Do Overseas investments create or replace trade?
New insights from a macro-sectoral study on Japan

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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 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 exports is overestimated when using the Ordinary Least Square (OLS) estimator. Furthermore, the PPML method allows a sectoral estimation of the relationship. We find that whether outward FDI creates or replaces trade depends on the industry under scrutiny. Thus, our results indicate that the complementary relationship between FDI and trade is dominant in the Japanese manufacturing sector, especially in electric machinery, transportation equipements and precision machinery. We also find that Japanese overseas investments substitute for exports in chemicals 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 liberalisation, known as the globalisation process promotes internationalisation of production and growth of both capital and trade flows. The world stock of Foreign direct investment (FDI) has been multiplied by 38 and has known an average growth of 13 % per annum between 1980 and 2011. Japan was the third largest source of FDI in 1990, 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 or China. In 2011, Japan is only the seventh largest investor abroad with a share of 4.54 % of the total stock of outward FDI. Besides, since 1990, the Japanese stock of outward FDI has known an average increase of around 8 %. During the same period, Japanese exports and imports have grown slower recording an average increase of around 6.5 % for exports and 5.8 % for imports. As a consequence,

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the Japanese trade balance is in surplus since 1990 with the exception of 2011 on account of the nuclear accident of Fukushima[2]. Japanese overseas investments, exports and imports are concentrated in Asian countries, especially in China, in the United States and in Europe[3]. Japanese outward FDI also concerns mainly chemicals products, transportation equipments, electric machinery and general machinery[4].

Along with this combination of increase in both capital and trade flows, there has been a growing interest in the academic literature to investigate the relationship between these two variables. Yet, the question of whether overseas investments is trade replacing or creating has remained unresolved. On one hand, if FDI is a simple replication of the firm in a foreign country, as in horizontal investments, FDI and trade are seen to be alternative modes and the decision between them will depend on trade and transport costs. On the other hand, if FDI implies the international fragmentation of production (Arndt and Kierzkowski, 2001), i-e the splitting-up of the production process into separate components so they can be produced in different locations, as in vertical FDI, foreign production and trade could be complements. Therefore, a lot of theoretical and empirical works have focused on the nature of the relationship between outward FDI and trade.
Serveral empirical studies have analyzed the impact of outward FDI on the Japanese trade. These works find that globally FDI and trade are complements in Japan, especially at the country level (Pantulu and Poon, 2003). If Head and Ries (2001) use firm level data to shed the light on a complementary relationship between vertical FDI and trade in the Japanese manufacturing industry, Blonigen (2001) rely on a product level analysis and show that a substitutive effect can be found when the data are disaggregated, especially in the automotive industry. Yamawaki (1991) also uses firm level data and finds a strong complementary relationship between Japanese FDI in wholesale distribution in the United States and Japanese exports of goods to the United States.

This paper's contribution is to evaluate the relationship between overseas investments and both exports and imports using a macro-sectoral level analysis. Thus, the data differ from those used in previous studies along several dimensions. First, our analysis covers a very recent period from 2005 to 2011. Moreover, we use sectoral level data which allow conclusions for nine Japanese manufacturing industries. Our data also cover 30 trading partners from Japan[5]. Furthermore, we estimate the gravity model of trade using the Poisson pseudo-maximum likelihood (PPML) proposed by Silva and Tenreyro (2006) which allow us to deal with zero-value observations and heteroskedasticity problems. Hence, our sample covers 9 manufacturing industries, 30 trading partners over the period 2005-2011, which corresponds to 1890 observations.
The rest of this paper is organized as follows. Section II surveys the theoretical and empirical literature concerning the relationship between FDI and trade. Section III

[2]See figure 1 in appendices.
[3]See table 4 in appendices.
[4]See table 5 in appendices.
[5]The complete list is available on appendix 5.

presents our data and the econometric specification of the estimated models. Section IV summarizes estimation results of our gravity equation. Finally, section V contains concluding remarks.

2. Theoretical and empirical background

2.1. Theoretical evidence

The effect of FDI on exports, that is, whether outward FDI and exports are substitutes or complements has been a subject of a lot of both theoretical and empirical studies 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 studying the relationship between FDI and trade was proposed by Mundell (1957). Assuming perfect competition, no transportations costs and identical demand and production functions with constant returns to scale in a standard Heckscher-Ohlin model, he shows that FDI and trade flows are perfect substitutes. Indeed, in this theory, trade and FDI flows depend on the differences in factor prices and factor endowments between countries. Therefore, under the model hypotheses, the equalisation of factor prices can be brought either through trade flows or through the international factor mobility. In the latter case, factor mobility which corresponds to FDI is a substitute for trade.
Kojima (1975) reaches opposite conclusions. Indeed, Mundell's model supposes that FDI occurs in the sector in which the home country has a comparative advantage. But if, as in models from Kojima (1982) and Ozawa (1991), FDI occurs in the sector in which the home country suffers from a comparative disadvantage, a complementary relationship can dominate. In this case, the complementarity has an intra-sectoral nature.
The main limit to this kind of analyses in terms of factor mobility versus mobility of goods is to fail to take into account the existence of multinational enterprises (MNEs).

The theory of industrial organization brings new important elements to understand the relationship between horizontal FDI and trade. A firm who wants to produce in a foreign country has to compare disadvantages of it in terms of communication costs, differences in culture, language or legislation to the alternatives like exporting or licensing. This eclectic approach has been introduced by Dunning (1977) in his Ownership-Location-Internalization (OLI) paradigm. According to this theory, a company's choice between the three strategies (exporting, licensing or investing abroad) depends on three types of advantages: the ownership-specific advantages (innovation, trademark, patents, etc.), the locational advantages in the targeted market (consumers' proximity, knowledge of local competitors, etc.) and the internalisation advantages. If the firm has the three types of advantages, it would rather invest abroad and make an FDI. If the firm has ownership-specific and internalization advantages, it would rather export. Finally, if it has only ownership-specific advantages, the firm would rather license abroad. Thus, the OLI paradigm confirms the substitution relationship between capital and trade flows along with the three types of advantages. Furthermore, firms may also invest abroad in order to overcome trade barriers as in the model of 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) expands 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 also locate their production abroad in order to avoid trade costs like transportations costs or tariffs. In a word, the decision to export rather than establish foreign affiliates depends on the benefits of proximity to consumers relative to the benefits of concentrating production in one location in order to exploit scale economies. This is the theory of "proximity-concentration" proposed by Brainard (1997). In this approach, trade costs will determine the firm's decision to locate its production abroad. If transportations costs and tariffs are high, then firms are most likely to locate their production abroad near the final demand since they have lower marginal costs. In other words, if the gains of proximity are higher than the gains of concentration, there will be a substitution relationship between trade and capital flows. The firm's choice between exports and establish a foreign affiliate will, therefore, depends on several factors such as transportations costs, relative factor endowments, relative size of countries, etc.
Overseas investment replaces exports in these models of the MNE primarily because they focus on trade in final goods. The introduction of intermediate goods into these models leads to different conclusions.

New trade theory underlines that production process can be divided in different stages which can be located in 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 those models developed by Helpman (1984) and Helpman and Krugman (1985), the firm's choice for the location of its production depends on the relative factor costs and resource endowments. If there are no transaction costs, vertical FDI will create complementary trade flows of final products from affiliates to their parent company and intra-firms transfer of intermediate goods, such as headquarter activities, from parent company to its foreign affiliates. Helpman and Krugman (1985) indicate that firms from the north split their production in emerging countries in order to benefit from lower production costs and there is evidence of an intra-firm trade between the parent company, located in an industrialized country and its foreign affiliates, located in emerging countries.

More recent works developed by Carr et al. (2001) and Markusen and Maskus (2001) have tried to unify the two approaches on horizontal and vertical FDI. Those studies are known as Knowledge-capital (KK) models. The KK models make the assumption that production involves both qualified and non-qualified work in different proportions. Consequently, firms rely on both vertical and horizontal FDI. Thus, the model predicts several combinations of horizontal and vertical multinationals depending on the country characteristics, such as trade costs, size differences or factor endowments differences. Moreover, KK models show that horizontal FDI is prevalent for countries with similar factor endowments and with high trade costs, whereas vertical FDI which arises when there are differences in factor endowments between countries and when trade costs are low. Therefore, trade and capital flows tend to be substitutes between industrialized countries and are more likely to be complementary between developed and emerging countries.

The introduction of heterogeneity of firms (Melitz, 2003) in MNEs models has shed the light on the importance of productivity. Indeed, Helpman et al. (2004) emphasize that only the most productive firms can afford to be MNEs and to face fixed costs associated with the creation of new plants abroad. Less productive firms have to rely on an export strategy. In these models, the dispsersion of firms' productivity accross each sector will determine the substitutive relationship between FDI and exports. The more productive firms replace their exports by FDI. On the contrary, sectors in which firms' productivity is homogeneous will be characterized by a complementary relationship between FDI and exports (Head and Ries, 2003).

2.2. Empirical evidence

If the theoretical literature does not reach a consensus on the relationship between FDI and trade, empirical studies tend to support the idea of trade creation. This has been true not only for country-level and industry-level analyses but also for firm-level and product level studies.

Most empirical studies have been developed at the country-level. They study wether FDI replaces or increases trade relying on a gravity specification that controls for the GDP and distance between home country and partners. Eaton and Tamura (1994) apply this method to estimate the reltionship between outward FDI and exports flows between Japan and the United States over the period 1985-1990. Their results clearly indicate that outward FDI increases exports for both countries. Support for trade substituability has been found by the study of Pain and Wakelin (1998). They refer to a traditional export equation to analyze the relationship between FDI and exports covering 11 OECD countries from 1971-1995. They find an overall small negative relationship for all countries of their sample. However, results for Japan, Italy and Denmark support the opposite idea, that net outward investment improves export performance. Clausing (2000) find evidence of FDI creating trade using U.S. multinationals investment in 29 host countries and 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 of foreign trade of the U.S. using data on the stock of outward FDI from the U.S. with 51 of its main trading partners over the period 1982-1994. Pantulu and Poon (2003) also examine the relationship between FDI and trade. They analyse the outward investment of Japan and the United States to 29 and 32 countries for the period 1996 to 1999. Their results show that trade creating effect dominates on the whole, but the effect

depends on the partner under scrutiny. Camarero and Tamarit (2004) conduct a panel study from an export equation for 13 OECD countries. Using cointegration tests, they indicate a complementary relationship between outward FDI and exports and between FDI inflows and exports.
Other studies at the country-level have been conducted using Granger causality tests (Pfaffermayr, 1994, 1996; Bajo-Rubio and Montero-Munoz 2001; De Mello et al., 2000; Alguacil and Orts, 2002 and Chiappini, 2011). For instance, Pfaffermayr (1994) find a significant bi-directional causal relationship between FDI and exports in Austria using data from 1961 to 1991. Alguacil and Orts (2002) reveal only a one-way causal relationship from FDI to exports in Spain. Finally, Chiappini (2011) find strong evidence of heterogeneity in the causal relationship from exports to FDI in his sample of European countries. His results support the idea of FDI creating trade for Austria, Germany, Netherlands, Portugal and Spain.

Results of industry-level analyses are more divsersified. First, Lipsey and Weiss (1981) show a positive relationship between U.S. exports and U.S. production abroad to 40 countries in 1970. They conclude that an extra dollar of overseas production leads to an increase in exports of 2 to 78 % to the corresponding market. Blomström et al. (1988) do not find evidence of FDI replacing trade in Swedish industries, but show that there is a negative effect of foreign production on exports for several U.S. industries. Marchant et al. (2002) illustrate that FDI creates trade in the U.S. agrifood industry. On the opposite, Brainard (1997) confirms his theory of "proximity-concentration" for 27 U.S. industries and found that when the per capita income of the partner country catches the United States, outward FDI tends to substitute for exports. In similar vein, Kim and Kang (1997), in their study concerning South Korea and Japan over the period 1989-1993, show that there is a substitution relationship between Korean and Japanese exports and outward FDI, especially for textile. More recently, Madariaga (2010) finds more diversified results for France and 58 trading partners in 22 industries for the period 2002-2008. If globally the complementary relationship prevails, results are more heterogeneous among sectors of the sample. Thus, only six industries confirm the hypothesis that FDI creates trade whereas seven sectors are concerned by a substitutive relationship. Note that for 7 sectors, conclusions are not significant. Finally, the study of Chiappini (2012) on the French automotive industry reveals that the increase in foreign production has strongly affected the french export performance in the sector. Therefore, this study shed the lignt on a substitutive relationship between FDI and exports in the French automotive sector.

As previous studies, firm-level analyses support the idea that foreign production increases export flows from the firm. Lipsey and Weiss (1984) reveal a strong complementary effect between the U.S. production of intermediate goods in the host country and exports from the U.S. to the same area in 1970. Swedenborg (1979) confirms this study for Swedish MNEs and find that intra-firm exports to overseas affiliates are complementary to foreign production. Svensson (1996) extended and refined Swendenborg's study and show that foreign production has a significant and negative effect on final

goods exports to Euopean countries. However, this effect is partly offset by the complementary impact of foreign production on intermediate goods exports. Belderbos and Sleuwaegen (1998) find similar conclusions in their study using micro data on Japanese electronic firms established in the European Community (EC) during the late 1980s. The substitutive relationship between FDI and exports arises from a tariff jumping strategy. Indeed, firms facing strong import protection are likely to substitute foreign production for exports to avoid the protection.
In contrast, the study of Head and Reis (2001), developed from a panel of 932 Japanese firms over the period 1966-1990, find evidence of a complementary relationship between FDI and trade. However, the authors emphasize that this relationship is different across firms and the nature of the investment. Thus, for firms that are not vertically integrated, the results indicate that FDI is trade replacing.

Finally, studies can be developed at the product-level as in the analysis of Blonigen (2001). This paper provides evidence that subsitution effects are relatively easy to identify in product-level data. Indeed, he shows that seven final consumer products of eleven studied are concerned by a negative significant relationship between U.S. production by Japanese firms and Japanese exports of these products to the United States. Results for automotive products are even more clear. Blonigen (2001) finds that for nine automobile parts, there is a negative impact of Japanese production in the U.S. on U.S. imports of Japanese automobile parts. In contrast, his results support the idea of a complementary relationship between Japanese automobile production in the U.S. and imported Japanese automobile parts. In similar vein, Swenson (2004) reveal that substitution effects are revealed for broad products data levels whereas the complementary effects emerge at higher levels of aggregation. In a more recent study, Türkcan (2007) identifies a complementary relationship between U.S. exports of intermediate goods and U.S. outward FDI with a gravity model for 25 trading partners of the United States. However, his results also support that there is 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

The transposition of the concept of "gravity" to trade flows was first introduced by Tinbergen (1962), Pöyhönen (1963) and Linnemann (1966). The "gravity equation" model for trade has, then, been widely used in determining bilateral trade flows. This model is sometimes seen as one of the great success stories in 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, pp. 53). Indeed a lot of paper have provided formal theoretical foundations of 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 porportional 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 into account multilateral resistance terms. Therefore, the formulation of the gravity equation can be written algebraically as follows:

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

Where γ_0, γ_1, γ_2, γ_3, α_i and α_j are the parameters to be estimated and d_i and d_j are dummies identifying the exporter and the importer (Silva and Tenreyro, 2006).

The most popular approach in the trade literature is to log-linearize the equation (1) and to estimate the parameters of interest by the fixed effects ordinary least squares (OLS). However, this process raises a problem because the log-linearized model cannot be defined for zero-value observations (Silva and Tenreyro, 2006; Westerlund and Whilhelmsson, 2011). This especially the case when zero-value observations are high in the sample, as in a 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 by 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 a selection bias if zeros are not randomly distributed (Westerlund and Whilhelmsson, 2011).

To correct this sources of biases, 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 nonliner form. This method overcomes the problem of zero-value observations in the sample. Silva and Tenreyro (2006) write the gravity equation in its exponential form:

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

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

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

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 Silva and Tenreyro (2006) the data do not have to be Poisson at all.

3.2. Specification of the model

Most empirical studies investigating the relationship between FDI and trade rely on the gravity equation of trade (see Fontagné and Pajot, 1999 ; Clausing, 2000 ; Hejazi and Safarian, 2001 ; Egger, 2001 ; Türkcan, 2007; Madariaga, 2010). In these models, outward FDI are included into the gravity equation with traditional variables, such as countries size, relative factor endowments, distance or multilateral resistence terms. In line with previous empirical models (Egger, 2001; Türkcan, 2007; Madariaga, 2010), our two gravity equations has the following form:

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

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

Where X_{ijkt} and M_{ijkt} represent, respectively, exports and imports from Japan to country j in sector k at the time t. $Real\ FDI_{ijkt}$ measures the Japanese outward FDI stock in country j, in sector k at time t. $SIMGDP_{ijt}$ corresponds to the similarity in the levels of GDPs between Japan and its trade partners at time t. $SUMGDP_{ijt}$ measures the sum of GDPs of Japan and its trading partners at time t. $DGDP_{ijt}$, is the absolute value of the difference between the Japanese GDP and its trading partner GDP at time t. $DGDPperC_{ijt}$, represents the alsolute value of the difference between the Japanese per capita GDP and country j 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 which equals one if country j has a free trade agreement with Japan at time t. α_j, α_k and α_t captures country, industry and time fixed effects, respectively.

We decide, as Madariaga (2010), to treat the FDI variable using its level in our model specification. Indeed, as for imports and exports, the problem of zero-value observations

for this variable, entails a selection bias which can lead to a wrong specification of the gravity equation. Moreover, our variable $Real\ FDI_{ijkt}$ contains 32 % of zero-values observations, which represents 608 observations. Therefore, we cannot choose to log-linearize this variable without loosing important informations about the relationship between outward FDI and trade in Japan.
As a consequence, the parameter γ_1 can no longer be interpreted as an elasticity, but as a semi-elasticity. This parameter gives the percentage change in trade flows between Japan and country j, in sector k, in terms of a change in one unit of the Japanese outward FDI stock in the same country and in the same sector.

Following the theoretical works of Helpman (1984) and Helpman and Krugman (1985) several explanatory variables are included in the gravity equation in order to measure relative size of countries and differences in factor endowments. Thus, the sum of GDPs (SUMGDP) is a proxy to estimate factor income of the two partners' countries, the similarity index of GDPs (SIMGDP) is a measure of the similarity of the two markets, the absolute difference between GDPs evaluates the size of supply and demand in each country and the absolute difference between per capita GDPs 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 traditionnal dummies capturing common language or contiguity are not included in the equation because Japan is an island and has no common language with other countries of our sample.

3.3. The Data

Our analysis covers trade flows from Japan to 30 countries[6] in 9 sectors[7] 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 the sectoral level expressed in current dollars comes from the UNcomtrade database. These two variables are expressed in real terms using the Japanese Consumer Price Index (CPI) and its trading partners CPI. Data on the Japanese outward FDI stock in trading partners at the sectoral level expressed in current yen come from the Bank of Japan's database. This explanatory variable is converted into constant dollars using Consumer Price Index and the bilateral exchange rate between yen and dollar. Note that this three variables contain zero-value observations. The repartition of these values are reported in table 7 in appendices.
Following works of Helpman (1987) and Hummels and Levinsohn (1995), countries sizes are evaluated using the sum of GDPs as in:

[6] See table 6 in appendices
[7] Food and beverages, Textile and apparel, Chemicals, Glass and ceramics, Primary metals, General machinery, Electric machinery, Transportation equipment and Precision machinery.

$$SUMGDP_{ijt} = GDP_{it} + GDP_{jt} \tag{7}$$

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

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

Each values of $SIMGDP_{ijt}$ range between 0 and 0.5. The more the index is near 0.5, the more countries sizes are similar. We also have:

$$DGDP_{ijt} = |GDP_{it} - GDP_{jt}| \tag{9}$$

$$DGDPperC_{ijt} = |GDP\ per\ capita_{it} - GDP\ per\ capita_{jt}| \tag{10}$$

Data concerning real GDP and real per capita GDP in constant dollars are taken from the World Bank's *World Development Indicators*. Bilateral real exchange rates are computed using nominal bilateral exchange rates from the IMF's *International Financial Statistics* and CPI of each country. Bilateral distance is calculated using the distance in kilometers between the two countries capital city. 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 the table 6 in appendices. Table 8 in appendices provides a description of the variables and displays the summary statistics.

4. Results

4.1. Linear vs. non linear estimation

Table 1 presents regression results along with test statistics for OLS and PPML specifications. The first and the thrid column report OLS estimates using the logarithm of trade as the dependent variable and the logarithm of real FDI as an explanatory variable. The second and the fourth columns report the PPML estimates restricting the sample to positive-export and positive-FDI pairs, in order to compare results with those obtained using OLS. Finally, the last two columns show the estimation results of exports and imports equations using the PPML method proposed by 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
	Dependent variable					
	Ln(Real exports)	Real exports	Ln(Real imports)	Real imports	Real exports	Real imports
	OLS	PPML	OLS	PPML	PPML	
Ln(real FDI)	0.0682***		0.1393***			
	(0.0098)		(0.0183)			
Real FDI		0.0308***		0.0234***	0.0279***	0.0210***
		(0.0070)		(0.0064)	(0.0064)	(0.0061)
Ln(SIMGDP)	1.8706***	1.6088***	1.3333**	1.2570*	1.6093***	1.0201
	(0.3396)	(0.5617)	(0.6326)	(0.6774)	(0.5539)	(0.7025)
Ln(SUMGDP)	3.7669***	3.6910**	2.7777	3.1674*	3.8429***	3.2690*
	(0.9633)	(1.6410)	(1.7908)	(1.7382)	(1.5418)	(1.7898)
Ln(DGDP)	0.6496*	0.6845	0.6673	0.6465	0.6955	0.5831
	(0.3617)	(0.4996)	(0.6732)	(0.5148)	(0.4999)	(0.5528)
Ln(DGDP$perC$)	-0.1107	-0.1134	-0.2143	-0.0496	-0.0699	0.0541
	(0.0948)	(0.1567)	(0.1766)	(0.1973)	(0.1515)	(0.1888)
Ln(Real EX)	0.0188	-0.1966	-0.3272	0.1429	-0.1311	0.2516
	(0.2265)	(0.4442)	(0.4217)	(0.4171)	(0.4090)	(0.4016)
Ln(DIST)	-2.1949***	-2.7764**	-2.4679**	-1.1648	-2.6389**	-0.8212
	(0.5781)	(1.1555)	(1.0766)	(1.1072)	(1.0985)	(1.1381)
FTA dummy	-0.0958	-0.0155	-0.2297	0.0482	-0.0060	0.1647
	(0.1431)	(0.1773)	(0.2665)	(0.1857)	(0.1734)	(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

The first remark that we can make concerning those results, is that PPML-estimated coefficients are highly similar using the whole sample and using the positive trade and FDI subsample, both for exports and imports. This observation is also valid concerning the semi-elasticity of real FDI which is relatively the same in the two PPML regressions for imports and for exports. However, several coefficients estimated using the PPML method differ significantly from those generated by OLS. Silva and Tenreyro (2006) and Westerlund and Whilhelmsson (2011) attribute this 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 in order to explain imports flows from Japan: the elasticity under PPML is less than a half of the one generated with OLS. Furthermore, as in the study of Tenreyro (2007), the OLS estimator show that free trade agreements have a negative impact on both exports and imports. On the contrary, the PPML estimator indicates a positive relationship between free trade agreements and imports. Results concerning our interest variable are aslo substantially different according to the method applied for the estimation. Indeed, the elasticity associated with outward FDI is 6.8 % for exports and 13.9 % for imports. It means that an increase of 1 % in Japanese outward FDI leads to an average increase of 6.8 % of Japanese exports and of 13.9 % of Japanese imports for given partner and industry. It confirms that FDI is trade creating in 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, semi-elasticities are smaller. In fact, according to our estimations, an increase in one billion dollars invested by Japan abroad entails an average increase of only 2.8 % of Japanese exports and an average increase of only 2.1 % in each considered industry and each considered trading partner. As noticed by Silva and Tenreyro (2006), the PPML estimator correct the overevaulation of coefficients estimated by the OLS method.
Our results also indicate that the more Japan and its trading partner are similar in terms of GDP and the more they trade. Distance is also a key variable to understand Japanese exports and imports overseas. Estimation results reported in table 1, strongly support the idea that FDI and trade are complements in the Japanese manufacturing sector. This confirms previous studies on Japan at the country-level, especially those developed by Eaton and Tamura (1994) and Pantulu and Poon (2003). However, our results reveal that the intensity of the relationship is less important than in these previous analyses. Furthermore, the estimation using PPML points out that Japanese overseas investments have only a very small positive effect on the Japanese trade balance. It contrasts with OLS results which suggest a negative impact on the Japanese trade balance.

4.2. Sectoral breakdown of results

Table 2 and 3 report the estimated parameters from the nonlinear form of the model specification presented in equations (4) and (5) using the fixed effects PPML estimator for each of the nine sectors of 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	-0.0086	-0.0421	-0.0921	-0.0069***	-0.0005	0.0195	0.0062	0.0393	0.0392
	(0.0100)	(0.0088)	(0.0849)	(0.0849)	(0.0031)	(0.0045)	(0.0300)	(0.0253)	(0.0273)	(0.0244)
Ln(SIMGDP)	0.8021**	0.3697	0.0336	1.9051***	1.0459**	0.4078	1.3568***	0.7204	1.7464***	1.8378***
	(0.4035)	(0.3138)	(0.3815)	(0.3974)	(0.2557)	(0.3776)	(0.4217)	(0.4900)	(0.3132)	(0.4152)
Ln(SUMGDP)	-1.3951	-1.6625	-4.9655***	1.8521	3.3835***	-1.5464	3.2577*	1.7411	3.6543***	-2.2781
	(3.1394)	(1.6234)	(1.1508)	(1.1443)	(0.9114)	(2.1280)	(1.6981)	(1.3427)	(1.3151)	(1.8849)
Ln(DGDP)	0.3965	-0.0030	-1.1202***	0.3239	0.5718**	-0.8093	-0.1410	-0.0358	0.9557***	-0.6333
	(0.5853)	(0.4641)	(0.3108)	(0.3101)	(0.2381)	(0.5627)	(0.3828)	(0.3414)	(0.3596)	(0.4697)
Ln(DGDP*perC*)	0.3597***	-0.1795***	-0.1235**	-0.0491	-0.1388***	0.0179	-0.1386**	-0.0468	-0.0510	-0.2530***
	(0.0597)	(0.0727)	(0.0593)	(0.0687)	(0.0452)	(0.0392)	(0.0647)	(0.0486)	(0.0564)	(0.0773)
Ln(Real EX)	-0.2328	0.1287	-0.5410***	-0.6626***	0.0452	0.0161	0.2901	0.2936	-0.0355	0.2675*
	(0.2372)	(0.1988)	(0.2178)	(0.1901)	(0.0994)	(0.1738)	(0.2030)	(0.2203)	(0.1610)	(0.1598)
Ln(DIST)	-0.3320	1.1550	1.0618	-3.5497***	-1.8750***	1.4403	-1.2533	0.2735	-2.8769***	1.1369
	(1.4571)	(1.1657)	(0.7935)	(0.7795)	(0.4545)	(1.2032)	(0.8824)	(0.9421)	(0.8324)	(0.9574)
FTA dummy	0.0111	0.1033**	-0.0618	0.1145	0.0903***	0.2191***	-0.0207	-0.0547	0.0066	0.1485
	(0.1044)	(0.0504)	(0.0609)	(0.0832)	(0.0340)	(0.0586)	(0.1062)	(0.0661)	(0.0711)	(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

	PPML							
	General Machinery		Electric Machinery		Transportation		Precision Machinery	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
Real FDI	-0.0456***	-0.0537***	0.0130*	0.0023	0.0065***	-0.0054	0.0130	0.0650**
	(0.0148)	(0.0131)	(0.0070)	(0.0058)	(0.0024)	(0.0048)	(0.0201)	(0.0318)
Ln(SIMGDP)	1.0159***	0.5278	0.1084	-0.0137	3.1172***	1.9982**	0.2227	-1.0884
	(0.3734)	(0.3817)	(0.2678)	(0.2860)	(0.4440)	(0.9242)	(0.3481)	(0.8176)
Ln(SUMGDP)	4.9083***	2.1841***	3.8206***	1.5456	6.1748***	-2.3158	-1.9709	-4.5679**
	(1.9045)	(0.7999)	(1.2281)	(0.9993)	(1.5406)	(3.7666)	(1.2807)	(1.9009)
Ln(DGDP)	0.4227	-0.3441**	0.5639*	-0.1899	0.4770	-1.1281	-0.9615***	-0.9433**
	(0.4171)	(0.1488)	(0.3137)	(0.2544)	(0.4201)	(1.0076)	(0.3026)	(0.4845)
Ln(DGDP$perC$)	0.0096	-0.0439	0.0945**	0.0009	-0.0925**	0.0597	0.0208	0.0467
	(0.0627)	(0.0294)	(0.0437)	(0.0405)	(0.0465)	(0.0920)	(0.0557)	(0.0989)
Ln(Real EX)	-0.4186***	-0.3837***	-0.4460***	-0.3908*	-0.5295***	-0.7461	-0.8683***	-2.6241***
	(0.1641)	(0.1436)	(0.1394)	(0.2157)	(0.1883)	(0.4902)	(0.1984)	(0.6189)
Ln(DIST)	-3.4708***	-1.9032***	-3.1624***	-1.5507***	-4.0450***	-0.4868	0.4153	-0.3009
	(0.9590)	(0.5235)	(0.7464)	(0.6079)	(1.1221)	(2.2355)	(0.7501)	(0.9701)
FTA dummy	0.0057	0.0817*	0.0039	-0.0497	0.0470	0.3944***	0.0072	-0.2842***
	(0.0607)	(0.0447)	(0.0669)	(0.1014)	(0.0892)	(0.1488)	(0.0799)	(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 estimations include both country and time fixed effects. At first glance, we can remark that results are heterogeneous and depend on the sector under scrutiny. This conclusion concerns every explanatory variables, especially the one capturing real FDI.

Our estimations clearly point out that Japanese export flows are increasing with similarity between countries. Indeed, we can notice that the coefficient associated with the variable $SIMPIB_{ijt}$ is positive and highly significant for 6 sectors, especially for transportation equipments. The elasticity of this variable ranges from 0.80 to 3.11. Same conclusions can be done regarding the effect of $SUMGDP_{ijt}$ on exports, for which the coefficient is also positive and significant for 5 sectors under scrutiny. As for the variable $SIMPIB_{ijt}$, the strongest eslatiscity is recorded for transportation equipements. It means that the more the bilateral market size is high and the similarity in demand conditions is important and the more Japanese exports to this country in transportation equipments will be high. On the contrary results concerning textile and apparel show that Japanese exports increase when the trading partner has a small GDP relative to Japan.
Effects of these variables on Japanese imports are more diversified. Indeed, we can notice that similarity between Japan and its trading partners is only significant for textile and apparel, primary metals and transportation equipments. It confirms that trade in transportation equipements concerns mainly Japan and similar country, reflecting intra-industry trade.

Results concerning differences in factor endowments and factor incomes are also heterogeneous. Our estimations reveal that Japanese export flows in textile and apparel and in precision machinery decrease when the difference between the Japanese GDP and the GDP of its trading partner is high. This variable captures the ability of countries to provide differenciated products (Helpman and Krugman, 1985). Thus, in textile and precision machinery industries, demand for differentiated products will converge when countries have similar market sizes. In contrast, the elasticity of this variable is positive and significant for chemicals products, primary metals and electric machinery. Furthermore, this variable is only significant and negative for Japanese imports of general machinery.
Results concerning *per capita* GDP differences reflect the existence of intra-industry trade. Indeed, the more differences in *per capita* GDP are high, the more differences in factor endowments are important. When factor endowments are similar in two countries, it implies intra-industry trade. We can notice that for textile, chemicals, glass and ceramics and transportation equipements, the elasticity of the variable $DGDPperC_{ijt}$ is significant and negative and ranges from -0.09 to -0.14. This outcome reveal that these four sectors are characterized by an important intra-industry trade. Results are the opposite for food and beverages and electric machinery. This variable is also significant and negative for Japanese imports of food and beverages and primary metals.

We also find evidence that trade variables are important to evaluate Japan export performance in the manufacturing industry. Indeed, the PPML estimator indicates that

bilateral real exchange rate coefficient is statistically significant and negative for textile, general machinery, electric machinery, transportation equipments and precision machinery. These sectors have, therefore, been strongly affected by the appreciation of the yen against the dollar since the end of 2007[8]. 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 also reveal that estimated coefficients on distance are negative in most cases for Japanese manufacturing exports. This is noatbly the case for chemicals, primary metals, general machinery, electric machinery and transportation equipments. This suggest 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 no longer a trade impairment factors as it used to be due to the increased means of communication and transport. Results concerning distance and Japanese imports of manufacturing products are even less significant. Indeed, only three sectors (textile and apparel, general machinery and electric machinery) display a significant and negative coefficient for distance.
The dummy variable FTA_{ijt} have been introduced to identify the trade creation effect of free trade agreements. The results indicate that these agreements have only increased Japanese exports in chemicals products. In contrast, the estimated elasticities for Japanese imports are positive and significant in serveral manufacturing sectors. Thus, free trade trade agreements have enhanced Japanese imports of food and beverages, chemicals, general machinery and transportation equipments. This latter sector is even characterized by an elasticity of around 0.4.

Turning to the main focus of this paper, the effect of overseas investments appears to be heterogeneous for each Japanese manufacturing industry. First, we can notice that the Japanese stock of outward FDI has no significant impact on both exports and imports of food and beverages, textile and apparel, glass and ceramics and primary metals. For these sectors, there is no significant relationship between FDI and trade in Japan.
In contrast, the results indicate that overseas investments in chemicals products substitutes to Japanese exports in the same industry. However, the relationship is very small between FDI and exports. Indeed, an increase in one billion dollars invested by Japan abroad entails an average decrease of only 0.7 % of Japanese exports in chemicals products. At the end, outward FDI has a very small positive impact on trade balance of chemicals products. On the contrary, electric machinery is characterized by a small complementary relationship between Japanese overseas investment and exports.
The results for transportation equipments seem to confirm previous analysis on the Japanese automotive industry (Blonigen, 2001). In fact, we find evidence that Japanese overseas investements in transportation equipments creates exports on the world market. However, the semi-elasticity estimated using the PPML estimator for transportation equipments (0.006) is weak, especially relative to the one estimated for general machinery (in absolute terms). This suggest that the intensity of the complementary relationship between FDI and exports in the Japanese transportation industry is lower than we ex-

[8]Around 45 % in nominal terms according to the International Monetary Fund statistics

cpect and has strongly decreased over the recent period. A same observation has been made by Madariaga (2010) regarding the French automotive sector.
For the Japanese precision machinery industry, our results reveal there is only a complementary relationship between FDI and imports, which has a negative impact on the Japanese trade balance. Each new billion dollar 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 to both Japanese exports and imports in the general machinery industry. Indeed, an increase in Japanese outward investment of one billion dollars entails an average decrease of 4.6 % of Japanese exports of general machinery and an average decrease of 5.4 % of Japanese imports of general machinery. This leads to a strong increase of the Japanese trade balance.

5. Conclusion

The primary purpose of this paper was to investigate whether Japanese overseas investments in the manufacturing sector create or replace Japanese trade. To answer this problematic, we have run a macro-sectoral analysis using data on Japanese exports, imports and outward FDI stock concerning nine industries, thirty trading partners during the 2005-2011 period. Futhermore, as in the paper of Silva and Tenreyro (2006), we argue that the standard empirical procedures to estimate gravity equations with FDI as explanatory variable are inappropriate. Indeed, the estimation of gravity models of trade using OLS leads to biaised results on account of an heteroskedasticity problem and the fail to take into account zero-value observations (Westerlund and Whilhelmsson, 2011). To adress this problems, we choose to use the solution proposed by Silva and Tenreyro (2006) and implement a Poisson pseudo-maximum likelihood method to estimate our gravity equation. When we compare results of this estimation with those relying on the OLS estimator, we document significant differences, especially concerning real outward FDI. Thus, conclusions from the OLS estimator lead to overestimate the complementary relationship between Japanese overseas investments and trade. Indeed, if the PPML method confirms that Japanese outward FDI is globally trade creating in the manufacturing industry, the intensity of the relationship seems weaker than that suggested by the OLS estimator. These results support the idea that the PPML estimator should be used as a substitute for the standard log linear model in order to estimate gravity equations when assessing the relationship between FDI and trade.

The second contribution in this paper is to document the relationship between Japanese outward FDI and trade at a sectoral level. Our results demontrate that the complementary relationship found at the aggregate level is mainly due to three sectors: electric machinery, transportation equipment and precision machinery. The first two sectors are characterized by FDI creating exports and the third one, by Japanese overseas investments involving imports. We also find evidence that the relationship between 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 the evidence that international outsourcing run by Japanese firms has increased the Japanese export performance in the manufacturing industry. However, the impact seems weaker than in past years.

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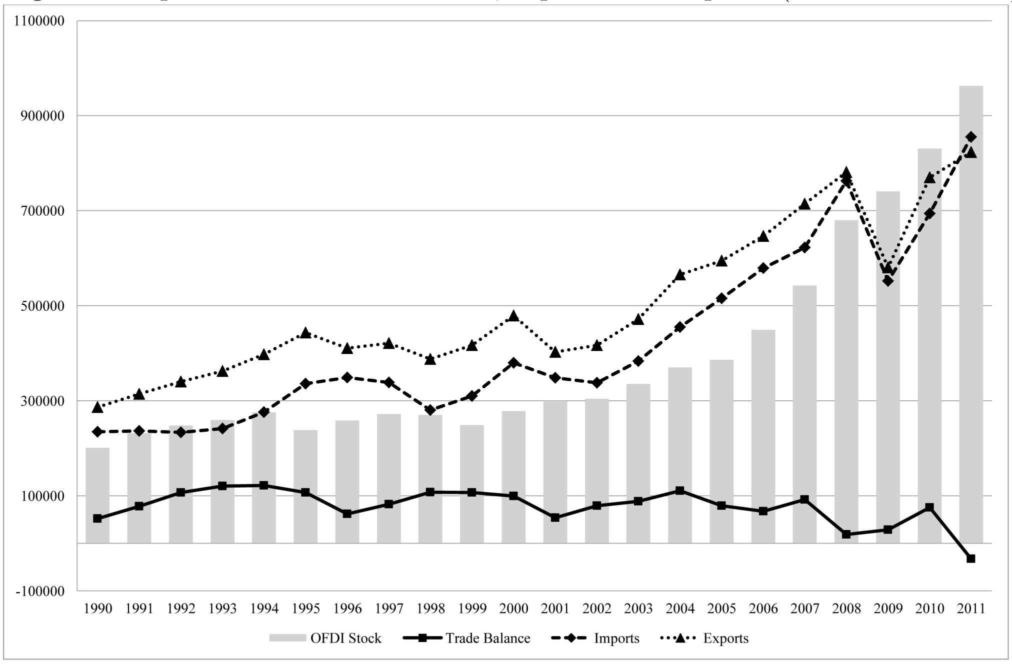
Appendices

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



Sources: UNCTAD, OECD

Table 4: Geographical distribution of Japan Outward FDI, exports and imports in 2010

	OFDI	Exports	Imports
Asia	37.5 %	53.8 %	43.8 %
China	13.4 %	22.0 %	22.8 %
North America	27.7 %	17.1 %	11.1%
United States	26.5 %	15.1 %	9.5 %
Latin America	5.2 %	5.5 %	3.5 %
Australie/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

Table 5: 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 %
Textile	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	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

Table 6: 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

Table 7: 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%
Textile 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%

Table 8: 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