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► **To cite this version:**

Raphaël Chiappini. Do Overseas investments create or replace trade? New insights from a macro-sectoral study on Japan. 2013. hal-00854109

HAL Id: hal-00854109

<https://hal.science/hal-00854109>

Preprint submitted on 26 Aug 2013

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DO OVERSEAS INVESTMENTS CREATE OR REPLACE TRADE? NEW INSIGHTS FROM A MACRO-SECTORAL STUDY ON JAPAN

Documents de travail GREDEG
GREDEG Working Papers Series

RAPHAËL CHIAPPINI

GREDEG WP No. 2013-24

<http://www.gredeg.cnrs.fr/working-papers.html>

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Do overseas investments create or replace trade?

New insights from a macro-sectoral study on Japan

Raphaël Chiappini¹

Abstract

This paper investigates the relationship between outward foreign direct investment (FDI) and both exports and imports from Japan. Using the Poisson pseudo-maximum likelihood (PPML) estimator developed by Santos Silva and Tenreyro (2006) to deal with the problem of zero trade flows when estimating a gravity equation, we show that the complementary relationship between FDI and trade is overestimated when using the Ordinary Least Square (OLS) estimator. The PPML method also allows sectoral estimation of the relationship. We find that whether outward FDI creates or replaces trade depends on the industry under scrutiny. Our results indicate that the complementary relationship between FDI and trade is dominant in the Japanese manufacturing sector, especially in electric machinery, transportation equipment, and precision machinery. We find also that Japanese overseas investments substitute for exports in chemicals products, and for both exports and imports in general machinery.

Keywords: Exports, imports, outward foreign direct investment (FDI), Poisson pseudo-maximum likelihood (PPML)

JEL Classification: C23, F14, F21

1. Introduction

Large-scale liberalization, known as the globalization process has promoted the internationalization of production and growth of both capital and trade flows. As a consequence, the world stock of Foreign Direct Investment (FDI) has increased 38 fold, with average growth of 13 % per annum between 1980 and 2011. In 1990, Japan was the third largest source of FDI behind the United States (U.S.) and the United Kingdom (U.K.), accounting for 9.62 % of world FDI. Its share has reduced with increasing FDI outflows from countries such as Germany and China. In 2011, Japan was the seventh largest investor abroad, with a share of 4.54 % of the total stock of outward FDI. Between 1990 and 2011, Japanese outward FDI stock increased on average by some 8 %. During the same period, Japanese exports and imports have shown slower growth, recording an average increase of around 6.5 % for exports and 5.8 % for imports. As a result, Japan's trade

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balance was in surplus for almost all the period, except for 2011². Japanese overseas investments, exports, and imports are concentrated in the Asian countries, especially China, the U.S. and Europe³. Japanese outward FDI is related mainly to chemicals products, transportation equipment, electric machinery, and general machinery⁴.

Accompanying this combined increase in capital and trade flows, there has been increased academic interest in the relationship between these two variables. Nevertheless, the question of whether overseas investments are trade replacing or creating remains unresolved. On the one hand, if FDI is the simple replication of a firm in a foreign country, as in the case of horizontal investments, FDI and trade considered to be alternative modes, and the decision of which to exploit will depend on trade and transport costs. On the other hand, if FDI implies international fragmentation of production (Arndt and Kierzkowski, 2001), i.e. the splitting-up of the production process into different components that can be produced in different locations, as in vertical FDI, foreign production and trade could be complements. Thus, numerous theoretical and empirical works focus on the nature of the relationship between outward FDI and trade.

Several empirical studies analyze the impact of outward FDI on Japanese trade. These works find that globally FDI and trade are complements for Japan, especially at country level (Pantulu and Poon, 2003). Head and Ries (2001) use firm level data to shed light on the complementary relationship between vertical FDI and trade in the Japanese manufacturing industry; Blonigen (2001) relies on a product level analysis to demonstrate a substitutive effect when the data are disaggregated, especially for the automotive industry. Yamawaki (1991) also uses firm level data and finds a strong complementary relationship between Japanese FDI in wholesale distribution in the U.S. and Japanese exports of goods to the U.S.

This paper's contribution is to employ a macro-sectoral level analysis to evaluate the relationship between overseas investments and both exports and imports. Thus, the data differ in several dimensions from those used in previous studies. First, our analysis covers a very recent period - 2005 to 2011. Second, we use sectoral level data covering nine Japanese manufacturing industries, and 30 Japanese trading partners⁵. Third, we estimate a trade gravity model using the Poisson pseudo-maximum likelihood (PPML) proposed by Santos Silva and Tenreyro (2006) which allows us to deal with zero-value observations and heteroskedasticity problems. Our sample covers corresponds to 1890 observations over the period 2005-2011.

The rest of the paper is organized as follows. Section 2 reviews the theoretical and empirical literature on the relationship between FDI and trade. Section 3 presents the data and econometric specification of the estimated models. Section 4 summarizes the results of our gravity equation estimations. Section 5 provides some concluding remarks.

²See Appendix 1.

³See Appendix 2.

⁴See Appendix 3.

⁵The complete list is contained in Appendix 4.

2. Theoretical and empirical background

2.1. Theoretical evidence

The effect of FDI on exports, i.e. whether outward FDI and exports are substitutes or complements, has been the subject of numerous theoretical and empirical work since the 1970s. The theoretical literature distinguishes between horizontal and vertical FDI to assess the nature of the relationship between those two variables.

The first theoretical approach to studying the relationship between FDI and trade was proposed by Mundell (1957). Assuming perfect competition, no transportation costs, and identical demand and production functions with constant returns to scale in a standard Heckscher-Ohlin model, Mundell (1957) shows that FDI and trade flows are perfect substitutes. Indeed, according to this theory, trade and FDI flows depend on the differences in factor prices and factor endowments between countries. Therefore, under the model hypotheses, the equalization of factor prices can be brought either through trade flows or through international factor mobility. In the latter case, factor mobility, which corresponds to FDI, is a substitute for trade.

Kojima (1975) provides a contrasting study. Mundell's model supposes that FDI occurs in a sector in which the home country has comparative advantage. In the models proposed by Kojima (1982) and Ozawa (1991), FDI occurs in a sector where the home country suffers comparative disadvantage, which means a complementary relationship can dominate. In this case, the complementarity is intra-sectoral in nature.

The main limitations of these kinds of analyses in terms of factor mobility versus mobility of goods, is failure to take account of the existence of multinational enterprises (MNEs).

The theory of industrial organization introduces important new elements to understanding the relationship between horizontal FDI and trade. A firm that wants to produce in a foreign country needs to compare the disadvantages of this action in terms of communication costs, and different culture, language, and legislation, with alternatives such as exporting or licensing. This eclectic approach was introduced by Dunning (1977) in his Ownership-Location-Internalization (OLI) paradigm. According to this theory, a company's choice among the three strategies (exporting, licensing, or investing abroad) depends on three types of advantages: ownership-specific advantages (innovation, trademark, patents, etc.), locational advantages related to the targeted market (consumers' proximity, knowledge of local competitors, etc.), and internalisation advantages. If the firm will benefit from all three types of advantages, it will prefer to invest abroad *via* FDI. If the firm will benefit from ownership-specific and internalization advantages, it will prefer to export. If the firm will benefit only from ownership-specific advantages, the firm will choose to license abroad. Thus, the OLI paradigm confirms the substitution relationship between capital and trade flows accompanying the three types of advantages. Firms may also decide to invest abroad in order to overcome trade barriers as in the model proposed by Buckley and Casson (1981). In this case, when tariffs or non-tariff barriers to trade are high, the desire to serve the foreign market locally leads to the

replacement of exports by FDI.

Markusen (1984) extends Dunning's approach with the introduction of imperfect markets. In this model, multinational firms choose to create foreign affiliates on a targeted market rather than exporting, if the additional fixed costs of establishing new plant in the foreign country are less than the fixed cost of a new firm. Firms may also locate their production abroad in order to avoid trade costs such as transportations expenses or tariffs. In other words, the decision to export rather than to establish a foreign affiliate depends on the relative benefits of proximity to consumers and production concentrated in one location in order to exploit scale economies. This is the theory of "proximity-concentration" proposed by Brainard (1997) which supposes that trade costs determine the firm's decision to locate its production abroad. If transportations costs and tariffs are high, then firms are more likely to locate their production abroad near to final consumers to benefit from lower marginal costs. Thus, if the gains from proximity are higher than the gains related to concentration, then a substitution relationship will exist between trade and capital flows. The firm's choice between exporting and establishing a foreign affiliate, therefore, will depend on several factors such as transportations costs, relative factor endowments, relative country sizes, etc.

Overseas investment replaces exporting in these MNE models primarily because they focus on trade in final goods. The introduction into these models of intermediate goods leads to different conclusions.

New trade theory underlines that the production process comprises various stages which can be distributed across different countries. In this case, the relationship between FDI and trade becomes complementary rather than substitutive. Indeed, FDI and trade in intermediate goods grow simultaneously (Svensson, 1996). In the models developed by Helpman (1984) and Helpman and Krugman (1985), the firm's choice about the location of its production depends on relative factor costs and resource endowments. If there are no transaction costs, vertical FDI will create complementary trade flows of final products from the affiliates to the parent company, and intra-firm transfers of intermediate goods, such as headquarter activities, from the parent company to its foreign affiliates. Helpman and Krugman (1985) indicate that firms in the North distribute their production activities across emerging countries in order to benefit from lower production costs, and provide evidence of intra-firm trade between the parent company located in an industrialized country, and its foreign affiliates in emerging countries.

More recent studies developed by Carr et al. (2001) and Markusen and Maskus (2001) try to combine the horizontal and vertical FDI approaches using what are referred to Knowledge-capital or KK models. KK models assume that production involves both qualified and non-qualified work, in different proportions, meaning that firms rely on both vertical and horizontal FDI. They predict different combinations of horizontal and vertical multinationals depending on country characteristics, such as trade costs, size differences, and factor endowment. KK models show that horizontal FDI is prevalent in countries with similar factor endowments and high trade costs, while vertical FDI

prevails when there are differences in the factor endowments of countries and trade costs are low. Therefore, trade and capital flows between industrialized countries to be substitutes while they are more likely to be complementary if they are between developed and emerging countries.

The introduction of firm heterogeneity (Melitz, 2003) in MNE models highlights the importance of productivity. For example, Helpman et al. (2004) emphasize that only the most productive firms can afford to become MNEs and cope with the fixed costs associated with the creation of new plant abroad. Less productive firms have to rely on an exports strategy. In these models, the dispersion of firm' productivity across each sector determines the substitutive relationship between FDI and exports. More productive firms replace exporting with FDI. Sectors where firms' productivity is similar are characterized by a complementary relationship between FDI and exports (Head and Ries, 2003).

2.2. Empirical evidence

Although the theoretical literature is not in a consensus over the relationship between FDI and trade, empirical studies tend to support the idea of trade creation. This applies to both country-level and industry-level analyses and to firm-level and product level studies.

Most empirical studies are at country-level. They study whether FDI replaces or increases trade, relying on a gravity specification that controls for GDP and distance between the home country and partners. Eaton and Tamura (1994) apply this method to estimate the relationship between outward FDI and exports flows between Japan and the U.S. in the period 1985-1990. Their results indicate clearly that outward FDI increases exports for both countries. Support for trade substitution is provided in a study by Pain and Wakelin (1998). They use a traditional export equation to analyze the relationship between FDI and exports, for 11 OECD countries over the period 1971-1995. They find an overall small negative relationship for all countries in their sample. This contrasts with data for Japan, Italy and Denmark which support the opposite idea that net outward investment improves export performance. Clausing (2000) finds evidence of FDI creating trade using U.S. multinationals' investments in 29 host countries and the investment operations of foreign multinationals in the U.S. from 1977 to 1994. In similar vein, Hejazi and Safarian (2001) show that outward FDI leads to an increase in foreign trade of the U.S. using data on the stock of outward U.S. FDI and 51 of its main trading partners, over the period 1982-1994. Pantulu and Poon (2003) examine the relationship between FDI and trade. They analyse the outward investment by Japan and the U.S. in respectively 29 and 32 countries in the period 1996 to 1999. Their results show that a trade creating effect mostly dominates, but that the effect depends on which partner is scrutinized. Camarero and Tamarit (2004) conduct a panel study based on an export equation for 13 OECD countries. Using co-integration tests, they indicate a complementary relationship between outward FDI and exports, and between

FDI inflows and exports.

Other country-level studies use Granger causality tests (Pfaffermayr, 1994, 1996; Bajo-Rubio and Montero-Munoz 2001; Alguacil and Orts, 2002 and Chiappini, 2011). For instance, Pfaffermayr (1994) finds a significant bi-directional causal relationship between FDI and exports using data for Austria from 1961 to 1991, while, for Spain, Alguacil and Orts (2002) provide evidence of a one-way causal relationship from FDI to exports. Alternatively, Chiappini (2011) finds that the causal relationship from exports to FDI is heterogeneous in his sample of European countries. His results also support the idea of FDI as trade creating for Austria, Germany, the Netherlands, Portugal and Spain.

The results of industry-level analyses show more variation. First, Lipsey and Weiss (1981) find a positive relationship between U.S. exports and U.S. production abroad, for 40 countries in 1970. They conclude that \$1 more of overseas production leads to an increase in exports to the corresponding market of between 2 % and 78 % . Blomström et al. (1988) find no evidence of FDI replacing trade for Swedish industries but show that there is a negative effect of foreign production on exports for several U.S. industries. Marchant et al. (2002) demonstrate that FDI creates trade in the U.S. food industry, while, Brainard (1997) finds support for his theory of "proximity-concentration" for 27 U.S. industries, showing that when the per capita income of the partner country catches up with the U.S., outward FDI tends to substitute for exports. A more recent study on French industries by Madariaga (2010) provides more diversified results for 58 trading partners in 22 industries for the period 2002-2008. Although overall a complementary relationship prevails, among sectors in the sample the results are more heterogeneous. Thus, the hypothesis that FDI creates trade is confirmed for only six industries, while for seven sectors the relationship is substitutive, and for a further seven, the conclusions are not significant. Finally, Chiappini's (2012) study of the French automotive industry reveals that the increase in foreign production has strongly affected France's export performance in the sector, suggesting a substitutive relationship between FDI and exports in the French automotive sector.

Firm-level analyses support the idea that foreign production increases the firm's export flows. Lipsey and Weiss (1984) reveal a strong complementary effect between U.S. production of intermediate goods in the host country and exports from the U.S. to that country in 1970. Swendenborg (1979) provides similar findings for Swedish MNEs and find that intra-firm exports to overseas affiliates complement foreign production. Svensson (1996) extends and refines Swendenborg's study and shows that foreign production has a significant and negative effect on final goods exports to European countries. However, this effect is partly offset by the complementary impact of foreign production on intermediate goods exports. Belderbos and Sleuwaegen (1998) reach similar conclusions in their study using micro data on Japanese electronics manufacturers established in the European Community (EC) during the late 1980s. The substitutive relationship between FDI and exports arises from a tariff jumping strategy; firms subject to strong import protection are likely to substitute foreign production for exports to avoid any penalty. In contrast, the study by Head and Reis (2001), which uses a panel of 932 Japanese

firms during the period 1966-1990, finds evidence of a complementary relationship between FDI and trade. However, the authors emphasize that this relationship differs across firms and with the nature of the investment. Thus, for non-vertically integrated firms, the results indicate that FDI is trade replacing.

There are also several product-level analyses (e.g. Blonigen, 2001). Blonigen (2001) provides evidence that substitution effects are relatively easy to identify in product-level data. He shows that among 11 final consumer products, 7 involve a negative significant relationship between U.S. production by Japanese firms and Japanese exports of these products to the U.S. The results for automotive products are even more clear. Blonigen (2001) finds that for nine automotive parts, there is a negative impact of Japanese production in the U.S. on U.S. imports of Japanese automotive parts. In contrast, his results support the idea of a complementary relationship between Japanese automotive production in the U.S. and imported Japanese automotive parts. Similarly, Swenson (2004) reveals that substitution effects are revealed for broad products data levels whereas the complementary effects emerge at higher levels of aggregation. Türkcan (2007) employs a gravity model and identifies a complementary relationship between U.S. exports of intermediate goods and U.S. outward FDI for 25 U.S. trading partners. However, his results also find a weak substitution effect between final goods exports and outward FDI.

3. Empirical model specification and data description

3.1. The problem of zero-value observations

Transposition of the concept of "gravity" to trade flows was proposed by Tinbergen (1962), Pöyhönen (1963) and Linnemann (1966). Since then, the "gravity equation" model for trade has been widely used to determine bilateral trade flows. It has been considered one of the great "success stories" of empirical economics (Feenstra et al., 2001). According to Frankel (1997) the equation "has gone from an embarrassing poverty of its theoretical foundations to an embarrassment of riches" (Frankel, 1997, p. 53). Numerous papers provide formal theoretical foundations for the model (see Anderson, 1979; Krugman, 1980; Bergstrand, 1985, 1989; Helpman and Krugman, 1985; Deardorff, 2001; Anderson and Van Wincoop, 2003, among others). In the traditional gravity equation, trade flows from country i to country j , denoted T_{ij} , is proportional to the product of two countries' GDPs, denoted Y_i and Y_j , and inversely proportional to their distance, D_{ij} . However, Anderson and Van Wincoop (2003) argue that this specification fails to take account of multilateral resistance terms. Therefore, the algebraic formulation of the gravity equation can be written algebraically as follows:

$$E(T_{ij}|Y_i, Y_j, D_{ij}, d_i, d_j) = \gamma_0 Y_i^{\gamma_1} Y_j^{\gamma_2} D_{ij}^{\gamma_3} e^{\alpha_i d_i + \alpha_j d_j} \quad (1)$$

where $\gamma_0, \gamma_1, \gamma_2, \gamma_3, \alpha_i$ and α_j are the parameters to be estimated and d_i and d_j are dummies identifying exporter and importer (Santos Silva and Tenreyro, 2006).

The most popular approach in the trade literature is to log-linearize equation (1) and estimate the parameters of interest using fixed effects ordinary least squares (OLS). However, this raises a problem because the log-linearized model cannot be defined for zero-value observations (Santos Silva and Tenreyro, 2006; Westerlund and Whilhelmsson, 2011). This is especially problematic when there is a large number of zero-value observations in the sample, as in three-dimensional data analysis (partner, industry, time). The presence of zeros is attributed to failure to meet the fixed costs associated with establishing trade flows (Helpman et al., 2008).

Furthermore, the OLS estimator of the log-linearized model can suffer from biases due to the presence of heteroskedasticity. The approach followed in most empirical studies dealing with gravity equations is simply to drop the pairs with zero exports or imports from the data set. This solution entails selection bias if zeros are not randomly distributed (Westerlund and Whilhelmsson, 2011).

To correct this source of biases, Santos Silva and Tenreyro (2006), Tenreyro (2007) and Westerlund and Whilhelmsson (2011) propose the use of the Poisson pseudo-maximum likelihood (PPML) to estimate the gravity model directly from its non-linear form. This resolves the problem of zero-value observations in the sample. Santos Silva and Tenreyro (2006) write the gravity equation in its exponential form:

$$T_{ij} = \exp(x_{ij}\beta) + \epsilon_{ij} \quad (2)$$

where T_{ij} represents bilateral trade between country i and country j , x_{ij} is a vector of the explanatory variables (of which some may be linear, some logarithms, and some dummy variables) and β is the parameters to be estimated. The PPML estimator is defined by (Santos Silva and Tenreyro, 2006; Tenreyro, 2007):

$$\tilde{\beta} = \arg \min_b \sum_{i,j}^n [T_{ij} - \exp(x_{ij}b)]^2 \quad (3)$$

which is equivalent to solving the following set of first-order conditions:

$$\sum_{i,j}^n [T_{ij} - \exp(x_{ij}\tilde{\beta})]x_{ij} = 0 \quad (4)$$

The estimator defined in equation (4) is numerically equal to the PPML estimator. According to Santos Silva and Tenreyro (2006) the data do not need to be Poisson.

3.2. Specification of the model

Most empirical studies investigating the relationship between FDI and trade rely on the gravity trade equation (see Fontagné and Pajot, 1999 ; Clausing, 2000 ; Hejazi

and Safarian, 2001 ; Egger, 2001 ; Türkcan, 2007; Madariaga, 2010). In these models, outward FDI are included in the gravity equation with traditional variables, such as country size, relative factor endowments, distance, and multilateral resistance terms. In line with previous empirical models (Egger, 2001; Türkcan, 2007; Madariaga, 2010), our two gravity equations have the following form:

$$\begin{aligned}
X_{ijkt} = & \gamma_0 + \gamma_1 Real FDI_{ijkt} + \gamma_2 \ln(SIMGDP_{ijt}) + \gamma_3 \ln(SUMGDP_{ijt}) & (5) \\
& + \gamma_4 \ln(DGDP_{ijt}) + \gamma_5 \ln(DGDP_{perC}_{ijt}) + \gamma_6 \ln(Real EX_{ijt}) \\
& + \gamma_7 DIST_{ij} + \gamma_8 FTA_{ijt} + \alpha_j + \alpha_k + \alpha_t
\end{aligned}$$

$$\begin{aligned}
M_{ijkt} = & \gamma_0 + \gamma_1 Real FDI_{ijkt} + \gamma_2 \ln(SIMGDP_{ijt}) + \gamma_3 \ln(SUMGDP_{ijt}) & (6) \\
& + \gamma_4 \ln(DGDP_{ijt}) + \gamma_5 \ln(DGDP_{perC}_{ijt}) + \gamma_6 \ln(Real EX_{ijt}) \\
& + \gamma_7 DIST_{ij} + \gamma_8 FTA_{ijt} + \alpha_j + \alpha_k + \alpha_t
\end{aligned}$$

where X_{ijkt} and M_{ijkt} are, respectively, exports and imports from Japan to country j in sector k at the time t . $Real FDI_{ijkt}$ measures Japan's outward FDI stock in country j , in sector k at time t . $SIMGDP_{ijt}$ corresponds to the similarity in GDP levels between Japan and its trade partners at time t . $SUMGDP_{ijt}$ measures the sum of the GDP of Japan and its trading partners at time t . $DGDP_{ijt}$, is the absolute value of the difference between the Japanese GDP and the GDP of its trading partner at time t . $DGDP_{perC}_{ijt}$ is the absolute value of the difference between the Japanese per capita GDP and country j 's per capita GDP at time t . $Real EX_{ijt}$, corresponds to the real bilateral exchange rate between Japan and country j at time t . $DIST_{ij}$ represents the bilateral distance between Japan and country j . The variable FTA_{ijt} is a dummy variable that equals 1 if country j has a free trade agreement with Japan at time t . α_j , α_k and α_t respectively capture country, industry and time fixed effects.

We, like Madariaga (2010), choose to treat the FDI variable using its level in our model specification. As in the case of imports and exports, the problem of zero-value observations for this variable entails a selection bias which can lead to a mis-specification of the gravity equation. Also, our variable $Real FDI_{ijkt}$ contains 32 % (608) of zero-values observations. Therefore, we cannot choose to log-linearize this variable without losing important information about the relationship between outward FDI and trade in Japan.

As a consequence, the parameter γ_1 can no longer be interpreted as elasticity, but only as semi-elasticity. This parameter gives the percentage change in trade flows between Japan and country j , in sector k , related to a change in one unit of Japanese outward FDI stock in the same country and in the same sector.

Following the theoretical works by Helpman (1984) and Helpman and Krugman (1985) we include several explanatory variables in the gravity equation in order to mea-

sure countries' relative sizes and differences in their factor endowments. Thus, the sum of their GDP (SUMGDP) is a proxy for estimating the factor incomes of the two partners' countries, the GDP similarity index (SIMGDP) is a measure of the similarity of the two markets, the absolute difference between their GDP evaluates the size of supply and demand in each country and the absolute difference between their per capita GDP represents consumer preferences and tastes and is a proxy for differences in factor endowments. The last three variables capture the effect of trade costs on exports and imports flows. Note that we do not include dummies for common language or contiguity in the equation because Japan is an island and does not have a common language with any other countries in our sample.

3.3. The Data

Our analysis covers trade flows from Japan to 30 countries⁶ in 9 sectors⁷ from 2005 to 2011. Hence, our data set consists of 1890 observations of bilateral export and import flows.

Informations on bilateral exports and imports at sectoral level expressed in current dollars comes from the UNcomtrade database. These two variables are expressed in real terms using the Consumer Price Indexes (CPI) for Japan and its trading partners. Data on Japanese outward FDI stock in trading partners at sectoral level expressed in current yen, are from the Bank of Japan database. This explanatory variable is converted into constant dollars using the CPI and the bilateral yen-dollar exchange rate. Note that these three variables contain zero-value observations. The repartition of these values is reported in Appendix 5.

Following the works of Helpman (1987) and Hummels and Levinsohn (1995), country sizes are estimated using the sum of GDPs as in:

$$SUMGDP_{ijt} = GDP_{it} + GDP_{jt} \quad (7)$$

We also use the similarity index introduced by Helpman (1987) which is defined as follows:

$$SIMGDP_{ijt} = \left[1 - \left(\frac{GDP_{it}}{GDP_{it} + GDP_{jt}} \right)^2 - \left(\frac{GDP_{jt}}{GDP_{it} + GDP_{jt}} \right)^2 \right] \quad (8)$$

Each value of $SIMGDP_{ijt}$ ranges between 0 and 0.5. The nearer the index to 0.5, the more similar in size are the countries. We also have:

$$DGDP_{ijt} = |GDP_{it} - GDP_{jt}| \quad (9)$$

⁶See Appendix 4.

⁷Food and beverages, Textiles and apparel, Chemicals, Glass and ceramics, Primary metals, General machinery, Electric machinery, Transportation equipment, and Precision machinery.

$$DGDPerC_{ijt} = |GDP \text{ per capita}_{it} - GDP \text{ per capita}_{jt}| \quad (10)$$

Data on real GDP and real per capita GDP in constant dollars are from the World Bank's *World Development Indicators*. Bilateral real exchange rates are computed using nominal bilateral exchange rates from the International Monetary Fund *International Financial Statistics* and each country's CPI. Bilateral distance is calculated using the distance in kilometres between the two countries' capital cities. This variable comes from the CEPII database. Finally, information on free trade agreements comes from the World Trade Organization (WTO). The list of free trade agreements considered in the analysis is displayed in Appendix 4. Appendix 6 presents a description of the variables and the summary statistics.

4. Results

4.1. Linear vs. non-linear estimation

Table 1 presents the regression results and the test statistics for the OLS and PPML specifications. Columns 2 and 4 report the OLS estimates using the logarithm of trade as the dependent variable and the logarithm of real FDI as an explanatory variable. Column 3 and 5 report the PPML estimates restricting the sample to positive-export and positive-FDI pairs to enable comparison with the results obtained using OLS. Column 6 and 7 show the results of the estimations of the exports and imports equations using the PPML method proposed by Santos Silva and Tenreyro (2006), for the whole sample.

Table 1: Estimation results: All sample

	FDI and trade > 0						All sample	
	Real exports			Real imports			Real exports	Real imports
	Ln(Real exports)	Real exports	Ln(Real imports)	Real imports	Real imports	Real exports	Real imports	
	OLS	PPML	OLS	PPML	PPML		PPML	
Ln(real FDI)	0.0682*** (0.0098)		0.1393*** (0.0183)					
Real FDI		0.0308*** (0.0070)		0.0234*** (0.0064)		0.0279*** (0.0064)	0.0210*** (0.0061)	
Ln(SIMGDP)	1.8706*** (0.3396)	1.6088*** (0.5617)	1.3333*** (0.6326)	1.2570* (0.6774)		1.6093*** (0.5539)	1.0201 (0.7025)	
Ln(SUMGDP)	3.7669*** (0.9633)	3.6910** (1.6410)	2.7777 (1.7908)	3.1674* (1.7382)		3.8429*** (1.5418)	3.2690* (1.7898)	
Ln(DGDP)	0.6496* (0.3617)	0.6845 (0.4996)	0.6673 (0.6732)	0.6465 (0.5148)		0.6955 (0.4999)	0.5831 (0.5528)	
Ln(DGDP $perC$)	-0.1107 (0.0948)	-0.1134 (0.1567)	-0.2143 (0.1766)	-0.0496 (0.1973)		-0.0699 (0.1515)	0.0541 (0.1888)	
Ln(Real EX)	0.0188 (0.2265)	-0.1966 (0.4442)	-0.3272 (0.4217)	0.1429 (0.4171)		-0.1311 (0.4090)	0.2516 (0.4016)	
Ln(DIST)	-2.1949*** (0.5781)	-2.7764** (1.1555)	-2.4679** (1.0766)	-1.1648 (1.1072)		-2.6389** (1.0985)	-0.8212 (1.1381)	
FTA dummy	-0.0958 (0.1431)	-0.0155 (0.1773)	-0.2297 (0.2665)	0.0482 (0.1857)		-0.0060 (0.1734)	0.1647 (0.1919)	
Time fixed effects	1.14	1.79	0.25	2.99		1.76	2.79	
Country fixed effects	22.16***	694.33***	26.91***	1636.02***		957.56***	988.67***	
Industry fixed effects	551.60***	1362.33***	52.33***	776.24***		1677.11***	857.24***	
Observations	1281	1281	1281	1281		1890	1890	
Adjusted R-squared	0.86		0.66					
Pseudo Log-likelihood		-1587.52		-1330.08		-1841.30	-1585.34	

*** and ** indicate 10 %, 5 % and 1 % levels of significance

Robust standard errors in parentheses

We observe first that PPML-estimated coefficients are extremely similar between the whole sample and the positive trade and FDI sub-sample, for both exports and imports. This observation is also valid for the semi-elasticity of real FDI which is relatively similar in the two PPML regressions for imports and for exports. However, several of the coefficients estimated using the PPML method differ significantly from those generated by OLS. Santos Silva and Tenreyro (2006) and Westerlund and Wilhelmsson (2011) attribute these differences to the problem of heteroskedasticity when using the OLS estimator which biases results. For instance, in our estimation, OLS exaggerates the leading role of distance for explaining imports flows from Japan: the elasticity under PPML is less than a half the elasticity generated with OLS. Furthermore, as Tenreyro (2007), the OLS estimator shows that free trade agreements have a negative impact on both exports and imports. In contrast, the PPML estimator indicates a positive relationship between free trade agreements and imports. The results for our variable of interest also differ substantially depending on the estimation method applied. Indeed, the elasticity associated with outward FDI is 6.8 % for exports and 13.9 % for imports. This means that an increase of 1 % in Japanese outward FDI leads to an average increase of 6.8 % in Japanese exports and 13.9 % in Japanese imports for given partner and industry. This is confirmation that FDI is trade creating for Japan. However, the OLS estimator seems to overestimate the intensity of the relationship between FDI, exports and imports. Indeed, if the complementary relationship between FDI and exports and FDI and imports is confirmed by the PPML method, the semi-elasticities are smaller. In fact, according to our estimations, an increase of \$1 billion invested abroad by Japan, entails an average increase of only 2.8 % in Japanese exports and an average increase of only 2.1 % in Japanese imports for each industry and each trading partner considered. As noted by Santos Silva and Tenreyro (2006), the PPML estimator corrects the overvaluation of the coefficients estimated using the OLS method.

Our results indicate also that the more similar the GDP of Japan and its trading partner, the more intensively they will trade. Distance is also a key variable for explaining Japanese exports and imports overseas. The estimation results reported in table 1 provide strong support for the idea that FDI and trade are complements in Japan's manufacturing sector. This confirms previous country-level studies on Japan, and especially those developed by Eaton and Tamura (1994) and Pantulu and Poon (2003). However, our results reveal a less intense relationship than found in these previous analyses. Furthermore, the PPML estimation points to Japanese overseas investments as having only a very small positive effect on the Japan's trade balance. It contrasts with the OLS results which suggest a negative impact on the Japan's trade balance.

4.2. Sectoral breakdown of results

Tables 2 and 3 report the estimated parameters from the non-linear form of the model specification presented in equations (4) and (5) using the fixed effects PPML estimator, for each of the nine sectors in our sample.

Table 2: Estimation results: Sectoral breakdown
PPML

	Food		Textile		Chemicals		Glass and ceramics		Primary metals	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
Real FDI	0.0012 (0.0100)	-0.0086 (0.0088)	-0.0421 (0.0849)	-0.0921 (0.0849)	-0.0069*** (0.0031)	-0.0005 (0.0045)	0.0195 (0.0300)	0.0062 (0.0253)	0.0393 (0.0273)	0.0392 (0.0244)
Ln(SIMGDP)	0.8021** (0.4035)	0.3697 (0.3138)	0.0336 (0.3815)	1.9051*** (0.3974)	1.0459** (0.2557)	0.4078 (0.3776)	1.3568*** (0.4217)	0.7204 (0.4900)	1.7464*** (0.3132)	1.8378*** (0.4152)
Ln(SUMGDP)	-1.3951 (3.1394)	-1.6625 (1.6234)	-4.9655*** (1.1508)	1.8521 (1.1443)	3.3835*** (0.9114)	-1.5464 (2.1280)	3.2577* (1.6981)	1.7411 (1.3427)	3.6543*** (1.3151)	-2.2781 (1.8849)
Ln(DGDP)	0.3965 (0.5853)	-0.0030 (0.4641)	-1.1202*** (0.3108)	0.3239 (0.3101)	0.5718** (0.2381)	-0.8093 (0.5627)	-0.1410 (0.3828)	-0.0358 (0.3414)	0.9557*** (0.3596)	-0.6333 (0.4697)
Ln(DGDP _{perC})	0.3597*** (0.0597)	-0.1795*** (0.0727)	-0.1235** (0.0593)	-0.0491 (0.0687)	-0.1388*** (0.0452)	0.0179 (0.0392)	-0.1386** (0.0647)	-0.0468 (0.0486)	-0.0510 (0.0564)	-0.2530*** (0.0773)
Ln(Real EX)	-0.2328 (0.2372)	0.1287 (0.1988)	-0.5410*** (0.2178)	-0.6626*** (0.1901)	0.0452 (0.0994)	0.0161 (0.1738)	0.2901 (0.2030)	0.2936 (0.2203)	-0.0355 (0.1610)	0.2675* (0.1598)
Ln(DIST)	-0.3320 (1.4571)	1.1550 (1.1657)	1.0618 (0.7935)	-3.5497*** (0.7795)	-1.8750*** (0.4545)	1.4403 (1.2032)	-1.2533 (0.8824)	0.2735 (0.9421)	-2.8769*** (0.8324)	1.1369 (0.9574)
FTA dummy	0.0111 (0.1044)	0.1033** (0.0504)	-0.0618 (0.0609)	0.1145 (0.0832)	0.0903*** (0.0340)	0.2191*** (0.0586)	-0.0207 (0.1062)	-0.0547 (0.0661)	0.0066 (0.0711)	0.1485 (0.1075)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	210	210	210	210	210	210	210	210	210	210
Pseudo Log-likelihood	-36.44	-161.49	-68.44	-80.65	-181.09	-177.30	-69.04	-55.61	-181.07	-144.14

*, ** and *** indicate 10 %, 5 % and 1 % levels of significance
Robust standard errors in parentheses

Table 3: Estimation results: Sectoral breakdown

	General Machinery		Electric Machinery		Transportation		Precision Machinery	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
Real FDI	-0.0456*** (0.0148)	-0.0537*** (0.0131)	0.0130* (0.0070)	0.0023 (0.0058)	0.0065*** (0.0024)	-0.0054 (0.0048)	0.0130 (0.0201)	0.0650** (0.0318)
Ln(SIMGDP)	1.0159*** (0.3734)	0.5278 (0.3817)	0.1084 (0.2678)	-0.0137 (0.2860)	3.1172*** (0.4440)	1.9982** (0.9242)	0.2227 (0.3481)	-1.0884 (0.8176)
Ln(SUMGDP)	4.9083*** (1.9045)	2.1841*** (0.7999)	3.8206*** (1.2281)	1.5456 (0.9993)	6.1748*** (1.5406)	-2.3158 (3.7666)	-1.9709 (1.2807)	-4.5679** (1.9009)
Ln(DGDP)	0.4227 (0.4171)	-0.3441** (0.1488)	0.5639* (0.3137)	-0.1899 (0.2544)	0.4770 (0.4201)	-1.1281 (1.0076)	-0.9615*** (0.3026)	-0.9433** (0.4845)
Ln(DGDP _{perC})	0.0096 (0.0627)	-0.0439 (0.0294)	0.0945** (0.0437)	0.0009 (0.0405)	-0.0925** (0.0465)	0.0597 (0.0920)	0.0208 (0.0557)	0.0467 (0.0989)
Ln(Real EX)	-0.4186*** (0.1641)	-0.3837*** (0.1436)	-0.4460*** (0.1394)	-0.3908* (0.2157)	-0.5295*** (0.1883)	-0.7461 (0.4902)	-0.8683*** (0.1984)	-2.6241*** (0.6189)
Ln(DIST)	-3.4708*** (0.9590)	-1.9032*** (0.5235)	-3.1624*** (0.7464)	-1.5507*** (0.6079)	-4.0450*** (1.1221)	-0.4868 (2.2355)	0.4153 (0.7501)	-0.3009 (0.9701)
FTA dummy	0.0057 (0.0607)	0.0817* (0.0447)	0.0039 (0.0669)	-0.0497 (0.1014)	0.0470 (0.0892)	0.3944*** (0.1488)	0.0072 (0.0799)	-0.2842*** (0.0877)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	210	210	210	210	210	210	210	210
Pseudo Log-likelihood	-176.00	-80.54	-207.40	-127.19	-283.90	-102.13	-150.43	-98.60

*** and ** indicate 10 %, 5 % and 1 % levels of significance

Robust standard errors in parentheses

All the estimations include both country and time fixed effects. At first glance, we see that the results are heterogeneous and depend on the sector under scrutiny. This applies to all the explanatory variables, and especially the variable capturing real FDI.

Our estimations show clearly that Japanese export flows are increasing with the similarity between the countries. The coefficient associated with the variable $SIMP_{ijt}$ is positive and highly significant for six sectors, especially so for transportation equipment. The elasticity of this variable ranges from 0.80 to 3.11. The same applies to the effect of $SUMGDP_{ijt}$ on exports, where the coefficient is positive and significant for five of the sectors considered. For the variable $SIMP_{ijt}$, the biggest elasticity is for transportation equipment. This means that the bigger the bilateral market size and the more similar the demand conditions, the higher will be the volume of Japanese exports to this country of transportation equipment. In contrast, results for textiles and apparel show that Japanese exports increase when the GDP of the trading partner is small relative to Japan's GDP.

The effects of these variables on Japanese imports are more diversified. Indeed, we can see that the similarity between Japan and its trading partners is significant only for textiles and apparel, primary metals and transportation equipments.

The results for the differences in factor endowments and factor incomes also vary. Our estimations reveal that Japanese export flows in textiles and apparel, and in precision machinery decrease when the difference between Japan's GDP and the GDP of its trading partner is high. This variable captures the ability of countries to provide differentiated products (Helpman and Krugman, 1985). Thus, in textiles and precision machinery industries, demand for differentiated products will converge for countries with similar market sizes. In contrast, the elasticity of this variable is positive and significant for chemicals products, primary metals and electric machinery, and the variable is significant and negative for only Japanese imports of general machinery.

Per capita GDP differences reflect the existence of intra-industry trade. Indeed, the larger the differences in *per capita* GDP, the more important will be differences in factor endowments. When the factor endowments are similar of the two countries are similar, there will likely be intra-industry trade. We notice that for textiles, chemicals, glass and ceramics, and transportation equipment, the elasticity of the variable $DGDP_{perC}_{ijt}$ is significant and negative and ranges from -0.09 to -0.14. This outcome reveal that these four sectors are characterized by important intra-industry trade. The results are the opposite for food and beverages and electric machinery. The variable is significant and negative for Japanese imports of food and beverages and primary metals.

We provide evidence that trade variables are important for evaluating Japan's export performance in manufacturing. Indeed, the PPML estimator indicates that the coefficient of the bilateral real exchange rate is statistically significant and negative for textiles, general machinery, electric machinery, transportation equipment, and precision machinery. Therefore, these sectors have been strongly affected by the appreciation of

the yen against the dollar since the end of 2007⁸. This effect is very important in the case of the precision machinery industry which has the strongest elasticity for this variable (-0.86). Our results reveal also that the estimated coefficients of distance in most cases are negative for Japanese manufacturing exports. This is especially notable in the cases of chemicals, primary metals, general machinery, electric machinery, and transportation equipment. This suggests that the trade pattern in most manufacturing industries is determined by distance. However, in a few models, the results suggest that distance is not significant and, due to better and more means of communication and transport, is no longer such a barrier to trade as in the past. The results for distance and Japanese imports of manufacturing products are even less significant; only three sectors (textiles and apparel, general machinery, and electric machinery) display significant and negative coefficients of distance.

The dummy variable FTA_{ijt} is introduced to identify the trade creating effect of free trade agreements. The results indicate that these agreements only increased Japanese exports in chemicals products. In contrast, the estimated elasticities for Japanese imports are positive and significant in several manufacturing sectors. Thus, free trade agreements have enhanced Japanese imports of food and beverages, chemicals, general machinery, and transportation equipment, this last sector being characterized by an elasticity of around 0.4.

Returning to the main focus of this paper, the effect of overseas investments appears to be heterogeneous for each Japanese manufacturing industry. First, notice that Japanese stock of outward FDI has no significant impact on either exports or imports of food and beverages, textiles and apparel, glass and ceramics, and primary metals. For these sectors, there is no significant relationship between FDI and trade for Japan.

In contrast, our results indicate that overseas investments in chemicals products substitutes for Japanese exports in the same industry. However, the relationship between FDI and exports is very small. Indeed, an increase in \$1 billion invested by Japan abroad results in an average decrease of only 0.7 % of Japanese exports in chemicals products. Ultimately, outward FDI has a very small positive impact on the trade balance for chemicals products, while electric machinery is characterized by a small complementary relationship between Japanese overseas investment and exports.

The results for transportation equipment seem to confirm previous analyses of the Japanese automotive industry (Blonigen, 2001). In fact, we find evidence that Japanese overseas investments in transportation equipment create exports in the world market. However, the semi-elasticity estimated using the PPML estimator for transportation equipments (0.006) is weak, especially relative to that estimated for general machinery (in absolute terms). This suggests that the intensity of the complementary relationship between FDI and exports in Japan's transportation industry is lower than expected and has decreased over the recent period. Madariaga (2010) shows similar evidence for France's automotive sector.

For the Japanese precision machinery industry, our results reveal a complementary re-

⁸Around 45 % in nominal terms according to the IMF statistics

relationship between FDI and imports, which has a negative impact on Japan's trade balance. Each billion dollars extra invested abroad leads to an average increase of 6.5 % in Japanese imports of precision machinery. Finally, we find evidence that Japanese overseas investments substitute for both Japanese exports and imports in the general machinery industry. Indeed, an increase in Japanese outward investment of \$1 billion entails an average decrease of 4.6 % in Japanese exports of general machinery and an average decrease of 5.4 % in Japanese imports of general machinery. This leads to a strong increase of the Japan's trade balance.

5. Conclusion

The main purpose of this paper was to investigate whether Japanese overseas investments in the manufacturing sector create or replace Japanese trade. To address this problematic, we ran a macro-sectoral analysis using data on Japanese exports, imports, and outward FDI stock, in relation to 9 industries and 30 trading partners during the 2005-2011 period. Like Santos Silva and Tenreyro (2006), we argue that the standard empirical procedures to estimate gravity equations with FDI as explanatory variable are inappropriate. Indeed, estimation of gravity trade models using OLS leads to biased results on account of an heteroskedasticity problem and failure to take account of zero-value observations (Westerlund and Wilhelmsson, 2011). To address these issues, we chose to use the solution proposed by Santos Silva and Tenreyro (2006) and implement a PPML method to estimate our gravity equation. When we compared the results of this estimation with those relying on the OLS estimator, we found significant differences, especially in relation to real outward FDI. Thus, the conclusions from the OLS estimator lead to an overestimation of the complementary relationship between Japanese overseas investments and trade. Although the PPML method confirms that Japanese outward FDI is overall trade creating in the manufacturing industry, the intensity of the relationship is weaker than suggested by the OLS estimator. These results support the idea that the PPML estimator should be used instead of the standard log linear model in order to estimate gravity equations to assess the relationship between FDI and trade.

The second contribution in this paper is to document the relationship between Japanese outward FDI and trade at the sectoral level. Our results demonstrate that the complementary relationship found at the aggregate level is due mainly to three sectors: electric machinery, transportation equipment, and precision machinery. The first two sectors are characterized by FDI creating exports, and the third, by Japanese overseas investments involving imports. We found evidence also that Japanese outward FDI and exports in chemicals products are substitutes. Finally, general machinery is characterized by a substitution effect for both Japanese exports and imports. Therefore, our results support evidence that international outsourcing by Japanese firms has increased Japan's manufacturing export performance but that the impact has become smaller.

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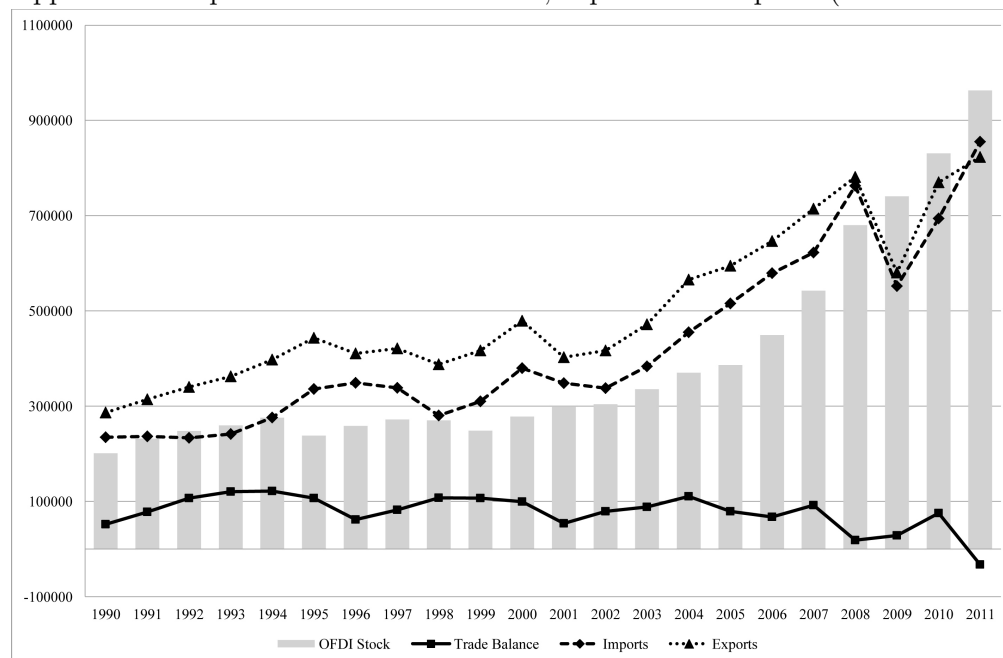
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Appendices

Appendix 1: Japanese outward FDI stock, exports and imports (in current dollars)



Sources: UNCTAD, OECD

Appendix 2: Geographical distribution of Japan Outward FDI, exports and imports in 2010

	OFDI	Exports	Imports
Asia	37.5 %	53.8 %	43.8 %
<i>China</i>	13.4 %	22.0 %	22.8 %
North America	27.7 %	17.1 %	11.1%
<i>United States</i>	26.5 %	15.1 %	9.5 %
Latin America	5.2 %	5.5 %	3.5 %
Australia/New-Zealand	3.5 %	2.4 %	2.4 %
Europe	26.6 %	14.5 %	13.7 %
Middle East	0.9 %	3.1 %	17.4 %
Others	0.6 %	3.6 %	8.1 %

Sources: Bank of Japan, OECD

Appendix 3: Sectoral distribution of Japan Outward FDI, exports and imports in the manufacturing industry in 2009

	OFDI	Exports	Imports
Food	13.0 %	0.7 %	11.7 %
Textiles	1.1 %	1.1 %	8.8 %
Chemicals	20.8 %	16.9 %	21.2 %
Glass and ceramics	3.7 %	1.5 %	1.2 %
Primary metals	6.8 %	10.3 %	7.3 %
General Machinery	8.3 %	14.1 %	6.6 %
Electric Machinery	17.5 %	22.0 %	21.5 %
Transportation equipment	19.5 %	25.6 %	5.8 %
Precision Machinery	2.2 %	5.7 %	5.5 %
Others	7.1 %	2.1 %	10.3 %

Sources: Bank of Japan, OECD

Appendix 4: List of countries

Australia	Italy	India
Belgium	Korea	Singapore (FTA since 2002)
Brazil	Luxembourg	South Africa
Canada	Malaysia (FTA since 2005)	Spain
China	Mexico (FTA since 2005)	Sweden
France	Netherlands	Switzerland (FTA since 2009)
Germany	New Zealand	Thailand (FTA since 2007)
Hong Kong	Philippines (FTA since 2006)	United Arab Emirates
Indonesia (FTA since 2005)	Russia	United Kingdom
Iran	Saudi Arabia	United States

Appendix 5: Summary statistics on zero-values observations

	Exports		Imports		FDI	
	Number	Share	Number	Share	Number	Share
Food and beverages	6	2,9%	0	0%	68	32.4%
Textiles and apparel	0	0%	0	0%	118	56.2%
Glass and ceramics	0	0%	0	0%	49	23.3%
Primary metals	0	0%	0	0%	52	24.8%
General machinery	0	0%	2	1.0%	45	21.4%
Electric machinery	0	0%	1	0.5%	56	26.7%
Transportation equipment	0	0%	0	0%	39	18.6%
Precision machinery	0	0%	0	0%	66	31.4%
Total	6	0.3%	4	0.2%	608	32.2%

Appendix 6: Summary statistics

	Mean	Standard deviation
Real exports	1.4426	3.9482
Real imports	0.8958	2.3987
Real FDI	1.0492	3.1956
Ln(SUMGDP)	8.6773	0.2193
Ln(SIMGDP)	-2.1004	0.8991
Ln(DGDP)	10.7034	0.1912
Ln(DGDP _{perC})	9.0999	1.0233
Ln(Real EX)	-2.9459	2.5428
Ln(DIST)	-9.5345	0.5720
FTA	0.2	0.4001

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