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# The Sensitivity of Export Quantities to Exchange Rates in the Context of Intra-Industry Trade

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# The Sensitivity of Export Quantities to Exchange Rates in the Context of Intra-Industry Trade[†]

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## ABSTRACT

This paper adds to the literature that suggests that exports become less sensitive to exchange rate movements under certain circumstances. Focusing on the industry-specific sensitivity of export quantities to exchange rates in the context of intra-industry trade (IIT), this paper theoretically and empirically investigates this relationship. The model presented shows that the extent of bilateral IIT is higher the lower the elasticity of substitution between differentiated products and/or the smaller the gap in production costs between two countries. The empirical analysis investigates cross-country industry-panels for the bilateral trade of eight East Asian countries, Japan, and the United States with the EU, Asia, Japan, and North America. The results confirm that the sensitivity of export quantities to exchange rates declines as the extent of IIT increases. The policy implication of the results is that exchange rate revaluations become a less powerful tool to redress trade imbalances when substantial IIT exists.

Keywords: trade, exchange rates, intra-industry trade, product differentiation
JEL Classification Numbers: F00, F10, F14, F19

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# I. INTRODUCTION

Exchange rates play a key role in the literature on the determinants of trade, and this role receives a great deal of attention in the context of global imbalances. But whereas in past decades, trade disputes and exchange rate issues concentrated on Japan, more recently, such frictions have centered on China. There have been growing calls for China to allow its currency to appreciate to help rectify global imbalances. Yet, to what extent exchange rate realignment would indeed affect trade flows is still uncertain, despite the large number of studies that have tried to determine the influence of exchange rates on trade. The traditional approach placed great emphasis on the Marshall-Lerner condition, which is satisfied when the sum of the absolute value of the price elasticities of imports and exports exceeds one, using aggregate trade data (see, e.g., Houthakker and Magee (1969)). That is, studies along these lines examine whether or not the appreciation of a country's currency leads to the deterioration of its trade balance based on the Marshall-Lerner condition. There are also a number of more recent studies for various countries that are concerned with the Marshall-Lerner condition in the framework of partial equilibrium analysis, but empirical results regarding the effect of exchange rates on trade vary (see, e.g., the results of Rose (1990, 1991), Hooper, Johnson and Marquez (1998), and Chinn (2004, 2005)).

In addition, a considerable number of researchers have been interested in a more direct investigation of the relationship between trade and exchange rates. A series of studies on bilateral exchange rate elasticities of trade, mostly on U.S. trade with developed countries, concludes that trade flows are significantly affected by real exchange rates (e.g., Cushman (1990), Marquez (1990), Eaton and Tamura (1994), Bahmani-Oskooee and Brooks (1999), Nedenicheck (2000), and Bahmani-Oskooe and Goswami (2004)). An example of a study that includes developing countries is that by Thorbecke (2006), which uses panel gravity regression analysis to examine the trade of East Asian countries with the OECD countries, Argentina, Brazil, Mexico, and India. The advantage of bilateral trade analysis such as that conducted in these studies is that it reduces the aggregation bias found in the multilateral trade balance approach. However, more detailed and systematic investigation is necessary, because exchange rate elasticities of trade may differ across industries, and may be affected by various surrounding factors. Breuer and Clements (2003) found commodity-specific exchange rate elasticities for trade between the United States and Japan.

This paper adds to the literature that suggests that exports become less sensitive to exchange rate movements under certain circumstances. It is assumed that intra-industry trade (IIT) is an example of deepening bilateral trade ties. Focusing on the industry-specific sensitivity of exports to exchange rates in the context of IIT, this is, to the author's best knowledge, the first study to theoretically and empirically investigate this relationship. By definition, IIT is the exchange of goods in the same product category, and it is specifically assumed here that IIT consists of trade in differentiated products. Thus, it is assumed that more IIT implies a smaller elasticity of substitution among products and vice versa.[1] The theoretical model presented later in this paper clearly shows that higher IIT implies a smaller substitutability, and that the difference in production costs has an influence on IIT as well.

This paper hypothesizes that higher IIT reduces the effect of exchange rates on export quantities as a result of a smaller substitutability between differentiated products. The empirical analysis investigates cross-country industry-panels for the bilateral trade of notable trading pairs, that is, trade between eight East Asian countries (including China), Japan, and the United States on the one hand and the European Union countries (EU), Japan, Asia, and North America on the other (see Figure 1). Furthermore, unlike other studies that use real trade values, the present paper uses export quantity indices to measure real exports in order to determine the real effect of exchange rate movements on exports. Since it is assumed that the price and quantity of exports do not necessarily respond in the same way to exchange rate movements, it is more appropriate to measure "real" exports in quantities. The empirical results confirm that the exchange rate elasticities of export quantities decline as the extent of IIT increases as a result of a lower elasticity of substitution between differentiated products. An obvious policy implication of the findings is that the effectiveness of exchange rate adjustments as a policy tool for addressing trade imbalances diminishes when there is substantial IIT.

The remainder of this paper is organized as follows: Section 2 shows the linkages between IIT, the elasticity of substitution, and the difference in production costs using a monopolistic competition model. Section 3 presents the empirical model, and Section 4 discusses the data used in the empirical analysis. The results are presented in Section 5, and Section 6 concludes.

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[1] Brander and Krugman (1983) show that it is possible that IIT includes trade in standardized products as well. The analysis in this paper is based on the assumption that nearly standardized products (=products with a high substitution elasticity) play a negligible role in IIT.

## II. BACKGROUND AND THEORY

The aim of this paper is to show both theoretically and empirically that trade quantities between a pair of countries becomes less sensitive to exchange rate movements as intra-industry trade (IIT) deepens. IIT is defined as the exchange of goods in the same product category, and it is specifically assumed here that IIT consists of trade in differentiated products. That is, it is assumed that as product differentiation increases, IIT deepens and, at the same time, the elasticity of substitution among products becomes smaller. Thus, it is assumed that more IIT implies a smaller elasticity of substitution among products and vice versa. If a pair of countries produce non-differentiated products with a high elasticity of substitution, it would be more efficient for the two countries to gather all the production of a particular commodity in the country that has a comparative advantage.

In this paper, it is simply assumed that IIT is the exchange of differentiated products and IIT is not classified into different categories. However, in general, IIT is often divided into two types, vertical intra-industry trade (VIIT) and horizontal intra-industry trade (HIIT) (see, e.g., Fukao, Ishido and Ito (2003); Greenaway, Hine and Milner (1995); and Fontagné, Freudenberg and Péridy (1997)).[2] HIIT is presumed to occur in the case of goods that simply differ in terms of their attributes. On the other hand, VIIT is often considered to be the trade of differentiated products that have quality differences, since IIT is defined as vertical when the unit price of a commodity traded between a pair of countries is substantially different. Suppose countries *A* and *B* produce T-shirts *A* and *B* respectively, and they exchange their differentiated products. In the case that the prices of T-shirts *A* and *B* are similar, the exchange is called HIIT. On the other hand, if the prices of T-shirts *A* and *B* differ substantially, the exchange is regarded as VIIT. However, both T-shirts each face their own demand regardless of the types of IIT because they differ.

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[2] In these previous studies, IIT is first defined as cases where the extent of trade overlap is greater than 10 percent, and is then classified into VIIT and HIIT based on unit value ratios:

$$\frac{UVE_z}{UVI_z} < \frac{1}{\xi}, \frac{UVE_z}{UVI_z} > \xi \text{ : vertical intra-industry trade (VIIT)}$$

$$\frac{1}{\xi} \leq \frac{UVE_z}{UVI_z} \leq \xi \text{ : horizontal intra-industry trade (HIIT)}$$

where $\xi$ is 1.15 or 1.25, *UV* is the unit value, and *E* and *I* are the exports and imports of industry *z*.

Before moving on to the discussion of the theoretical model, it is useful to examine the importance of IIT by having a brief look at recent trends in the extent of IIT (see equation (8) for the derivation of the measure of the extent of IIT.) Figure 2(a) shows the time-series movements (from 1987 to 2004) in the average extent of IIT among thirty-eight trade pairs for the sixteen manufacturing industries analyzed in this paper: textiles, pulp and paper, chemical products, ceramics, iron and steel, metal products, general machinery, electrical machinery, transport equipment, precision instruments, leather products, apparel, lumber and wood products, rubber and plastics, petrochemical products, and non-ferrous. The figure indicates that the extent of IIT among the trade pairs analyzed in this paper has been on an increasing trend. In other words, IIT is playing an increasingly important role worldwide. In addition, Figure 2(b) shows the trends in China's IIT with four trading partner groups: the EU, Japan, Asia, and North America. Looking at the two figures, it can be seen that the extent of IIT in the different industries for China (Figure 2(b)), a leading emerging economy, is similar to the average for all thirty-eight trading pairs (Figure 2(a)). Moreover, it can be expected that IIT will continue to expand globally as income and technology levels of developing countries converge to those of developed countries.

The model presented in this section shows that the extent of IIT is higher the lower the elasticity of substitution between two products and/or the smaller the gap in production costs between two countries. The model assumes there are $Z$ industries and $N$ countries, and assumes trade in differentiated products in industry $z$ under Dixit and Stiglitz (1977) type monopolistic competition among $N$ countries. Furthermore, it is assumed that there exist $F_{z,n}$ identical firms in country $n$'s industry $z$.[3] All consumers have identical preferences. The utility-maximization problem of a representative consumer in importing country $j$ is as follows:[4]

$$\max \prod_{z=1}^{Z} \left( \sum_{n=1}^{N} \sum_{f=1}^{F_{z,n}} c_{z,n,f,j}{}^{\frac{\theta_z - 1}{\theta_z}} \right)^{\alpha_z \frac{\theta_z}{\theta_z - 1}} \tag{1}$$

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[3] An earlier version of this paper presented a two-country model (Oguro (2008)). However, the extension of the two-country setting into the $N$-country setting does not affect the model outcome.

[4] The derivation of equations (1) to (4) and of equation (7) basically follows Fukao, Okubo and Stern (2003).

subject to

$$\sum_{z=1}^{Z}\sum_{n=1}^{N}\sum_{f=1}^{F_{z,n_j}} p_{z,n,f}\cdot c_{z,n,f,j} = Y_j \tag{2}$$

$\theta_z$ denotes the elasticity of substitution among the differentiated products produced by all firms in industry *z*, which is greater than one. $c_{z,n,f,j}$ is country *j*'s consumption of firm *f*'s output in industry *z* in country *n*. $p_{z,n,f}$ denotes the price of firm *f*'s product in industry *z* in country *n*. For simplicity, trade costs are assumed to be zero. Moreover, it is assumed that a certain portion, $\alpha_z$, of country *j*'s national income, $Y_j$, is used for the consumption of industry *z*'s products produced in *N* countries.

Solving the utility maximization problem, country *j*'s demand for firm *f*'s output in industry *z* in country *n*, $c_{z,n,f,j}$, is derived as follows:

$$c_{z,n,f,j} = \frac{1}{\sum_{n=1}^{N} F_{z,n}}\cdot\left(\frac{p_{z,n,f}}{P_{z,j}}\right)^{-\theta_z}\cdot\frac{\alpha_z Y_j}{P_{z,j}} \tag{3}$$

where $$P_{z,j} = \left[\frac{\sum_{n=1}^{N}\sum_{f=1}^{F_{z,n}}\left(p_{z,n,f}\right)^{1-\theta_z}}{\sum_{n=1}^{N} F_{z,n}}\right]^{\frac{1}{1-\theta_z}} \tag{4}$$

Assume further that the number of firms in industry *z* in country *n*, $F_{z,n}$, is defined as a certain ratio, $\eta_z$, to country *n*'s national income, $Y_n$. In addition, $p_{z,n,f} = p_{z,n}$, since firms are assumed to be identical in each country. In addition, country *j*'s price index of industry *z*'s output, $P_{z,j}$, above can be simplified as $P_z$.[5] Then, the value of exports in industry *z* from country *A* to country *B* and that from country *B* to country *A* respectively are defined as follows:

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[5] All prices are considered in the U.S. dollar, and this paper implicitly assumes perfect exchange rate pass-through into trade prices. Additionally, trade costs are assumed to be zero. Hence, a firm's product is sold for the same price in U.S. dollar everywhere.

$$EX_{z,AB} = \frac{\eta_z Y_A}{\eta_z (Y_A + Y_B + \cdots + Y_N)} \cdot p_{z,A} \cdot \left( \frac{p_{z,A}}{P_z} \right)^{-\theta_z} \cdot \frac{\alpha_z Y_B}{P_z} = \frac{Y_A}{\sum_{n=1}^{N} Y_n} \cdot p_{z,A} \cdot \left( \frac{p_{z,A}}{P_z} \right)^{-\theta_z} \cdot \frac{\alpha_z Y_B}{P_z} \tag{5}$$

$$EX_{z,BA} = \frac{\eta_z Y_B}{\eta_z (Y_A + Y_B + \cdots + Y_N)} \cdot p_{z,B} \cdot \left( \frac{p_{z,B}}{P_z} \right)^{-\theta_z} \cdot \frac{\alpha_z Y_A}{P_z} = \frac{Y_B}{\sum_{n=1}^{N} Y_n} \cdot p_{z,B} \cdot \left( \frac{p_{z,B}}{P_z} \right)^{-\theta_z} \cdot \frac{\alpha_z Y_A}{P_z} \tag{6}$$

The next step is to solve for $p_{z,n}$. Each identical firm in industry *z* in country *n* is defined to have cost function $C_{z,n,f} = C_{z,n}$, consisting of marginal cost $MC_{z,n,f} = MC_{z,n}$, and fixed cost $FC_{z,n,f} = FC_{z,n}$. Using the profit maximization condition, $p_{z,n,f} = p_{z,n}$ is derived as follows:[6]

$$p_{z,n,f} = p_{z,n} = \frac{\theta_z}{\theta_z - 1} \cdot MC_{z,n,f} = \frac{\theta_z}{\theta_z - 1} \cdot MC_{z,n} \tag{7}$$

Following previous studies (such as Fukao, Ishido and Ito (2003); Greenaway, Hine and Milner (1995); and Fontagné, Freudenberg and Péridy (1997)), the degree of intra-industry trade (IIT) in industry *z* between countries *A* and *B* is defined as the value of trade overlap and takes a value between 0 and 1:[7]

$$\mathrm{IIT}_{z,AB}\text{:}\quad \frac{Min(EX_{z,AB}, EX_{z,BA})}{Max(EX_{z,AB}, EX_{z,BA})} = \frac{Min(EX_{z,AB}, IM_{z,AB})}{Max(EX_{z,AB}, IM_{z,AB})} \tag{8}$$

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[6] Following Dixit and Stiglitz (1977), the price changes of any individual firms have a negligible impact on industry *z*'s price level. In addition, reasons that may make $\theta_z$ vary, such as differences in the degree of competition in each country, are not considered here. Hence, each firm's optimal price $p_{z,n,f} = p_{z,n}$ is a constant mark-up over marginal cost $MC_{z,n,f} = MC_{z,n}$.

[7] $IM_{z,AB}$ represents country *A*'s value of imports of industry *z* goods from country *B*. The calculation of the IIT index for country *A* in this paper is conducted using $EX_{z,AB}$ and $IM_{z,AB}$, and is inevitably biased because the export data are reported on an f.o.b. basis while the import data are measured on a c.i.f. basis.

Grubel and Lloyd (1975) developed a similar index for IIT, and the index is one of the earliest works on IIT:

$$GLI_{z,AB} = 1 - \frac{\sum |EX_{z,AB} - EX_{z,BA}|}{\sum |EX_{z,AB} + EX_{z,BA}|}$$

Using (5), (6), (7), and (8), IIT$_{z,AB}$ can be written as follows:[8]

$$\mathrm{IIT}_{z,AB} = \frac{EX_{z,AB}}{EX_{z,BA}} = \left(\frac{p_{z,A}}{p_{z,B}}\right)^{1-\theta_z} = \left(\frac{\frac{\theta_z}{\theta_z - 1}\cdot MC_{z,A}}{\frac{\theta_z}{\theta_z - 1}\cdot MC_{z,B}}\right)^{1-\theta_z} = \left(\frac{MC_{z,B}}{MC_{z,A}}\right)^{\theta_z - 1} \quad \text{when } MC_{z,A} > MC_{z,B}$$

$$= \frac{EX_{z,BA}}{EX_{z,AB}} = \left(\frac{p_{z,B}}{p_{z,A}}\right)^{1-\theta_z} = \left(\frac{\frac{\theta_z}{\theta_z - 1}\cdot MC_{z,B}}{\frac{\theta_z}{\theta_z - 1}\cdot MC_{z,A}}\right)^{1-\theta_z} = \left(\frac{MC_{z,A}}{MC_{z,B}}\right)^{\theta_z - 1} \quad \text{when } MC_{z,A} < MC_{z,B} \tag{9}$$

Thus, the model shows that IIT in industry *z* between two countries becomes larger as the elasticity of substitution $\theta_z$ and/or the bilateral $MC_z$ gap become smaller.[9]

## III. EMPIRICAL MODEL

The hypothesis that export sensitivity to exchange rates is reduced in the context of IIT is tested using a data set for the bilateral trade of ten countries with four major trading partner groups. As shown in Figure 1, the ten exporting countries are: China, Hong Kong SAR, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Thailand, and the United States; and the four importing groups are: (i) the EU15 (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom), (ii) Japan, (iii) Asia (China, Hong Kong SAR,

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[8] While the theoretical model presented here assumes that the elasticity of substitution is the same among products in the same product category in *N* countries, this assumption is relaxed in the empirical analysis for each industry later in this paper and differences in the elasticity of substitution among products in industry *z*, $\theta_z$, from trade pair to trade pair because of differences in commodity compositions are implicitly allowed for. In addition, time-series differences in $\theta_{z,t}$ between each pair of countries engaged in IIT because of yearly variations in commodity compositions are implicitly considered in the empirical analysis. $\theta_z$ may also differ for other reasons, such as differences in competition in a pair of countries, but these aspects are not considered here.

[9] As equation (9) shows, IIT is higher when it is horizontal given the same level of $\theta_z$.

Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan, Thailand),[10] and (iv) North America (Canada and the United States). Sixteen manufacturing industry panels[11] (textiles, pulp and paper, chemical products, ceramics, iron and steel, metal products, general machinery, electrical machinery, transport equipment, precision instruments, apparel, leather products, lumber and wood products, rubber and plastics, petrochemical products, and non-ferrous) consisting of the above thirty-eight trade pairs are compiled and examined.[12] The extent of IIT in the sixteen industries varies considerably, ranging from high to low. The average extent of IIT is shown at the bottom of Table 1 in the row labeled "IIT Average." The extent of IIT in the electrical machinery, precision instruments, and general machinery industries is high with averages of 0.297, 0.193, and 0.182, respectively. This result is in line with the study by Fukao, Ishido and Ito (2003), who also classify these as high IIT industries both in intra-East Asian and in intra-EU trade. The extent of IIT in the metal products, chemical products, transport equipment, rubber and plastics, and pulp and paper industries is in the intermediate range with an average of 0.157, 0.122, 0.118, 0.116, and 0.102, respectively. The average extent of IIT in the remaining industries is smaller than 0.1, which is below the threshold to be defined as IIT. The data used for this study are annual data for the period 1976 to 2004 (see Section IV below). The data set is an unbalanced panel with the data span for China being the shortest (starting in 1989).

The empirical model is derived from equation (5) or (6) and estimated. Equation (5) or (6) can be rewritten as the bilateral real export (export quantities, *QEX*) equation of industry *z*, from country *n* to country *j* as follows:

$$QEX_{z,nj} = \frac{Y_n \cdot Y_j}{P_z} \cdot \left( \frac{p_{z,n}}{P_z} \right)^{-\theta_z} \cdot \frac{\alpha_z}{\sum_{n=1}^{N} Y_n} \qquad (5)'$$

Log linearization of equation (5)' leads to the following equation:

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[10] When one of the countries in Asia as defined here is an exporter, the country itself is excluded from the group, Asia. For instance, China is excluded from Asia for the trading pair China–Asia.

[11] The paper follows the industry classification in Kuroko (2006), which is based on the SITC and consists of twenty industries. Four industries that are not analyzed in this paper are: agricultural products, mining, foodstuffs, and miscellaneous products.

[12] The pairs Japan–Japan and United States–North America are excluded.

$$\log QEX_{z,nj} = \log\left(\frac{Y_n}{P_z}\right) + \log\left(\frac{Y_j}{P_z}\right) - \theta_z \log\left(\frac{p_{z,n}}{P_z}\right) + \log\left(\frac{\alpha_z \cdot P_z}{\sum_{n=1}^{N} Y_n}\right) \tag{10}$$

Using this basic model, the aim is to obtain industry-specific exchange rate elasticities of exports and determine the influence of IIT on export sensitivity to exchange rates. The equation to be empirically estimated is derived from equation (10) with some modifications. First, $(Y_n / P_z)$ and $(Y_j / P_z)$ is rewritten as the exporter's real GDP ($GDPex_n$) and the importer's real GDP ($GDPim_j$), respectively, which are based on national currencies. Second, the real price of a firm's product in country *n*, $\left(p_{z,n}/P_z\right)$, is replaced by the real exchange rate ($ER_{nj}$) between two countries, which is used as a proxy for the relative price. Third, in the empirical analysis, a higher degree of IIT ($IIT_{z,nj}$) is used as a proxy for a smaller elasticity of substitution, $\theta_z$. Thus, it is necessary to control for the influence of the difference in production costs following the theoretical model presented. That is, the cross-term of the absolute value of the bilateral difference in per capita real GDP ($GDPpcgap_{nj}$) and $ER_{nj}$ is included as well in order to exclude any influence of $GDPpcgap_{nj}$ from $IIT_{z,nj}$.[13] $GDPpcgap_{nj}$ is used as a proxy for the gap in production costs between a pair of countries. Finally, as real exports might be influenced by past values of variables, lags of $ER_{nj}$, $GDPpcgap_{nj}$, and $IIT_{z,nj}$ are considered. Therefore, equation (11) below, which contains lagged terms, is estimated using panels for each industry:[14]

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[13] From equation (9),

$$\theta_z = \frac{\log IIT_{z,nj}}{\log\left(MC_{z,j}/MC_{z,n}\right)} \text{ when } MC_{z,n} > MC_{z,j}, \quad \theta_z = \frac{\log IIT_{z,nj}}{\log\left(MC_{z,n}/MC_{z,j}\right)} \text{ when } MC_{z,n} < MC_{z,j}.$$

Thus, $\theta_z$ is smaller the higher the extent of bilateral IIT under a certain level of the gap in production costs, and $\theta_z$ is smaller the larger the difference in production costs under a certain degree of IIT.

In addition, there is concern about the correlation between a higher IIT and a smaller per capita real GDP gap based on equation (9). In such a case, the regression results obtained are not reliable. The correlation coefficients between IIT and the gap in per capita GDP for the sixteen industries are reported at the bottom of Table 1. The correlation is not negligible only for the apparel industry with a correlation coefficient of -0.44.

[14] Each industry panel consists of the thirty-eight bilateral real export equations.

Since trade costs are assumed to be zero for simplicity in the theoretical model, the distance term does not appear in equation (11). However, the empirical results do not differ substantially when the distance term is

(continued…)

$$\begin{aligned}\log QEX_{z,njt} &= \beta_0 + \beta_1 \log GDPex_{n,t} + \beta_2 \log GDPim_{j,t} + \sum\nolimits_{k=0}^{K} \beta_{3k} \log ER_{nj,t-k} \\ &\quad + \sum\nolimits_{k=0}^{K} \beta_{4k} GDPpcgap_{nj,t-k} \cdot \log ER_{nj,t-k} + \sum\nolimits_{k=0}^{K} \beta_{5k} IIT_{z,nj,t-k} \cdot \log ER_{nj,t-k} \\ &\quad + \sum\nolimits_{k=0}^{K} \beta_{6k} GDPpcgap_{nj,t-k} + \sum\nolimits_{k=0}^{K} \beta_{7k} IIT_{z,ij,t-k} + \omega_{z,nj} + \varepsilon_{z,njt}\end{aligned}$$

$$\beta_1, \beta_2, \beta_{4k}, \beta_{5k} > 0; \quad \beta_{3k} < 0 \tag{11}$$

where $\omega_{z,nj}$ represents trade-pair-specific factors, and $\varepsilon_{z,njt}$ is the error term.

Since it is impossible to control for all trading-pair-specific factors, which are represented by $\omega_{z,nj}$, the thirty-eight bilateral trade pairs are considered as thirty-eight cross-sectional groups in each industry-panel. The expected sign of $\beta_{3k}$ is negative, whereas $\beta_{4k}$ and $\beta_{5k}$ are expected to be positive. This is because, in general, exports are negatively affected when the exporter's exchange rate appreciates, and a higher degree of IIT and a larger per capita real GDP gap are expected to lower export sensitivity to exchange rates as a result of a lower substitutability.

## IV. DATA

While other studies typically use real trade values, the present paper chooses to use export quantities in order to measure "real" exports. The rationale is that the price and quantity of exports do not necessarily respond in the same way to exchange rate movements. In addition, it is impossible to find industry-specific deflators for the value of each industry's exports. The real export volume ($QEX_{z,nj}$) used here is the export quantity index developed by Kuroko (2006) using the United Nations Commodity Trade Statistics

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or is not included as a whole, and the estimated coefficient of the term is statistically significant only in two industries: ceramics (significant at the 5 percent level with a positive sign) and iron and steel (significant at the 10 percent level with a negative sign). Therefore, the distance term is omitted from the regressions. The great circle distances between the economic centers are calculated using the latitude and longitude dataset provided by the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) (http://www.cepii.fr/anglaisgraph/bdd/distances.htm).

Database (Comtrade database). It is useful to use quantity index data rather than quantity data itself since quantity units differ from commodity to commodity.[15]

The real exchange rate ($ER_{nj}$) is defined as the units of importer currency per unit of exporter currency, and is deflated by the respective consumer price index (CPI).[16] Exporters' and importers' real GDP ($GDPex_n$, $GDPim_j$), exchange rates, and CPIs are taken from the IMF's *International Financial Statistics* (IFS), except in the case of Taiwan, for which data are taken from the database of CEIC Data Company Ltd. Per capita real GDP gaps ($GDPpcgap_{nj}$) are calculated in U.S. dollars. The degree of IIT for each trading pair and for the sixteen industries is calculated using the SITC 5-digit-based data of the Comtrade database, which is the most detailed data available. The SITC 5-digit-based extent-of-IIT data for each pair of countries are aggregated into the sixteen industries and the thirty-eight trade pairs weighted by trade values. Hence, the calculations of the degree of IIT avoid the inclusion of the exchange of goods that differ in each industry. The variables $QEX_{z,nj}$, $GDPex_n$, $GDPim_j$, and $ER_{nj}$ are indices which are set to 100 for the base year, 2000. Finally, when the trading partner is a group of countries, i.e., the EU, Asia, or North America, $GDPim_j$, $ER_{nj}$, and $GDPpcgap_{nj}$ are the weighted averages using GDP (in U.S. dollars) as the weight.[17]

## V. EMPIRICAL RESULTS

To estimate the real export equation (11), the analysis uses unbalanced annual data from 1976 to 2004. The maximum lag length adopted is two years given the limited time series for some pairs. As reported in Table 1, based on the Hausman test, a fixed effects model is accepted for the textiles, ceramics, metal products, general machinery, electrical machinery,

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[15] Kuroko's (2006) export quantity index is calculated by dividing the export value index by the Fisher unit price index. Almost 75 percent of the Comtrade data are in kilograms.

[16] Due to data constraints, the Balassa-Samuelson effect cannot be fully excluded.

[17] An earlier version of this paper (Oguro (2008)) additionally conducts the Johansen's (trace) cointegration test for each trade pair for each industry to examine the validity of the long-run equilibrium in the estimation model (equation (11)). The results show the existence of cointegrating relationships among variables in each time-series export equation for the thirty-eight trade pairs in the panel of each industry that the tests were conducted. Oguro (2008) analyzes only six industries: textiles, pulp and paper, metal products, general machinery, electrical machinery, and precision instruments.

precision instruments, apparel, lumber and wood products, and non-ferrous industries. A random effects model is accepted for the pulp and paper, chemical products, iron and steel, transport equipment, leather products, rubber and plastics, and petrochemical products industries.[18] Although regression results based on both the fixed effects and the random effects models are reported in Table 1, the discussion below concentrates on the results of the estimation model selected by the Hausman test.[19]

Six out of the sixteen industries are excluded from the discussion hereafter: leather products, apparel, lumber and wood products, rubber and plastics, petrochemical products, and non-ferrous. The average extent of IIT in these industries except in the rubber and plastics industry is smaller than 0.1 and is below the threshold to be defined as IIT. The empirical results for the six industries are shown only for the short-run in the last six columns of Table 1. The exports of the apparel, lumber and wood products, and petrochemical products industries seem to be independent of exchange rates. All of the estimated coefficients on $\log ER_{nj}(t)$, $\log ER_{nj}(t-1)$, and $\log ER_{nj}(t-2)$ are not statistically significant in the three industries. Also, the estimated coefficient of $\log ER_{nj}(t-2)$ for the leather products industry is significant only at the 10 percent level. In addition, for the rubber and plastics and non-ferrous industries, the coefficients of $\log ER_{nj}(t)$ are unexpectedly positive, but are statistically significant. That is, the realization of the relationship between exchange rate movements and export quantities seems to be different from the setting considered here for the two industries.

The empirical results for the short-run and long-run steady state for the ten industries are shown in Table 1: texitiles, pulp and paper, chemical products, ceramics, iron and steel, metal products, general machinery, electrical machinery, transport equipment, and precision instruments. In the short-run analysis, the estimated coefficients of the variables of primary interest, $\log ER_{nj}$ and $IIT_{z,nj}*\log ER_{nj}$, are statistically significant at least at one of the three times, $t$, $t-1$, and $t-2$, in all industries except in the general machinery industry. In the ten industries, the signs of the significant coefficients of $\log ER_{nj}$ are negative, and those of $IIT_{z,nj}*\log ER_{nj}$ are positive, as expected. In the case of the general machinery industry, the coefficient of $IIT_{z,nj}*\log ER_{nj}$ at times $t$, $t-1$, and $t-2$ are posititive, but are not significant.

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[18] The Hausman specification tests are conducted using the two covariance matrices based on the estimated disturbance variance from the efficient estimator.

[19] The estimation model selected by the Hausman test is underlined in Table 1. All regressions are with heteroskedasticity-robust standard errors.

The results indicate that, at least at one of the three times, real exports in the ten industries are negatively related with $\log ER_{nj}$ and a higher extent of IIT reduces export sensitivity to exchange rates. Among the statistically significant coefficients on $GDPpcgap_{nj}(t)*\log ER_{nj}(t)$, $GDPpcgap_{nj}(t-1)*\log ER_{nj}(t-1)$, and $GDPpcgap_{nj}(t-2)*\log ER_{nj}(t-2)$, negative coefficients can be found as well for the pulp and paper, chemical products, and electrical machinery industries, which is in conflict with expectations. Only the coefficient on $GDPpcgap_{nj}(t)*\log ER_{nj}(t)$ in the transport equipment industry is positive as expected and is significant. Thus, broadly speaking, the impact of the gap in production costs on export sensitivity to exchange rates varies across industries.

In the steady state analysis, the coefficients of the variables of primary interest, $\log ER_{nj}$ and $IIT_{z,nj}*\log ER_{nj}$, are significantly different from zero at the 1 or 5 percent level for all ten industries. As predicted, the coefficient of $\log ER_{nj}$ is negative, whereas that of $IIT_{z,nj}*\log ER_{nj}$ is positive. For instance, in Table 1, in the case of the electrical machinery industry, the estimated coefficient of $\log ER_{nj}$ is -2.234 and that of $IIT_{z,nj}*\log ER_{nj}$ is 7.124. However, amongst the ten industries, statistically significant coefficients for $GDPpcgap_{nj}*\log ER_{nj}$ with the expected (positive) sign are obtained only for the transport equipment industry.

The impact of IIT on the sensitivity of export quantities to exchange rates in the steady state can be clearly seen in the two rows highlighted in **bold** in Table 1. The estimates suggest that, in the case of the electrical machinery industry for example, a one percent increase in the real exchange rate results in a 2.234 percent decline in the quantity of exports in the absence of IIT. When IIT is taken into account, and using the average degree of IIT, the exchange rate elasticity of export quantities of the electrical machinery industry declines to -0.120.

As a whole, the results provide empirical support for the hypothesis that higher IIT reduces the export sensitivity to exchange rates as a result of a lower elasticity of substitution between differentiated products when the appreciation of exchange rates has the negative impact on exports. In other words, the empirical results show that a reduction in export quantities as a result of the appreciation of an exporter’s currency becomes less pronounced the higher the extent of IIT. According to the theoretical model presented above, IIT is higher the smaller the elasticity of substitution between differentiated products and/or the smaller the gap in production costs between a pair of countries. However, the influence of the gap in production costs on the exchange rate elasticities of exports varies across industries. The results presented here provide some insights as to why the exchange rate elasticities of exports of Asian countries with high or increasing IIT may be low or declining. For policy makers, these results imply that the effectiveness of exchange rate adjustments with the aim of addressing trade imbalances diminishes with the extent of IIT.[20]

## VI. CONCLUSION

Exchange rates have long been at the center of the debate on global imbalances. While in the 1980s, imbalances between Japan and the United States directed the spotlight at the yen, more recently it has been the imbalances between China and the United States, which have led to calls for a revaluation of yuan. Generally, it is assumed that the appreciation of an exporter's currency will increase the relative price of exports and hence is expected to reduce exports.

Against this background, the main purpose of this paper was to examine the hypothesis that the sensitivity of export quantities to exchange rates is reduced as the extent of IIT increases. The hypothesis is based on the assumption that a higher degree of IIT implies a lower elasticity of substitution among differentiated products and vice versa. That is, it is assumed that as product differentiation increases, IIT deepens, and at the same time the elasticity of substitution among products becomes smaller. A theoretical model was proposed that explains this relation. According to the model presented, a higher degree of IIT is also linked with a smaller bilateral gap in production costs. In order to test this model empirically, estimations were conducted using sixteen separate industry panels for thirty-eight trading pairs that include China, the United States, and Japan. The sixteen manufacturing industries analyzed in this paper vary regarding the extent of intra-industry trade (IIT). Using the export quantity index data to measure real exports, the empirical results confirm that the appreciation of an exporter's currency reduces export quantities, and confirm that the exchange rate elasticities of export quantities vary across industries. Moreover, the results confirm that the negative impact of exchange rate appreciation on exports decreases the higher the degree of IIT as a result of a lower elasticity of

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[20] A concrete example is provided in Oguro, Fukao and Khatri (2008), which presents the simulation of real exchange rate elasticities of China's exports to North America.

substitution between differentiated products. However, the impact of the gap in production costs on export sensitivity to exchange rates does not necessarily follow the theoretical model.

The empirical finding that IIT lowers trade sensitivity to exchange rates suggests that the role that exchange rates can play in addressing trade imbalances diminishes in circumstances where IIT is high. Both the theoretical model presented above (see equation (9)) as well as recent trends suggest that IIT is bound to continue to increase as income and technology levels of developing countries converge to those of developed countries. Consequently, exchange rate devaluations (or revaluations) are becoming a less powerful tool to redress global imbalances, and the empirical results obtained here suggest that even if China were to revalue its currency, the desired effect may be smaller than many of those calling for such a step expect.

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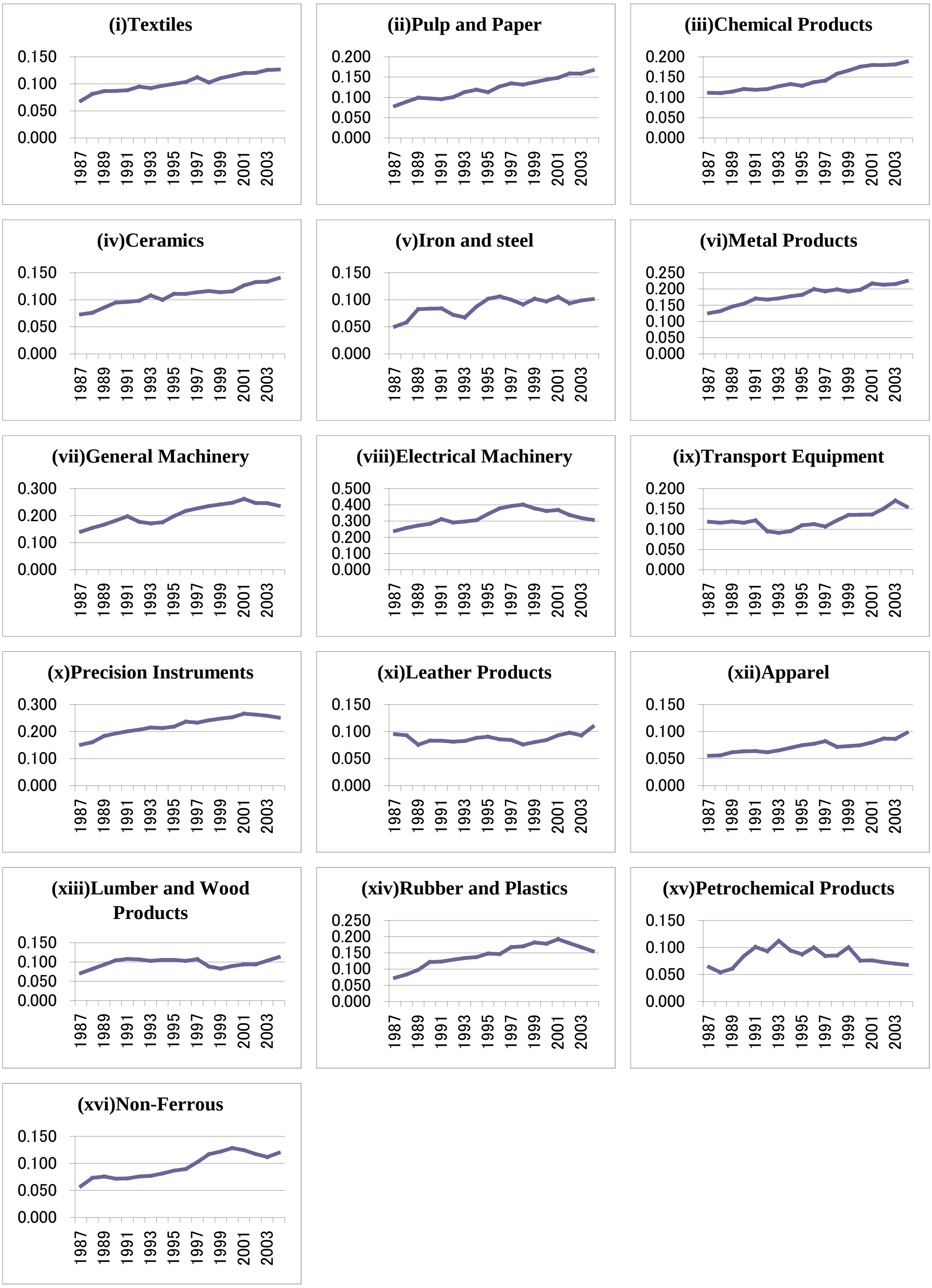
Figure 1: Thirty-Eight Trade Pairs

| **EXPORTERS** | **IMPORTERS** |
|---|---|
| China | the EU |
| Hong Kong SAR | (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, the United Kingdom) |
| Indonesia | |
| Japan | Japan |
| Korea | |
| Malaysia | |
| The Philippines | Asia |
| Singapore | (China, Hong Kong SAR, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan, Thailand) |
| Thailand | |
| the United States | North America |
| | (Canada, the United States) |

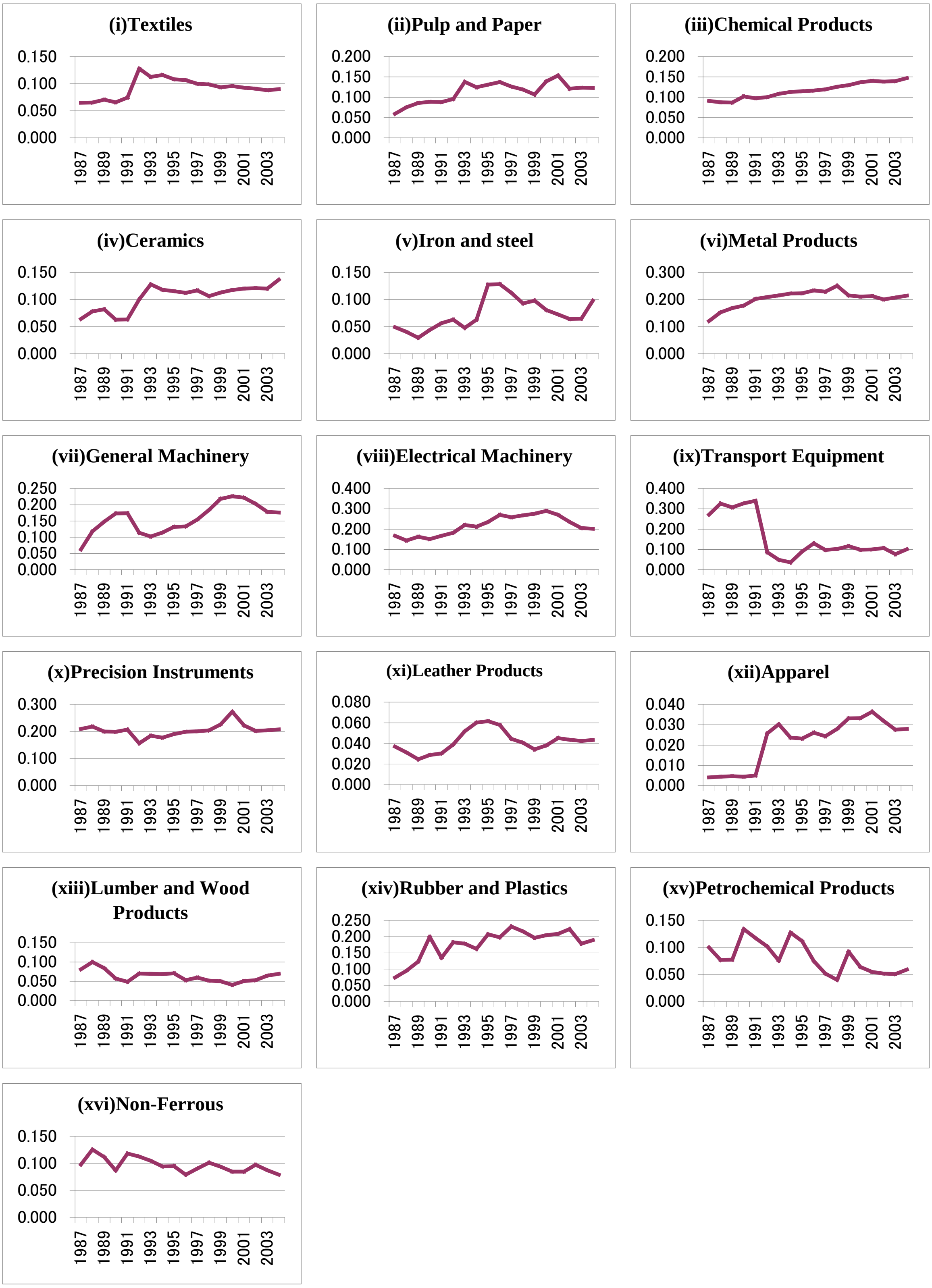
The sixteen manufacturing industries analyzed in this paper are:
textiles, pulp and paper, chemical products, ceramics, iron and steel, metal products, general machinery, electrical machinery, transport equipment, precision instruments, apparel, leather products, lumber and wood products, rubber and plastics, petrochemical products, and non-ferrous.

Figure 2(a): Degree of Intra-Industry Trade



Note: Average degree of intra-industry trade (IIT) among the 38 trade pairs.
Source: Author's calculations. See Section IV for details on data sources.

Figure 2(b): China’s Degree of Intra-Industry Trade



Note: China's average degree of intra-industry trade (IIT) with four trading partners:
EU, Japan, Asia, and North America.

Source: Author's calculations. See Section IV for details on data sources.

Table 1. Estimation Results of the Export Equation

| | (i) | | (ii) | | (iii) | | (iv) | |
|---|---|---|---|---|---|---|---|---|
| | **Textiles** | | **Pulp and Paper** | | **Chemical Products** | | **Ceramics** | |
| Dependent Variable: logQEX(t) | Fixed Effects Estimates | Random Effects Estimates | Fixed Effects Estimates | Random Effects Estimates | Fixed Effects Estimates | Random Effects Estimates | Fixed Effects Estimates | Random Effects Estimates |
| logGDPex(t) | 0.113 | 0.124 | 1.120 *** | 1.099 *** | 1.769 *** | 1.764 *** | 0.580 *** | 0.525 *** |
| | (1.40) | (1.55) | (7.56) | (7.35) | (17.79) | (17.53) | (5.26) | (4.55) |
| logGDPim(t) | 1.989 *** | 1.881 *** | 2.065 *** | 2.016 *** | 0.961 *** | 0.928 *** | 1.536 *** | 1.570 *** |
| | (14.14) | (14.59) | (11.27) | (10.85) | (9.00) | (8.42) | (9.14) | (9.63) |
| logER(t) | -1.413 *** | -1.369 *** | -0.845 | -0.834 | -0.803 ** | -0.790 ** | -0.209 | -0.264 |
| | (-3.30) | (-3.13) | (-1.62) | (-1.55) | (-2.20) | (-2.11) | (-0.49) | (-0.59) |
| logER(t-1) | -0.337 | -0.330 | -0.381 | -0.384 | -0.210 | -0.213 | -0.765 | -0.742 |
| | (-0.64) | (-0.60) | (-0.58) | (-0.56) | (-0.46) | (-0.45) | (-1.58) | (-1.42) |
| logER(t-2) | -0.902 *** | -0.857 ** | -1.017 ** | -1.005 ** | 0.351 | 0.403 | -1.145 *** | -1.155 *** |
| | (-2.70) | (-2.51) | (-2.25) | (-2.12) | (0.99) | (1.10) | (-2.92) | (-2.80) |
| GDPpcgap(t)*logER(t) | -0.007 | -0.006 | -0.048 ** | -0.045 ** | -0.007 | -0.005 | -0.014 | -0.013 |
| | (-0.40) | (-0.38) | (-2.15) | (-1.97) | (-0.53) | (-0.41) | (-0.66) | (-0.64) |
| GDPpcgap(t-1)*logER(t-1) | -0.003 | -0.003 | -0.002 | -0.002 | -0.007 | -0.007 | 0.006 | 0.005 |
| | (-0.18) | (-0.17) | (-0.09) | (-0.08) | (-0.44) | (-0.44) | (0.31) | (0.26) |
| GDPpcgap(t-2)*logER(t-2) | -0.000 | -0.001 | -0.072 *** | -0.070 *** | -0.019 | -0.019 * | -0.023 | -0.023 |
| | (-0.01) | (-0.06) | (-3.62) | (-3.55) | (-1.61) | (-1.72) | (-1.46) | (-1.41) |
| IIT(t)*logER(t) | 7.654 *** | 7.231 ** | 9.825 *** | 9.512 *** | 3.038 ** | 2.972 * | 7.101 *** | 7.328 *** |
| | (2.61) | (2.38) | (3.55) | (3.42) | (1.98) | (1.91) | (2.74) | (2.84) |
| IIT(t-1)*logER(t-1) | -1.467 | -1.418 | -1.522 | -1.443 | 0.661 | 0.679 | -0.803 | -0.757 |
| | (-0.43) | (-0.39) | (-0.44) | (-0.41) | (0.34) | (0.34) | (-0.28) | (-0.26) |
| IIT(t-2)*logER(t-2) | 3.151 | 2.978 | 10.489 *** | 10.228 *** | -0.332 | -0.552 | 6.464 *** | 6.526 *** |
| | (1.37) | (1.22) | (4.39) | (4.19) | (-0.23) | (-0.37) | (2.73) | (2.74) |
| GDPpcgap(t) | 0.026 | 0.027 | 0.209 ** | 0.200 ** | 0.030 | 0.027 | 0.092 | 0.080 |
| | (0.35) | (0.35) | (2.11) | (1.99) | (0.50) | (0.47) | (1.00) | (0.90) |
| GDPpcgap(t-1) | 0.015 | 0.016 | 0.010 | 0.007 | 0.031 | 0.028 | -0.041 | -0.032 |
| | (0.19) | (0.20) | (0.08) | (0.06) | (0.44) | (0.42) | (-0.46) | (-0.37) |
| GDPpcgap(t-2) | -0.000 | 0.002 | 0.323 *** | 0.317 *** | 0.073 | 0.078 | 0.107 | 0.101 |
| | (-0.00) | (0.04) | (3.59) | (3.58) | (1.37) | (1.53) | (1.50) | (1.40) |
| IIT(t) | -38.004 *** | -35.137 ** | -45.010 *** | -43.438 *** | -13.634 * | -13.252 * | -32.379 *** | -32.935 *** |
| | (-2.81) | (-2.51) | (-3.53) | (-3.39) | (-1.91) | (-1.84) | (-2.65) | (-2.72) |
| IIT(t-1) | 6.426 | 6.270 | 7.001 | 6.682 | -3.219 | -3.296 | 2.950 | 2.839 |
| | (0.40) | (0.37) | (0.43) | (0.41) | (-0.35) | (-0.35) | (0.22) | (0.21) |
| IIT(t-2) | -14.886 | -13.804 | -48.354 *** | -46.929 *** | 1.807 | 2.888 | -30.136 *** | -30.004 *** |
| | (-1.41) | (-1.24) | (-4.37) | (-4.16) | (0.27) | (0.41) | (-2.69) | (-2.67) |
| _cons | 7.665 *** | 7.470 *** | 0.628 | 0.671 | -4.595 *** | -4.855 *** | 4.367 *** | 4.671 *** |
| | (4.84) | (4.94) | (0.50) | (0.52) | (-5.21) | (-5.37) | (3.17) | (3.38) |
| R-sq: within | 0.734 | 0.733 | 0.756 | 0.756 | 0.802 | 0.802 | 0.633 | 0.631 |
| between | 0.448 | 0.510 | 0.637 | 0.653 | 0.526 | 0.571 | 0.130 | 0.207 |
| overall | 0.633 | 0.657 | 0.715 | 0.722 | 0.730 | 0.739 | 0.473 | 0.500 |
| Number of observations | 953 | | 931 | | 948 | | 900 | |
| Number of trade pairs | 38 | | 38 | | 38 | | 38 | |
| Hausman Specification Test | chi2(14) = 35.20<br>P>chi2 = 0.001 | | chi2(14) = 7.55<br>P>chi2 = 0.911 | | chi2(14) = 14.52<br>P>chi2 = 0.412 | | chi2(14) = 32.78<br>P>chi2 = 0.003 | |
| **Long-Run Steady State: X = X(t-k)** | X = logGDPex, logGDPim, logER, GDPpcgap*logER, IIT*logER, GDPpcgap, IIT (k=0,1,2) | | | | | | | |
| logGDPex | 0.113 | 0.124 | 1.120 *** | 1.099 *** | 1.769 *** | 1.764 *** | 0.580 *** | 0.525 *** |
| logGDPim | 1.989 *** | 1.881 *** | 2.065 *** | 2.016 *** | 0.961 *** | 0.928 *** | 1.536 *** | 1.570 *** |
| **logER** | **-2.652** *** | **-2.556** *** | **-2.243** *** | **-2.224** *** | **-0.662** *** | **-0.600** *** | **-2.119** *** | **-2.161** *** |
| GDPpcgap*logER | -0.010 | -0.010 | -0.122 *** | -0.117 *** | -0.033 *** | -0.031 *** | -0.031 * | -0.030 |
| **IIT*logER** | **9.338** *** | **8.792** *** | **18.792** *** | **18.297** *** | **3.367** *** | **3.098** *** | **12.762** *** | **13.097** *** |
| GDPpcgap | 0.041 | 0.044 | 0.543 *** | 0.524 *** | 0.134 *** | 0.133 *** | 0.159 * | 0.149 * |
| IIT | -46.464 *** | -42.671 *** | -86.364 *** | -83.685 *** | -15.046 *** | -13.660 *** | -59.565 *** | -60.099 *** |
| **(1+ave.IIT)*logER** | **-1.808** | **-1.761** | **-0.317** | **-0.348** | **-0.252** | **-0.222** | **-0.949** | **-0.960** |
| IIT Average | 0.090 | | 0.102 | | 0.122 | | 0.092 | |
| Min. | 0.001 | | 0.000 | | 0.001 | | 0.000 | |
| Max. | 0.444 | | 0.495 | | 0.483 | | 0.335 | |
| Std. Dev. | 0.075 | | 0.092 | | 0.101 | | 0.067 | |
| Correlation Coefficient between GDPpcgap(t) and IIT(t) | -0.269 | | -0.188 | | -0.169 | | -0.014 | |

*, **, ***: 10%, 5%, 1% significance of P>|t| for the fixed effects estimates, P>|z| for the random effects estimates, and P>F for the long-run analysis. The numbers in parentheses are t-values for the fixed effects estimates and z-values for the random effects estimates from heteroskedasticity-robust standard errors. The Hausman specification tests are conducted using the two covariance matrices based on the estimated disturbance variance from the efficient estimator. The estimation model selected by the Hausman test is underlined. IIT: Author's calculations. See Section IV for details.

Exporters: China, Hong Kong SAR, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, United States.
Importers: EU, Japan, Asia, North America.

Table 1. (continued) Estimation Results of the Export Equation

| | (v) | | (vi) | | (vii) | | (viii) | |
|---|---|---|---|---|---|---|---|---|
| | **Iron and steel** | | **Metal Products** | | **General Machinery** | | **Electrical Machinery** | |
| Dependent Variable: logQEX(t) | Fixed Effects Estimates | Random Effects Estimates | Fixed Effects Estimates | Random Effects Estimates | Fixed Effects Estimates | Random Effects Estimates | Fixed Effects Estimates | Random Effects Estimates |
| logGDPex(t) | 0.499 *** | 0.534 *** | 1.024 *** | 1.004 *** | 2.736 *** | 2.557 *** | 1.334 *** | 1.226 *** |
| | (2.76) | (2.77) | (12.85) | (12.59) | (14.70) | (12.83) | (11.63) | (10.59) |
| logGDPim(t) | 1.409 *** | 1.410 *** | 0.546 *** | 0.620 *** | 0.655 ** | 0.884 *** | 1.060 *** | 1.216 *** |
| | (5.68) | (5.60) | (4.18) | (4.99) | (2.32) | (3.09) | (6.42) | (7.85) |
| logER(t) | -1.488 *** | -1.489 *** | -1.743 *** | -1.791 *** | 0.347 | 0.288 | -0.160 | -0.216 |
| | (-3.25) | (-3.19) | (-3.87) | (-3.88) | (0.46) | (0.35) | (-0.31) | (-0.42) |
| logER(t-1) | -0.315 | -0.313 | -0.861 * | -0.853 | -0.333 | -0.245 | -0.690 | -0.696 |
| | (-0.51) | (-0.51) | (-1.67) | (-1.63) | (-0.36) | (-0.23) | (-1.02) | (-1.03) |
| logER(t-2) | 0.193 | 0.223 | -0.894 ** | -0.927 ** | -1.562 ** | -1.836 *** | -1.384 *** | -1.487 *** |
| | (0.48) | (0.56) | (-2.30) | (-2.35) | (-2.43) | (-2.59) | (-3.28) | (-3.48) |
| GDPpcgap(t)*logER(t) | 0.014 | 0.012 | 0.017 | 0.015 | -0.016 | -0.023 | -0.021 | -0.020 |
| | (0.55) | (0.51) | (1.16) | (1.02) | (-0.45) | (-0.71) | (-1.03) | (-1.04) |
| GDPpcgap(t-1)*logER(t-1) | 0.011 | 0.011 | -0.003 | -0.003 | 0.003 | -0.000 | -0.003 | -0.004 |
| | (0.34) | (0.36) | (-0.15) | (-0.20) | (0.07) | (-0.00) | (-0.13) | (-0.17) |
| GDPpcgap(t-2)*logER(t-2) | -0.011 | -0.015 | -0.008 | -0.008 | 0.021 | 0.019 | -0.046 *** | -0.045 *** |
| | (-0.53) | (-0.74) | (-0.51) | (-0.59) | (0.62) | (0.62) | (-2.63) | (-2.58) |
| IIT(t)*logER(t) | 5.726 *** | 5.823 *** | 7.830 *** | 8.088 *** | 1.023 | 1.648 | 1.762 * | 1.780 * |
| | (3.50) | (3.42) | (4.92) | (4.96) | (0.44) | (0.67) | (1.73) | (1.70) |
| IIT(t-1)*logER(t-1) | -1.485 | -1.530 | 2.587 | 2.562 | 0.268 | -0.100 | 1.548 | 1.551 |
| | (-0.67) | (-0.66) | (1.38) | (1.34) | (0.10) | (-0.04) | (1.25) | (1.20) |
| IIT(t-2)*logER(t-2) | -1.142 | -1.127 | 3.426 ** | 3.537 *** | 1.572 | 2.691 | 3.814 *** | 3.806 *** |
| | (-0.66) | (-0.61) | (2.56) | (2.62) | (0.88) | (1.45) | (4.04) | (3.86) |
| GDPpcgap(t) | -0.032 | -0.028 | -0.055 | -0.053 | 0.101 | 0.114 | 0.134 | 0.121 |
| | (-0.29) | (-0.27) | (-0.79) | (-0.77) | (0.65) | (0.80) | (1.50) | (1.39) |
| GDPpcgap(t-1) | -0.061 | -0.058 | -0.003 | 0.004 | -0.040 | -0.018 | -0.017 | -0.010 |
| | (-0.43) | (-0.44) | (-0.03) | (0.05) | (-0.20) | (-0.10) | (-0.16) | (-0.10) |
| GDPpcgap(t-2) | 0.040 | 0.052 | 0.043 | 0.041 | -0.057 | -0.059 | 0.244 *** | 0.229 *** |
| | (0.40) | (0.58) | (0.63) | (0.64) | (-0.37) | (-0.42) | (3.08) | (2.93) |
| IIT(t) | -24.014 *** | -24.552 *** | -35.017 *** | -36.157 *** | -1.507 | -4.210 | -7.740 | -7.631 |
| | (-3.11) | (-3.08) | (-4.77) | (-4.85) | (-0.14) | (-0.37) | (-1.63) | (-1.57) |
| IIT(t-1) | 7.452 | 7.615 | -11.747 | -11.590 | -1.106 | 0.711 | -7.052 | -6.992 |
| | (0.71) | (0.70) | (-1.35) | (-1.32) | (-0.09) | (0.05) | (-1.21) | (-1.15) |
| IIT(t-2) | 5.049 | 4.949 | -15.564 ** | -16.105 *** | -6.382 | -11.384 | -17.671 *** | -17.436 *** |
| | (0.62) | (0.57) | (-2.51) | (-2.59) | (-0.77) | (-1.33) | (-3.97) | (-3.77) |
| _cons | 2.800 ** | 2.561 * | 12.862 *** | 13.100 *** | -6.014 *** | -4.798 *** | 2.960 *** | 3.584 *** |
| | (2.26) | (1.91) | (11.03) | (10.40) | (-3.58) | (-2.88) | (2.59) | (3.19) |
| R-sq: within | 0.405 | 0.405 | 0.793 | 0.792 | 0.751 | 0.749 | 0.810 | 0.808 |
| between | 0.071 | 0.089 | 0.365 | 0.458 | 0.249 | 0.412 | 0.437 | 0.584 |
| overall | 0.276 | 0.284 | 0.663 | 0.691 | 0.631 | 0.671 | 0.714 | 0.754 |
| Number of observations | 897 | | 912 | | 915 | | 913 | |
| Number of trade pairs | 38 | | 38 | | 38 | | 38 | |
| Hausman Specification Test | chi2(14) = 16.85<br>P>chi2 = 0.264 | | chi2(14) = 26.20<br>P>chi2 = 0.024 | | chi2(14) = 45.87<br>P>chi2 = 0.000 | | chi2(15) = 53.29<br>P>chi2 = 0.000 | |
| **Long-Run Steady State: X = X(t-k)** | X = logGDPex, logGDPim, logER, GDPpcgap*logER, IIT*logER, GDPpcgap, IIT (k=0,1,2) | | | | | | | |
| logGDPex | 0.499 *** | 0.534 *** | 1.024 *** | 1.004 *** | 2.736 *** | 2.557 *** | 1.334 *** | 1.226 *** |
| logGDPim | 1.409 *** | 1.410 *** | 0.546 *** | 0.620 *** | 0.655 ** | 0.884 *** | 1.060 *** | 1.216 *** |
| **logER** | **-1.610** *** | **-1.579** *** | **-3.498** *** | **-3.571** *** | **-1.548** *** | **-1.793** *** | **-2.234** *** | **-2.398** *** |
| GDPpcgap*logER | 0.013 | 0.007 | 0.007 | 0.004 | 0.009 | -0.003 | -0.069 *** | -0.069 *** |
| **IIT*logER** | **3.099** ** | **3.166** ** | **13.843** *** | **14.187** *** | **2.863** * | **4.239** *** | **7.124** *** | **7.137** *** |
| GDPpcgap | -0.054 | -0.034 | -0.014 | -0.008 | 0.004 | 0.036 | 0.360 *** | 0.340 *** |
| IIT | -11.513 | -11.988 * | -62.327 *** | -63.853 *** | -8.995 | -14.882 ** | -32.463 *** | -32.059 *** |
| **(1+ave.IIT)*logER** | **-1.380** | **-1.343** | **-1.331** | **-1.351** | **-1.026** | **-1.021** | **-0.120** | **-0.281** |
| IIT Average | 0.074 | | 0.157 | | 0.182 | | 0.297 | |
| Min. | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| Max. | 0.555 | | 0.519 | | 0.734 | | 0.938 | |
| Std. Dev. | 0.087 | | 0.100 | | 0.143 | | 0.190 | |
| Correlation Coefficient between GDPpcgap(t) and IIT(t) | 0.199 | | 0.071 | | -0.209 | | 0.078 | |

*, **, ***: 10%, 5%, 1% significance of P>|t| for the fixed effects estimates, P>|z| for the random effects estimates, and P>F for the long-run analysis. The numbers in parentheses are t-values for the fixed effects estimates and z-values for the random effects estimates from heteroskedasticity-robust standard errors. The Hausman specification tests are conducted using the two covariance matrices based on the estimated disturbance variance from the efficient estimator. The estimation model selected by the Hausman test is underlined. IIT: Author's calculations. See Section IV for details.

Exporters: China, Hong Kong SAR, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, United States.
Importers: EU, Japan, Asia, North America.

Table 1. (continued) Estimation Results of the Export Equation

| | (ix) | | (x) | | (xi) | | (xii) | |
|---|---|---|---|---|---|---|---|---|
| | **Transport Equipment** | | **Precision Instruments** | | **Leather Products** | | **Apparel** | |
| Dependent Variable: logQEX(t) | Fixed Effects Estimates | Random Effects Estimates | Fixed Effects Estimates | Random Effects Estimates | Fixed Effects Estimates | Random Effects Estimates | Fixed Effects Estimates | Random Effects Estimates |
| logGDPex(t) | 1.375 *** | 1.400 *** | 1.276 *** | 1.194 *** | 0.482 *** | 0.467 *** | 0.159 * | 0.146 |
| | (8.16) | (7.79) | (10.56) | (9.82) | (2.94) | (2.80) | (1.68) | (1.62) |
| logGDPim(t) | 0.494 * | 0.431 * | 1.190 *** | 1.234 *** | 1.104 *** | 1.156 *** | 1.248 *** | 1.321 *** |
| | (1.89) | (1.65) | (6.29) | (6.90) | (5.50) | (5.59) | (7.87) | (9.04) |
| logER(t) | -1.388 ** | -1.390 ** | -1.403 *** | -1.407 ** | -0.384 | -0.397 | -0.285 | -0.291 |
| | (-2.43) | (-2.42) | (-2.57) | (-2.54) | (-0.79) | (-0.78) | (-0.64) | (-0.65) |
| logER(t-1) | 0.254 | 0.250 | -0.028 | -0.057 | -0.301 | -0.302 | -0.372 | -0.361 |
| | (0.34) | (0.34) | (-0.04) | (-0.08) | (-0.55) | (-0.53) | (-0.69) | (-0.69) |
| logER(t-2) | -0.630 | -0.657 | -0.647 | -0.656 | -0.742 * | -0.762 * | -0.451 | -0.473 |
| | (-1.40) | (-1.46) | (-1.19) | (-1.18) | (-1.73) | (-1.72) | (-1.17) | (-1.23) |
| GDPpcgap(t)*logER(t) | 0.051 ** | 0.051 ** | -0.011 | -0.008 | -0.006 | -0.007 | -0.003 | -0.007 |
| | (1.98) | (1.98) | (-0.55) | (-0.39) | (-0.24) | (-0.26) | (-0.16) | (-0.38) |
| GDPpcgap(t-1)*logER(t-1) | -0.012 | -0.011 | -0.031 | -0.029 | -0.004 | -0.004 | 0.001 | 0.000 |
| | (-0.38) | (-0.39) | (-1.22) | (-1.18) | (-0.14) | (-0.16) | (0.06) | (0.01) |
| GDPpcgap(t-2)*logER(t-2) | 0.019 | 0.020 | -0.023 | -0.018 | -0.008 | -0.008 | -0.009 | -0.011 |
| | (0.89) | (0.97) | (-1.23) | (-1.00) | (-0.40) | (-0.37) | (-0.52) | (-0.61) |
| IIT(t)*logER(t) | 5.548 *** | 5.648 *** | 6.846 *** | 6.911 *** | -0.648 | -0.672 | -0.500 | -0.599 |
| | (4.19) | (4.12) | (3.59) | (3.64) | (-0.34) | (-0.33) | (-0.35) | (-0.41) |
| IIT(t-1)*logER(t-1) | -0.736 | -0.754 | 0.406 | 0.417 | -0.524 | -0.530 | -2.432 | -2.354 |
| | (-0.45) | (-0.45) | (0.15) | (0.15) | (-0.23) | (-0.21) | (-1.45) | (-1.38) |
| IIT(t-2)*logER(t-2) | 0.386 | 0.481 | 3.212 | 2.862 | -2.571 | -2.514 | -2.360 | -2.300 |
| | (0.27) | (0.34) | (1.47) | (1.26) | (-1.58) | (-1.46) | (-1.53) | (-1.44) |
| GDPpcgap(t) | -0.229 ** | -0.229 ** | 0.052 | 0.036 | 0.059 | 0.056 | 0.024 | 0.033 |
| | (-2.02) | (-2.03) | (0.55) | (0.38) | (0.52) | (0.50) | (0.29) | (0.39) |
| GDPpcgap(t-1) | 0.024 | 0.024 | 0.123 | 0.116 | 0.023 | 0.027 | -0.006 | 0.003 |
| | (0.18) | (0.18) | (1.08) | (1.04) | (0.19) | (0.22) | (-0.06) | (0.03) |
| GDPpcgap(t-2) | -0.071 | -0.076 | 0.124 | 0.098 | 0.025 | 0.020 | 0.054 | 0.055 |
| | (-0.74) | (-0.82) | (1.43) | (1.17) | (0.26) | (0.21) | (0.65) | (0.69) |
| IIT(t) | -23.879 *** | -24.302 *** | -30.419 *** | -30.513 *** | 2.681 | 2.803 | -0.301 | 0.310 |
| | (-3.84) | (-3.78) | (-3.43) | (-3.47) | (0.28) | (0.28) | (-0.04) | (0.04) |
| IIT(t-1) | 3.689 | 3.806 | -1.220 | -1.161 | 3.129 | 3.153 | 11.099 | 10.715 |
| | (0.48) | (0.48) | (-0.10) | (-0.09) | (0.27) | (0.26) | (1.35) | (1.27) |
| IIT(t-2) | -1.855 | -2.251 | -15.546 | -13.635 | 12.615 | 12.298 | 10.317 | 10.122 |
| | (-0.28) | (-0.34) | (-1.58) | (-1.34) | (1.54) | (1.43) | (1.39) | (1.32) |
| _cons | 4.015 *** | 4.281 *** | 2.623 * | 2.858 * | 3.524 ** | 3.583 ** | 3.166 ** | 3.139 ** |
| | (3.41) | (3.54) | (1.78) | (1.94) | (2.12) | (2.04) | (2.12) | (1.96) |
| R-sq: within | 0.504 | 0.504 | 0.748 | 0.747 | 0.446 | 0.446 | 0.560 | 0.558 |
| between | 0.224 | 0.235 | 0.435 | 0.493 | 0.193 | 0.209 | 0.073 | 0.152 |
| overall | 0.425 | 0.428 | 0.685 | 0.696 | 0.350 | 0.354 | 0.365 | 0.415 |
| Number of observations | 870 | | 896 | | 900 | | 921 | |
| Number of trade pairs | 38 | | 38 | | 38 | | 38 | |
| Hausman Specification Test | chi2(15) = 12.68<br>P>chi2 = 0.627 | | chi2(14) = 34.83<br>P>chi2 = 0.002 | | chi2(15) = 13.43<br>P>chi2 = 0.569 | | chi2(15) = 29.75<br>P>chi2 = 0.013 | |
| **Long-Run Steady State: X = X(t-k)** | X = logGDPex, logGDPim, logER, GDPpcgap*logER, IIT*logER, GDPpcgap, IIT (k=0,1,2) | | | | | | | |
| logGDPex | 1.375 *** | 1.400 *** | 1.276 *** | 1.194 *** | | | | |
| logGDPim | 0.494 * | 0.431 * | 1.190 *** | 1.234 *** | | | | |
| **logER** | **-1.763** *** | **-1.796** *** | **-2.077** *** | **-2.120** *** | | | | |
| GDPpcgap*logER | 0.058 *** | 0.059 *** | -0.065 *** | -0.056 *** | | | | |
| **IIT*logER** | **5.198** *** | **5.375** *** | **10.464** *** | **10.189** *** | | | | |
| GDPpcgap | -0.275 *** | -0.281 *** | 0.298 *** | 0.250 *** | | | | |
| IIT | -22.044 *** | -22.747 *** | -47.185 *** | -45.308 *** | | | | |
| **(1+ave.IIT)*logER** | **-1.150** | **-1.161** | **-0.056** | **-0.152** | | | | |
| IIT Average | 0.118 | | 0.193 | | 0.089 | | 0.071 | |
| Min. | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| Max. | 0.796 | | 0.665 | | 0.598 | | 0.477 | |
| Std. Dev. | 0.123 | | 0.121 | | 0.092 | | 0.080 | |
| Correlation Coefficient between GDPpcgap(t) and IIT(t) | -0.092 | | -0.114 | | -0.175 | | -0.440 | |

*, **, ***: 10%, 5%, 1% significance of P>|t| for the fixed effects estimates, P>|z| for the random effects estimates, and P>F for the long-run analysis. The numbers in parentheses are t-values for the fixed effects estimates and z-values for the random effects estimates from heteroskedasticity-robust standard errors. The Hausman specification tests are conducted using the two covariance matrices based on the estimated disturbance variance from the efficient estimator. The estimation model selected by the Hausman test is underlined. IIT: Author's calculations. See Section IV for details.

Exporters: China, Hong Kong SAR, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, United States.
Importers: EU, Japan, Asia, North America.

Table 1. (continued) Estimation Results of the Export Equation

| | (xiii) **Lumber and Wood Products** | | (xiv) **Rubber and Plastics** | | (xv) **Petrochemical Products** | | (xvi) **Non-Ferrous** | |
|---|---|---|---|---|---|---|---|---|
| Dependent Variable: logQEX(t) | Fixed Effects Estimates | Random Effects Estimates | Fixed Effects Estimates | Random Effects Estimates | Fixed Effects Estimates | Random Effects Estimates | Fixed Effects Estimates | Random Effects Estimates |
| logGDPex(t) | 0.395 *** | 0.328 ** | 0.200 | 0.189 | 0.471 | 0.516 * | 0.376 ** | 0.348 ** |
| | (3.05) | (2.49) | (1.11) | (0.92) | (1.63) | (1.95) | (2.43) | (2.10) |
| logGDPim(t) | 0.989 *** | 1.104 *** | 1.425 *** | 1.562 *** | 0.813 ** | 0.808 *** | 1.367 *** | 1.391 *** |
| | (5.97) | (6.29) | (5.20) | (4.73) | (2.38) | (2.64) | (5.98) | (5.65) |
| logER(t) | -0.190 | -0.196 | 0.872 ** | 0.807 * | -0.038 | -0.117 | 0.751 ** | 0.799 ** |
| | (-0.61) | (-0.60) | (2.19) | (1.92) | (-0.06) | (-0.19) | (1.98) | (1.96) |
| logER(t-1) | -0.493 | -0.509 | 0.034 | 0.038 | -0.193 | -0.194 | -0.462 | -0.497 |
| | (-1.14) | (-1.17) | (0.06) | (0.06) | (-0.23) | (-0.23) | (-0.98) | (-0.99) |
| logER(t-2) | -0.460 | -0.487 | 0.131 | 0.041 | 0.354 | 0.333 | 0.597 | 0.702 * |
| | (-1.44) | (-1.52) | (0.32) | (0.09) | (0.59) | (0.55) | (1.62) | (1.81) |
| GDPpcgap(t)*logER(t) | -0.004 | -0.007 | -0.036 * | -0.039 ** | 0.039 | 0.040 | -0.004 | -0.008 |
| | (-0.25) | (-0.46) | (-1.90) | (-2.10) | (1.40) | (1.40) | (-0.21) | (-0.44) |
| GDPpcgap(t-1)*logER(t-1) | 0.011 | 0.010 | -0.008 | -0.007 | -0.016 | -0.015 | -0.005 | -0.004 |
| | (0.58) | (0.56) | (-0.31) | (-0.32) | (-0.45) | (-0.44) | (-0.19) | (-0.19) |
| GDPpcgap(t-2)*logER(t-2) | 0.017 | 0.015 | -0.025 | -0.024 | -0.019 | -0.021 | -0.031 | -0.037 ** |
| | (1.16) | (1.03) | (-1.16) | (-1.21) | (-0.68) | (-0.78) | (-1.40) | (-2.04) |
| IIT(t)*logER(t) | 1.670 | 1.713 | -3.066 | -2.234 | -2.503 | -2.937 | -6.406 *** | -6.148 *** |
| | (0.76) | (0.70) | (-0.91) | (-0.65) | (-0.88) | (-1.09) | (-3.26) | (-3.14) |
| IIT(t-1)*logER(t-1) | -1.101 | -0.969 | -0.157 | -0.398 | -0.582 | -0.520 | 2.385 | 2.403 |
| | (-0.63) | (-0.48) | (-0.04) | (-0.09) | (-0.16) | (-0.16) | (0.88) | (0.88) |
| IIT(t-2)*logER(t-2) | -2.091 ** | -1.902 ** | -0.271 | 0.451 | -2.255 | -2.572 | -3.927 | -3.858 |
| | (-2.37) | (-2.03) | (-0.10) | (0.16) | (-0.96) | (-1.16) | (-1.58) | (-1.55) |
| GDPpcgap(t) | 0.035 | 0.045 | 0.201 ** | 0.199 ** | -0.136 | -0.147 | 0.009 | 0.031 |
| | (0.49) | (0.62) | (2.30) | (2.34) | (-1.08) | (-1.14) | (0.09) | (0.36) |
| GDPpcgap(t-1) | -0.047 | -0.042 | 0.011 | 0.017 | 0.089 | 0.088 | 0.020 | 0.015 |
| | (-0.55) | (-0.50) | (0.10) | (0.16) | (0.54) | (0.55) | (0.18) | (0.16) |
| GDPpcgap(t-2) | -0.087 | -0.081 | 0.147 | 0.131 | 0.070 | 0.072 | 0.140 | 0.169 ** |
| | (-1.27) | (-1.20) | (1.48) | (1.46) | (0.53) | (0.58) | (1.35) | (2.01) |
| IIT(t) | -11.083 | -11.112 | 12.892 | 9.044 | 15.006 | 17.103 | 30.580 *** | 29.233 *** |
| | (-1.08) | (-0.98) | (0.87) | (0.60) | (1.14) | (1.37) | (3.29) | (3.16) |
| IIT(t-1) | 5.180 | 4.598 | 0.805 | 1.862 | 2.875 | 2.661 | -11.602 | -11.763 |
| | (0.60) | (0.47) | (0.04) | (0.10) | (0.17) | (0.18) | (-0.92) | (-0.92) |
| IIT(t-2) | 7.605 * | 6.817 | 2.920 | -0.522 | 8.743 | 10.291 | 17.398 | 17.010 |
| | (1.76) | (1.47) | (0.24) | (-0.04) | (0.82) | (1.01) | (1.52) | (1.49) |
| _cons | 3.889 *** | 3.956 *** | -8.629 *** | -8.147 *** | -3.279 * | -2.864 * | -7.333 *** | -7.935 *** |
| | (3.94) | (3.73) | (-5.99) | (-5.41) | (-1.94) | (-1.71) | (-5.99) | (-6.34) |
| R-sq: within | 0.420 | 0.419 | 0.270 | 0.266 | 0.170 | 0.170 | 0.194 | 0.193 |
| between | 0.000 | 0.006 | 0.068 | 0.072 | 0.123 | 0.178 | 0.055 | 0.077 |
| overall | 0.144 | 0.179 | 0.065 | 0.091 | 0.135 | 0.154 | 0.156 | 0.163 |
| Number of observations | 943 | | 936 | | 803 | | 933 | |
| Number of trade pairs | 38 | | 38 | | 38 | | 38 | |
| Hausman Specification Test | chi2(15) = 33.94<br>P>chi2 = 0.004 | | chi2(14) = 19.99<br>P>chi2 = 0.131 | | chi2(15) = 12.69<br>P>chi2 = 0.626 | | chi2(14) = 30.93<br>P>chi2 = 0.006 | |

| **Long-Run Steady State: X = X(t-k)** | X = logGDPex, logGDPim, logER, GDPpcgap*logER, IIT*logER, GDPpcgap, IIT (k=0,1,2) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| logGDPex | | | | | | | | |
| logGDPim | | | | | | | | |
| **logER** | | | | | | | | |
| GDPpcgap*logER | | | | | | | | |
| **IIT*logER** | | | | | | | | |
| GDPpcgap | | | | | | | | |
| IIT | | | | | | | | |

| | | | | |
|---|---|---|---|---|
| IIT Average | 0.087 | 0.116 | 0.075 | 0.078 |
| Min. | 0.000 | 0.000 | 0.000 | 0.000 |
| Max. | 0.760 | 0.514 | 0.668 | 0.453 |
| Std. Dev. | 0.104 | 0.107 | 0.102 | 0.086 |
| Correlation Coefficient between GDPpcgap(t) and IIT(t) | -0.182 | 0.141 | -0.134 | -0.134 |

*, **, ***: 10%, 5%, 1% significance of P>|t| for the fixed effects estimates, P>|z| for the random effects estimates, and P>F for the long-run analysis. The numbers in parentheses are t-values for the fixed effects estimates and z-values for the random effects estimates from heteroskedasticity-robust standard errors. The Hausman specification tests are conducted using the two covariance matrices based on the estimated disturbance variance from the efficient estimator. The estimation model selected by the Hausman test is underlined. IIT: Author's calculations. See Section IV for details.

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