 1,333.2 km.

[8] Here, key suppliers are synonymous with members of the Toyota group including Toyota Industries Corporation, Aichi Steel Corporation, JTEKT Corporation, Toyota Auto Body Co.,Ltd, Toyota Tsusho Corporation, Aisin Seiki Co.,Ltd., Denso Corporation, Toyota Boshoku Corporation and Toyoda Gosei Co.,Ltd.

[9] This is because according to the classification of HS code, some products are classified into several HS codes (e.g. tyres and engines. See Appendix 1 for more details). For example, Tyres has 7 product categories based on HS code (i.e. 401110000, 401120000, 401140000, 401211000, 401212000, 401220000 and 401310000). For simplicity, I group these products into one product group (i.e. Tyres in this case).

[10] As of 2009, Denso is selling products to GM, Ford and Chrysler in North America, VW, Volvo, Jaguar, Daimler, Audi, Land Rover, Fiat, Iveco, Maserati, Porche, Ford, SEAT, Renault, Alfa Romeo, Ferrari, Lamborghini, Lancia, PSA, and BMW in Europe, GM, BMW, Hyundai, and Tata in Asia (IRC 2009).