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Trade Sensitivity to Exchange Rates in the Context of Intra-Industry Trade

Yoko Oguro, Kyoji Fukao, and Yougesh Khatri

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Trade Sensitivity to Exchange Rates in the Context of Intra-Industry Trade[1]

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Abstract

This paper theoretically and empirically investigates export sensitivity to exchange rates in the context of intra-industry trade (IIT). It is assumed that more IIT implies a smaller elasticity of substitution among differentiated products and vice versa. The model presented suggests the gap in production costs between two countries has an influence on IIT as well. Industry-level panel regressions of thirty-eight trading pairs provide strong empirical support for the idea that the exchange rate sensitivity of exports declines in concert with the extent of IIT. An obvious policy implication is that the effectiveness of exchange rates in addressing trade imbalances will diminish as the extent of IIT increases.

JEL Classification Numbers: F00, F10, F14, F19

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I. Introduction

Exchange rates feature prominently in the vast literature on the determinants of trade and have been receiving much attention in the context of global imbalances. In past decades, trade disputes and exchange rate issues concentrated on Japan, but more recently such frictions have centered on China. There have been growing calls for China to allow its currency to appreciate to help address global imbalances. Yet, the extent to which 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 empirical approach relates a country's export and import volumes to real exchange rates and real foreign and domestic incomes, and focuses on the Marshall-Lerner condition.[1] However, empirical results regarding the effect of exchange rates on trade balances vary (see, e.g., the results of Houthakker and Magee (1969), Rose (1990, 1991), Hooper, Johnson and Marquez (1998), Chinn (2004, 2005), and IMF (2007)). In addition, a considerable number of studies have examined bilateral trade elasticities, mostly for U.S. trade with other developed countries, and find that trade flows are significantly affected by real exchange rates.[2] Thorbecke (2006) investigated how changes in real exchange rates affect bilateral trade within Asia (in the context of Asian production and distribution networks) and between Asia and the United States, and found that exchange rate elasticities for trade between Asia and the U.S. are not large enough to lend confidence that a dollar depreciation would improve the U.S. trade balance with Asia. Compared with the multilateral trade balance approach, aggregation bias problems are reduced in bilateral trade analyses, but will likely persist if exchange rate elasticities of trade differ across industries. Breuer and Clements (2003) for example found that, for trade between the United States and Japan, there are commodity-specific exchange rate elasticities.

This paper adds to the literature that suggests that exports become less sensitive to exchange rate movements under certain circumstances. To our best knowledge, this is the first study that theoretically and empirically investigates the industry-specific sensitivity of exports to exchange rates in the context of intra-industry trade (IIT). The empirical analysis uses six industry-panels that consist of bilateral trade (export) equations, which help reduce concerns about aggregation bias.

IIT is generally defined as the international trade of goods in the same product category, and this paper more specifically assumes IIT to be the trade of differentiated products. It is further assumed that more IIT implies a smaller elasticity of substitution between products and vice versa.[3] The theoretical model presented below (Section II) suggests that differences

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[1] The Marshall-Lerner conditions requires that the sum of the absolute values of the price elasticities of imports and exports exceed one for an appreciation to result in a deterioration of a country's trade balance.

[2] See for example Cushman (1990), Marquez (1990), Eaton and Tamura (1994), Bahmani-Oskooee and Brooks (1999), Nedenicheck (2000), and Bahmani-Oskooe and Goswami (2004).

[3] Brander and Krugman (1983) show that it is also possible that IIT includes trade in standardized products. 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.

in production costs have an influence on IIT as well. Cross-country industry-panel regressions for key trading pairs among eight East Asian countries, Japan, and the United States with the European Union countries (EU), Asia, Japan, and North America are estimated (see specifications in Section III). To focus on the real effect of exchange rate movements on export volumes, the analysis in this paper (unlike other studies that use real trade values) uses *export quantity indices*, since export prices and quantities may respond differently to exchange rate movements (Section IV provides a discussion of the data). The empirical results (Section V) confirm that the exchange rate sensitivity declines in concert with the extent of IIT. In fact, according to our simulation (see Box), the impact of IIT on the exchange rate elasticities of exports from China to North America has been expanding. An obvious policy implication of the findings is that the role of exchange rate adjustments as a means of addressing trade imbalances diminishes in the context of large or growing IIT (as discussed in the concluding Section VI).

II. Background and Theory

The aim of this paper is to theoretically and empirically investigate the idea that exports between a pair of countries become less sensitive to exchange rate movements as the extent of intra-industry trade (IIT) increases. IIT is defined as the trade of goods in the same product category, and it is specifically assumed here that IIT consists of trade in differentiated products. It is further 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. To illustrate this idea, consider the extreme opposite case in which two countries produce non-differentiated products with a high elasticity of substitution. It would be more efficient for the pair of countries to gather all the production of a particular commodity in that country which possesses a comparative advantage and for that country then to export to the other country (thus, there would be no IIT).

This paper simply assumes that IIT is the exchange of differentiated products and does not attempt to classify the "type" of IIT. However, IIT is often classified as vertical intra-industry trade (VIIT) or horizontal intra-industry trade (HIIT). VIIT is associated with qualitative differences in products in the same category, since IIT is classified as vertical when there exists a substantial difference in unit prices (see, e.g., Fukao, Ishido and Ito (2003), Greenaway, Hine and Milner (1995), and Fontagné, Freudenberg and Péridy (1997)).[4] On the

[4] 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:

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

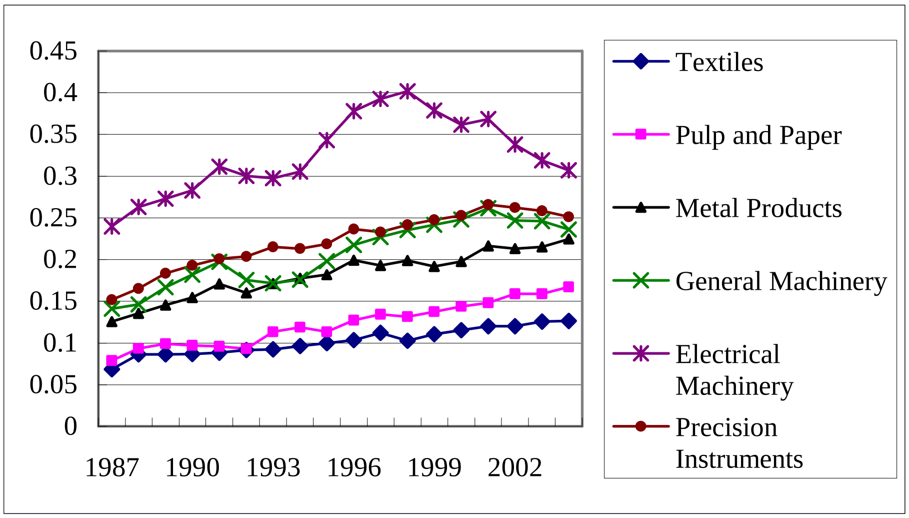
$$\frac{1}{A} \leq \frac{UVE_z}{UVI_z} \leq A \text{: horizontal intra-industry trade (HIIT)}$$

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

other hand, HIIT occurs in the context of differences in attributes. Suppose countries *A* and *B* produce T-shirts *A* and *B* respectively, and they exchange these as IIT. In the case that the difference in price between T-shirts *A* and *B* is substantially large, the exchange is regarded as VIIT. On the other hand, if the prices of T-shirts *A* and *B* are very similar, the exchange is classified as HIIT. However, both T-shirts each face their own demand regardless of the type of IIT, because they differ. Consequently, this paper assumes that the extent of product differentiation determines the extent of IIT no matter whether IIT is horizontal or vertical.

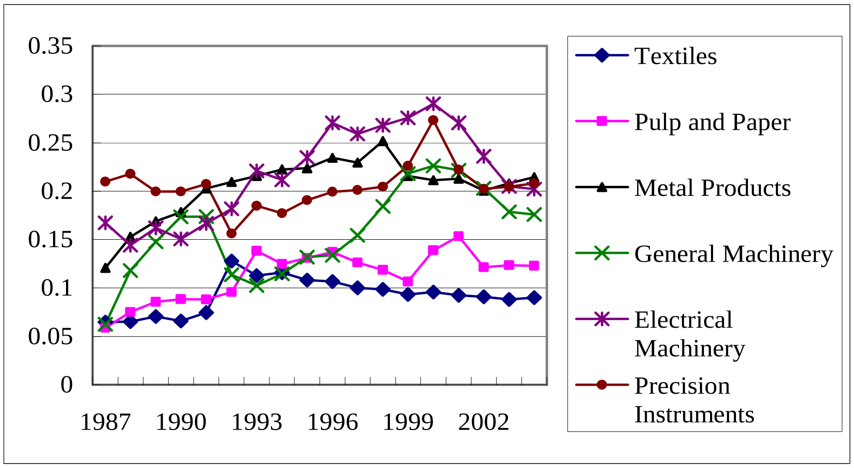
Before moving on to the discussion of the theoretical model, it is useful to examine the importance of IIT by having a brief look at recent trends in the extent of IIT (see equation (8) for the derivation of the measure of the extent of IIT). Figure 1.a. shows the time-series movements of the extent of IIT for the six industries analyzed in this paper (averaged across the thirty-eight trading pairs): textiles, pulp and paper, metal products, general machinery, electrical machinery, and precision instruments. In addition, Figure 1.b. shows the trends in China's IIT with four trading partner groups: the EU, Japan, Asia, and North America. The figures indicate that there is a discernable increasing trend in IIT between the trading pairs, including China. Looking at the two figures, it can be seen that the extent of IIT in the different industries for China (Figure 1.b.), on which concerns regarding global imbalances have focused, is very similar to the average for all thirty-eight trading pairs (Figure 1.a.). Moreover, both figures show that IIT is playing an increasingly important role both worldwide and in China, and IIT can be expected to continue to expand as income and technology levels of developing countries converge to those of developed countries.

Figure 1.a. Degree of Intra-Industry Trade



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

Figure 1.b. China's Degree of Intra-Industry Trade



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

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

The model presented in this section suggests that a smaller substitution elasticity and/or a smaller gap in production costs are associated with a higher degree of IIT. The model assumes (1) trade in differentiated products in industry *z* under Dixit and Stiglitz (1977) type monopolistic competition between two countries (i=2); (2) there exist F_i identical firms in country *i*'s industry *z*;[5] (3) identical consumer preferences in the two countries; and (4) that a representative consumer in importing country *j* seeks to maximize utility. This leads to the following utility-maximization problem of a representative household in importing country *j*:[6]

$$\max_{c_{i,f,j}} \left(\sum_{i-1}^{2} \sum_{f=1}^{F_i} c_{i,f,j}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \tag{1}$$

subject to

$$\sum_{i-1}^{2} \sum_{f=1}^{F_i} p_{i,f} \cdot c_{i,f,j} = \overline{\alpha} Y_j \tag{2}$$

---

[5] In the equations, the industry subscript "*z*" is omitted for variables such as $F, c, \theta, p, \overline{\alpha}, \overline{\eta}, MC, FC$ for notational convenience.

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

where θ denotes the elasticity of substitution among the differentiated products of all firms in industry *z*, which is greater than one; $c_{i,f,j}$ is country *j*'s consumption of firm *f*'s output in industry *z* of country *i*; and $p_{i,f}$ denotes the price of firm *f*'s product in industry *z* of country *i*. For simplicity, trade costs are assumed to be zero here. It is assumed that a certain portion, $\overline{\alpha}$, of country *j*'s national income, Y_j, is used for the consumption of industry *z*'s products produced in both countries.[7]

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

$$c_{i,f,j} = \frac{1}{\sum_{i=1}^{2} F_i} \cdot \left(\frac{p_{i,f}}{P_j} \right)^{-\theta} \cdot \frac{\overline{\alpha} Y_j}{P_j} \tag{3}$$

$$\text{where } P_j = \left[\frac{\sum_{i=1}^{2} \sum_{f=1}^{F_i} \left(p_{i,f} \right)^{1-\theta}}{\sum_{i=1}^{2} F_i} \right]^{\frac{1}{1-\theta}} \tag{4}$$

Assume further that the number of firms in industry *z* of country *i*, F_i, is defined as a certain ratio, $\overline{\eta}$, of country *i*'s national income, Y_i.[8] Also, $p_{i,f} = p_i$, since firms are assumed to be identical in each country. Hence, country *j*'s price index of industry *z*'s output, P_j, above can be simplified as P. Then, the value of industry *z* exports from country *A* to *B* and from *B* to *A* are defined respectively as:

$$EX_{AB}^{z} = \frac{\overline{\eta} Y_A}{\overline{\eta} Y_A + \overline{\eta} Y_B} \cdot \left(\frac{p_A}{P} \right)^{-\theta} \cdot \frac{\overline{\alpha} Y_B}{P} = \frac{Y_A}{Y_A + Y_B} \cdot \left(\frac{p_A}{P} \right)^{-\theta} \cdot \frac{\overline{\alpha} Y_B}{P} \tag{5}$$

$$EX_{BA}^{z} = \frac{\overline{\eta} Y_B}{\overline{\eta} Y_A + \overline{\eta} Y_B} \cdot \left(\frac{p_B}{P} \right)^{-\theta} \cdot \frac{\overline{\alpha} Y_A}{P} = \frac{Y_B}{Y_A + Y_B} \cdot \left(\frac{p_B}{P} \right)^{-\theta} \cdot \frac{\overline{\alpha} Y_A}{P} \tag{6}$$

---

[7] If there are *Z* industries in country *j*,

$Y_j = \overline{\alpha}_1 \cdot Y_j + \overline{\alpha}_2 \cdot Y_j + \cdots + \overline{\alpha}_z \cdot Y_j$, where $\overline{\alpha}_1 + \overline{\alpha}_2 + \cdots + \overline{\alpha}_z = 1$. As noted above, the industry subscript *z* on $\overline{\alpha}_z$ is omitted in equation (2).

[8] In other words, it is assumed that product variety depends on national income, Y_i.

The next step is to solve for $p_{i,f} = p_i$. Each identical firm in industry *z* in country *i* is defined to have cost function $C_{i,f}^z = C_i^z$, consisting of marginal cost $MC_{i,f} = MC_i$, and fixed cost $FC_{i,f} = FC_i$. Each identical firm in industry *z* in country *i* is defined to have the cost function $C_{i,f}^z = C_i^z$ that consists of marginal cost, $MC_{i,f} = MC_i$, and fixed cost, $FC_{i,f} = FC_i$. Using the profit maximization condition, $p_{i,f} = p_i$ is derived as:

$$p_{i,f} = p_i = \frac{\theta}{\theta - 1} \cdot MC_{i,f} = \frac{\theta}{\theta - 1} \cdot MC_i \qquad (7)$$

Following previous studies (such as Fukao, Ishido and Ito (2003); Greenaway, Hine and Milner (1995); Fontagné, Freudenberg and Péridy (1997)), the degree of intra-industry trade (IIT) is defined as the value of trade overlap for industry *z* and takes a value between 0 and 1:[9]

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

Using (5), (6), (7), and (8), IIT^z can also be written as follows (assuming $MC_A > MC_B$):[10]

$$\text{IIT}^z = \frac{EX_{AB}^z}{EX_{BA}^z} = \left(\frac{p_A}{p_B}\right)^{-\theta} = \left(\frac{\frac{\theta}{\theta-1} \cdot MC_A}{\frac{\theta}{\theta-1} \cdot MC_B}\right)^{-\theta} = \left(\frac{MC_B}{MC_A}\right)^{\theta} \qquad (9)$$

Thus, the model predicts that IIT will be inversely related to the elasticity of substitution, θ, and to the *MC* gap.

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[9] IM_{AB}^z represents country *A*'s imports of industry *z* goods from country *B*. The calculation of the IIT index for country *A* in this paper is conducted using EX_{AB}^z and IM_{AB}^z, 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:

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

[10] While the theoretical model presented here assumes that the elasticity of substitution, θ, is the same among products in the same product category, and thus the same between two countries that engage in IIT, this assumption is relaxed in the empirical analysis for each industry later in this paper and differences in θ from trade pair to trade pair because of differences in commodity compositions are allowed for. θ may also differ for other reasons, such as differences in competition in a pair of countries. However, these aspects are not considered here.

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 2, 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: the EU15 (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom), Japan, Asia (China, Hong Kong SAR, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand),[11] and North America (Canada and the United States). Six manufacturing industry panels[12] (textiles, pulp and paper, metal products, general machinery, electrical machinery, and precision instruments) consisting of the above thirty-eight trade pairs are compiled and examined.[13]

The extent of IIT in the six industries varies from high to low. The average extent of IIT is shown at the bottom of Tables 1.a. and 1.b. 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 0.291, 0.184, and 0.177, respectively. The extent of IIT in the metal products industry is in the intermediate range with an average of 0.149, while that in the pulp and paper and textile industries is low with 0.100 and 0.90, respectively. The data used for this study are annual data for the period 1974 to 2004 (see below). The data set is an unbalanced panel, with China's data span being the shortest (starting in 1987).

Figure 2. Thirty-Eight Trade Pairs

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

The six industries analyzed in this paper are:
Textiles, pulp and paper, metal products, general machinery, electrical machinery, and precision instruments.

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[11] When the exporter is one of the countries in our Asia group, the country itself is excluded from the group. For instance, China is excluded from Asia for the trading pair China–Asia.

[12] The paper follows the industry classification in Kuroko (2006), which is based on the SITC.

[13] The pairs Japan-Japan and United States-North America are excluded.

In the empirical analysis, a gravity 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 *i* to country *j* as follows:

$$QEX_{ij}^{z} = \frac{Y_i \cdot Y_j}{Y_i + Y_j} \cdot \left(\frac{p_i}{P}\right)^{-\theta} \cdot \frac{\overline{\alpha}}{P} \tag{5'}$$

Log linearization of equation (5)’ leads to the following gravity equation:[14]

$$\log QEX_{ij}^{z} = \frac{\overline{\alpha}}{P} + \log Y_i + \log Y_j - \theta \log\left(\frac{p_i}{P}\right) - \log\left(Y_i + Y_j\right) \tag{10}$$

Using this basic model, the aim is to obtain industry-specific exchange rate elasticities 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_i and Y_j are rewritten as the exporter’s real GDP (*GDPex*) and the importer’s real GDP (*GDPim*), respectively, which are based on national currencies. Second, the real price of a firm's product in country *i*, $\left(p_i/P\right)$, is replaced by the real exchange rate (*RER*) between two countries, which is used as a proxy for the relative price. Third, in the empirical analysis, a higher degree of IIT (*IIT*) is used as a proxy for a smaller elasticity of substitution, θ. 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 inverse value of the bilateral difference in per capita real GDP (*GDPpcgap*) and *RER* is included as well in order to exclude any influence of *GDPpcgap* from *IIT*, which is used as a proxy for θ. *GDPpcgap* is used as a proxy for the gap in production costs between a pair of countries. Fourth, $\left(Y_i + Y_j\right)$, which implicitly shows the costs of trade at arm’s length, is replaced by the distance between country *i* and *j*. Finally, as real exports might be influenced by past values of variables, lags of each variable are considered. Therefore, equation (11) below, which contains lagged terms, is estimated using panels for each industry:[15]

$$\begin{aligned}\log QEX_{ijt}^{z} = {} & a + \sum\nolimits_{k=0} b_k \log GDPex_{i,t-k} + \sum\nolimits_{k=0} c_k \log GDPim_{j,t-k} + \sum\nolimits_{k=0} d_k \log RER_{ij,t-k} \\ & + \sum\nolimits_{k=0} g_k GDPpcgap_{ij,t-k} \cdot \log RER_{ij,t-k} + \sum\nolimits_{k=0} m_k IIT_{ij,t-k} \cdot \log RER_{ij,t-k} \\ & + \sum\nolimits_{k=0} h_k GDPpcgap_{ij,t-k} + \sum\nolimits_{k=0} n_k IIT_{ij,t-k} + v\,\text{distance}_{ij} + \omega_{ij} + \varepsilon_{ijt}\end{aligned} \tag{11}$$

$$b, c, g, m > 0; \quad d, v < 0$$

[14] See Feenstra (2004) for further discussion on the empirical applications of gravity equations.

[15] Each industry panel consists of the thirty-eight bilateral real export equations.The empirical results do not differ substantially when the distance term is or is not included, and the term is therefore omitted from the regressions.

where ω_i represents trade-pair-specific factors other than distance, and ε_{it} is the error term.

The variables *QEX*, *GDPex*, *GDPim*, and *RER* are set up as indices (equal to 100 in the base year, which is 2000). Since it is impossible to control for all trading-pair-specific factors, which are represented by ω, the thirty-eight trade pairs are considered as thirty-eight cross-sectional groups in each industry-panel. The expected sign of *d* is negative while *g* and *m* are expected to be positive, as exports are expected to be negatively affected by an appreciation of the exporter's exchange rate, while higher IIT and a smaller per capita GDP gap are expected to lower export sensitivity to exchange rates. In other words, the signs of the coefficients on *IIT* and *GDPpcgap* are expected to be the opposite of the coefficients on *RER*.

IV. DATA

While other studies typically use real trade values, "real" exports in this paper are measured using export quantities, since export prices and quantities may respond differently to exchange rate movements. It is also not possible to find industry specific deflators with which to deflate export values to derive real export series. The real export volume (*QEX*) is the export quantity index which was produced by Kuroko (2006) using the United Nations Commodity Trade Statistics Database (Comtrade database).[16] This trade quantity index data is independent of the noise that arises from the difference in quantity units used for different commodities because of the indexation process. The real exchange rate (*RER*), is defined as units of importer currency per unit of exporter currency, deflated by the respective Consumer Price Index (CPI).[17] Real GDPs based on national currencies, exchange rates, and CPIs are taken from the IMF's *International Financial Statistics* (*IFS*), except for data relating to Taiwan, which is from the CEIC database. Per capita real GDP gaps (1/*GDPpcgap*) are calculated in U.S. dollars. The degree of IIT for each trading pair and for the six industries is calculated from equation (8) using the SITC 5-digit-based data of the Comtrade database, which is the most detailed data available. The IIT indices derived from the SITC 5-digit data are aggregated into the required six industry aggregates for the thirty-eight trading pairs using trade value based weights. Finally, when the trading partner is a group of countries, i.e., the EU, Asia, or North America, *GDPim*, *RER*, and *GDPpcgap* are the weighted averages using GDP (in U.S. dollars) as the weight.

The stationarity of residuals is confirmed by Johansen's (trace) cointegration test for the six industry panels (as reported in the Appendix Table in Oguro (2007)). The tests were conducted for each trade pair for each industry since each industry data set is a different unbalanced panel. However, for several of the thirty-eight trade pairs in each industry, it was impossible to conduct the cointegration test, since the time-span covered by the data is not

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

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

sufficiently long. It is assumed that all cross-sectional export equations in the panel of each industry satisfy stationarity.

V. Empirical Results

When estimating the export equation (11), each industry panel is specified to have a different lag structure for each explanatory variable using the Akaike Information Criterion (AIC).[18] Since the paper uses unbalanced annual data from 1974 to 2004, the maximum lag length adopted is two years (given the limited time series for some pairs). Based on the Hausman test, a random effects model is accepted for the textiles, pulp and paper, metal products, electrical machinery and precision instruments industries, while a fixed effects model is accepted for the general machinery industry. Although regression results based on both the random effects (Table 1.a.) and the fixed effects (Table 1.b.) model are reported for each industry, the discussion below concentrates on the results of the model selected by the Hausman test.[19]

The results provide empirical support for the hypothesis that higher degrees of IIT are associated with lower trade elasticities. In other words, the empirical results suggest that the reduction in exports related to an appreciation of an exporter's currency becomes less pronounced as the extent of IIT increases. The empirical results for the short-run and long-run steady state are shown in Tables 1.a. and 1.b. In the short-run analysis, most of the coefficients on the variables of primary interest, *logRER* and *logRER**IIT*,* are statistically significant at times *t* and *t-2* in the six industries. The signs of the coefficients on *logRER* at times *t* and *t-2* are negative. Higher IIT reduces export sensitivity to exchange rates, since the estimated coefficients on *logRER**IIT* at times *t* and *t-2* are, as predicted, positive.

In the steady state analysis, the coefficients on *logRER* are negative and those on *logRER**IIT* are positive and significantly different from zero at the 1 percent level for all six industries. The impact of IIT on trade sensitivity to exchange rates can be seen explicitly in the two rows highlighted in bold in Tables 1.a. and 1.b. For instance, in Table 1.a., in the case of the electrical machinery industry, the estimated real exchange rate elasticity of exports (i.e., the coefficient on *logRER*) is -3.318, while the offset related to the extent of IIT (i.e., the coefficient on *logRER**IIT*) is 7.292 in the steady state. Thus, when IIT is taken into account, the real exchange rate elasticity of electrical machinery exports declines to -1.196 percent (using the average degree of IIT).

The impact of a smaller gap in production costs (proxied by *GDPpcgap*) on export sensitivity to exchange rates varies across industries. In the short run analysis, among statistically significant coefficients for the current and lagged values of *logRER**GDPpcgap*,* negative coefficients can be found as well for the metal products and electrical machinery industries,

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[18] The lag lengths are determined based on a fixed effects model without the *GDPgap**logRER*, *IIT**logRER*, *GDPgap*, and *IIT* terms. The lag lengths chosen by the Bayesian Information Criterion (BIC) are used as a cross-check and both criteria are generally found to be consistent with regard to the choice of lag structures.

[19] All regressions are with heteroskedasticity-robust standard errors.

which is in conflict with our expectations. For the steady state, statistically significant coefficients with the expected (positive) sign are found in three of the six industry panels (namely textiles, pulp and paper, and precision instruments).

The empirical results thus support the idea that higher IIT reduces the export sensitivity to exchange rates as a result of a lower elasticity of substitution among differentiated products both in the short run and in the steady state. For the steady state, there is also some (but less robust) empirical support that a smaller gap in production costs (proxied by per capita GDP gaps) reduces the exchange rate sensitivity of exports in half of the industries considered. 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.

VI. Conclusion

The role of exchange rates has been a central and much debated feature in the discourse on how to address global imbalances, particularly in the context of the trade imbalance between China and the United States. Generally, the appreciation of an exporter's currency is expected to result in an increase in the exporter's relative price and hence reduce export volumes.

This paper investigated both theoretically and empirically the sensitivity of trade to exchange rates in the presence of IIT by estimating industry-specific panel regressions for six manufacturing industries for thirty-eight trading pairs that include China, the United States, and Japan. The six industries chosen in this paper vary with regard to the extent of IIT. The magnitude of the differences in the estimated exchange rate elasticities of trade across industries highlights the importance of the industry-specific (disaggregation) approach (and the potential for aggregation bias). The main focus of this paper was to test the hypothesis that export sensitivity to exchange rates declines as the extent of IIT increases. The empirical results provide strong support for the idea that the negative impact of exchange rate appreciation on exports moderates as the degree of IIT increases (as a result of a lower elasticity of substitution among differentiated products). There is also some empirical evidence that a smaller gap in GDP per capita (as a proxy for the gap in production costs) is associated with a lower sensitivity of exports to exchange rates.

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 will continue to increase as income and technology levels of developing countries converge to those of developed countries. Thus, the policy implication of the results is that exchange rate devaluations (or revaluations) are becoming a less powerful tool to redress global imbalances, and even if China were to revalue its currency, the desired effect may be smaller than many of those calling for such a step expect.

Box 1. Simulation of Real Exchange Rate Elasticities for China's Exports to North America

To demonstrate the implications of our results, this Box presents a simulation of the real exchange rate elasticity of trade between China and North America (Canada and the United States). The simulation is based on the long-run steady state results shown in Tables 1.a. and 1. b. (the estimated coefficients on *logRER*, *logRER*GDPpcgap*, and *logRER*IIT*).[1] The Box Figure shows that the industry-specific exchange rate elasticities of exports clearly decline as the degree of IIT increases.[2]

As shown in the Box Table, the six industries account for 24.5 percent of the exchange rate elasticity of China's total exports to North America in 1988, and this figure rises to 53.6 percent in 2003, using the export shares of the industries. Most of this is explained by the general machinery and electrical machinery industries, which alone accounted for 43.3 percent of the exchange rate elasticity of China's total exports to North America in 2003.

The impact of IIT on China's exchange rate elasticities of exports can be seen in the Box Table, which shows exchange rate elasticities without and with IIT as well as the difference between them for 1988, 1993, 1998, and 2003. For instance, the bottom row, which looks at China's exports in the six industries taken together, suggests that, in 2003, a 1 percent appreciation of China's real exchange rate in the absence of IIT was associated with a 1.47 percent decline in exports, but when taking IIT into account, that decline was only 0.88 percent. In other words, the decline associated with a 1 percent appreciation is 0.59 percentage points smaller as a result of IIT.[3] Moreover, as the final column in the table shows, and still concentrating on total exports in the six industries together, the impact of IIT on the exchange rate elasticity of China's exports to North America has grown over time as a result of the expansion of IIT and because the share of these industries in total exports has grown.

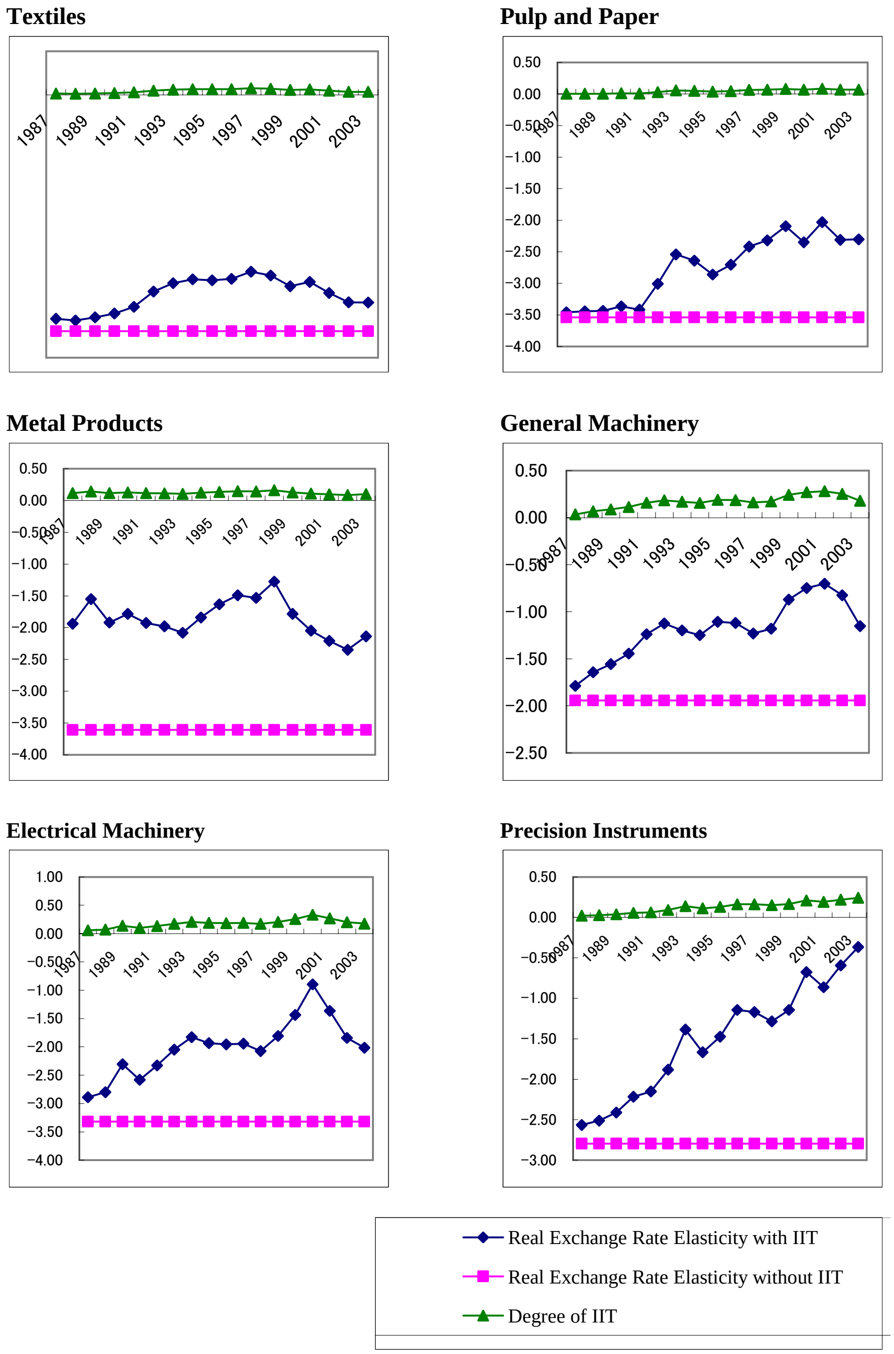
[1] The data used here are the same as those used in the empirical analysis. The share of each of the six industries in China's total exports to North America is calculated using the Comtrade database.

[2] Most of the influence of IIT on the exchange rate elasticities of exports from China to North America is explained by the elasticity of substitution among differentiated products, since the effect of the gap in production costs on the exchange rate elasticities of exports is very small. The gap in production costs (proxied by the gap in per capita real GDP) between China and North America grew slightly from 1987 to 2003.

[3] Exchange rate elasticities with IIT are calculated using the estimated coefficients on *logRER*GDPpcgap* and *logRER*IIT*.

Box 1. (continued):

Simulation for China's Exports to North America



Note: Simulated based on the long-run steady state results shown in Tables 1(a) and 1(b) following the theoretical model (equation (9)).

Box 1. (concluded):

Exchange Rate Elasticities of China's Exports to North America

	Degree of IIT between China-North America in the Industry	Share of the Industry in China's Total Exports to North America	Industry-Specific *e* without IIT = **A**	*e* without IIT in China's Total Exports to North America (Explained by **A**)	Industry-Specific *e* with IIT = **B**	*e* with IIT in China's Total Exports to North America (Explained by **B**)	Δ of Industry-Specific *e* = **C**	Δ of *e* in China's Total Exports to North America (Explained by **C**)
Textiles								
1988	0.01	15.5%	-2.70	-0.42	-2.57	-0.40	0.12	0.02
1993	0.06	5.3%	-2.70	-0.14	-2.15	-0.11	0.55	0.03
1998	0.07	3.0%	-2.70	-0.08	-2.06	-0.06	0.64	0.02
2003	0.04	2.8%	-2.70	-0.08	-2.37	-0.07	0.33	0.01
Pulp and Paper								
1988	0.01	0.2%	-3.54	-0.01	-3.44	-0.01	0.10	0.00
1993	0.06	0.5%	-3.54	-0.02	-2.54	-0.01	1.00	0.00
1998	0.07	0.6%	-3.54	-0.02	-2.32	-0.01	1.22	0.01
2003	0.07	0.7%	-3.54	-0.02	-2.30	-0.02	1.24	0.01
Metal Products								
1988	0.14	4.8%	-3.61	-0.17	-1.55	-0.07	2.06	0.10
1993	0.11	3.3%	-3.61	-0.12	-2.08	-0.07	1.53	0.05
1998	0.16	4.2%	-3.61	-0.15	-1.27	-0.05	2.33	0.10
2003	0.10	5.0%	-3.61	-0.18	-2.14	-0.11	1.47	0.07
General Machinery								
1988	0.07	2.3%	-1.94	-0.04	-1.64	-0.04	0.30	0.01
1993	0.17	4.7%	-1.94	-0.09	-1.20	-0.06	0.74	0.03
1998	0.17	11.7%	-1.94	-0.23	-1.18	-0.14	0.76	0.09
2003	0.18	21.6%	-1.94	-0.42	-1.15	-0.25	0.79	0.17
Electrical Machinery								
1988	0.07	1.3%	-3.32	-0.04	-2.80	-0.04	0.52	0.01
1993	0.20	12.7%	-3.32	-0.42	-1.83	-0.23	1.49	0.19
1998	0.21	17.1%	-3.32	-0.57	-1.81	-0.31	1.51	0.26
2003	0.18	21.7%	-3.32	-0.72	-2.02	-0.44	1.30	0.28
Precision Instruments								
1988	0.03	0.4%	-2.80	-0.01	-2.51	-0.01	0.28	0.00
1993	0.14	3.2%	-2.80	-0.09	-1.39	-0.04	1.41	0.05
1998	0.15	3.0%	-2.80	-0.08	-1.28	-0.04	1.51	0.05
2003	0.24	1.8%	-2.80	-0.05	-0.37	-0.01	2.43	0.04
Six Industries Total								
1988		**24.5%**		-0.70		-0.56		**0.13**
1993		**29.6%**		-0.88		-0.53		**0.35**
1998		**39.5%**		-1.13		-0.61		**0.52**
2003		**53.6%**		-1.47		-0.88		**0.59**

e : real exchange rate elasticities of exports.

Table 1.a. Estimation Results of the Export Equation [Random Effects (GLS)]

	Textiles	Pulp and Paper	Metal Products	General Machinery	Electrical Machinery	Precision Instruments
Dependent Variable: logQEX	**Estimated Coefficient**					
logGDPex(t)	0.151 **	1.169 ***	0.981 ***	2.491 ***	1.329 ***	2.729 ***
	(1.98)	(7.62)	(12.31)	(12.15)	(11.05)	(4.05)
logGDPex(t-1)						-1.454 **
						(-2.22)
logGDPex(t-2)						
logGDPim(t)	4.212 ***	6.350 ***	0.714 ***	2.585	1.228 ***	1.106 ***
	(4.79)	(4.07)	(6.13)	(1.04)	(7.63)	(6.33)
logGDPim(t-1)	-2.345 ***	-4.452 ***		-3.511		
	(-2.74)	(-2.92)		(-0.95)		
logGDPim(t-2)				2.031		
				(1.08)		
logRER(t)	-1.432 ***	-1.403 ***	-1.712 ***	-0.151	-0.637	-1.600 ***
	(-5.12)	(-2.94)	(-4.81)	(-0.22)	(-1.50)	(-3.78)
logRER(t-1)	-0.379	-0.217	-0.845 **	-0.055	-0.591	-0.320
	(-1.06)	(-0.35)	(-2.13)	(-0.07)	(-1.09)	(-0.64)
logRER(t-2)	-0.887 ***	-1.919 ***	-1.051 ***	-1.875 ***	-2.090 ***	-0.876 **
	(-3.72)	(-4.45)	(-3.55)	(-3.65)	(-5.59)	(-2.16)
logRER(t)*GDPpcgap(t)	0.025 ***	0.044 *	-0.034 *	0.051 **	-0.011	0.106 ***
	(3.07)	(1.69)	(-1.88)	(2.13)	(-0.82)	(3.19)
logRER(t-1)*GDPpcgap(t-1)	0.027 **	0.033 *	0.007	-0.005	0.010	0.057 **
	(2.57)	(1.71)	(0.70)	(-0.25)	(0.53)	(2.04)
logRER(t-2)*GDPpcgap(t-2)	-0.003	0.004	0.014 ***	0.002	-0.011 ***	-0.012
	(-0.37)	(0.62)	(2.93)	(0.24)	(-3.34)	(-1.55)
logRER(t)*IIT(t)	6.962 **	9.006 ***	8.612 ***	2.283	2.040 *	6.789 ***
	(2.38)	(3.01)	(5.06)	(0.92)	(1.86)	(3.59)
logRER(t-1)*IIT(t-1)	-1.287	-1.797	2.214	-0.479	1.390	0.442
	(-0.36)	(-0.47)	(1.17)	(-0.17)	(1.01)	(0.16)
logRER(t-2)*IIT(t-2)	3.250	10.645 ***	3.653 ***	3.553 *	3.862 ***	2.782
	(1.36)	(4.11)	(2.62)	(1.88)	(3.92)	(1.19)
GDPpcgap(t)	-0.126 ***	-0.222	0.159 *	-0.248 **	0.038	-0.512 ***
	(-3.08)	(-1.64)	(1.78)	(-2.10)	(0.57)	(-2.99)
GDPpcgap(t-1)	-0.141 ***	-0.166 *	-0.034	0.023	-0.067	-0.295 **
	(-2.83)	(-1.74)	(-0.69)	(0.27)	(-0.70)	(-2.01)
GDPpcgap(t-2)	0.009	-0.013	-0.055 ***	-0.007	0.039 ***	0.046
	(0.30)	(-0.59)	(-3.02)	(-0.23)	(2.95)	(1.59)
IIT(t)	-33.918 **	-41.364 ***	-38.603 ***	-7.079	-8.952 *	-29.955 ***
	(-2.54)	(-3.02)	(-4.94)	(-0.62)	(-1.75)	(-3.43)
IIT(t-1)	5.715	8.475	-9.907	2.349	-6.258	-1.372
	(0.35)	(0.48)	(-1.14)	(0.18)	(-0.97)	(-0.11)
IIT(t-2)	-15.160	-48.316 ***	-16.712 ***	-15.423 *	-17.487 ***	-13.078
	(-1.39)	(-4.05)	(-2.59)	(-1.76)	(-3.78)	(-1.26)
_cons	7.980 ***	6.418 ***	13.106 ***	-3.781 *	7.672 ***	5.976 ***
	(8.04)	(5.94)	(11.91)	(-1.79)	(7.17)	(4.84)
Number of obs.	953	931	912	915	913	896
R-sq: within	0.737	0.742	0.791	0.745	0.799	0.751
between	0.508	0.674	0.522	0.457	0.641	0.518
overall	0.662	0.715	0.708	0.678	0.759	0.711
Hausman Test	chi2(17) =16.71	chi2(15) =4.18	chi2(15) =3.93	chi2(17) =111.80	chi2(16) =5.93	chi2(17) = 17.77
	P>chi2 = 0.4739	P>chi2 = 0.9971	P>chi2 = 0.9980	P>chi2 = 0.0000	P>chi2 = 0.9888	P>chi2 = 0.4038
Long-Run Steady State: X = X(t-k)	X=logGDPex, logGDPim, logRER, (logRER)*GDPpcgap, (logRER)*IIT, GDPpcgap, IIT k=0,1,2					
logGDPex	0.151 **	1.169 ***	0.981 ***	2.491 ***	1.329 ***	1.275 ***
logGDPim	1.867 ***	1.899 ***	0.714 ***	1.106 ***	1.228 ***	1.106 ***
logRER	**-2.698** ***	**-3.539** ***	**-3.608** ***	**-2.081** ***	**-3.318** ***	**-2.796** ***
(logRER)*GDPpcgap	0.049 ***	0.080 ***	-0.013	0.049 *	-0.012	0.151 ***
(logRER)*IIT	8.925 ***	17.854 ***	14.479 ***	5.357 ***	7.292 ***	10.012 ***
GDPpcgap	-0.258 ***	-0.401 ***	0.070	-0.232 *	0.011	-0.761 ***
IIT	-43.363 ***	-81.205 ***	-65.222 ***	-20.153 **	-32.697 ***	-44.404 ***
(1+ave.IIT)*logRER	**-1.893** ***	**-1.761** ***	**-1.448** ***	**-1.135** **	**-1.196** ***	**-0.949** ***
IIT Average	0.090	0.100	0.149	0.177	0.291	0.184
Min.	0.001	0.000	0.000	0.000	0.000	0.000
Max.	0.444	0.495	0.519	0.734	0.938	0.665
Std. Dev.	0.075	0.091	0.102	0.144	0.193	0.124

*, **, ***: 10%, 5%, 1% significance of P>|z|, and P>F for the long-run analysis.

Note: The numbers in parentheses are z-values from heteroskedasticity-robust standard errors.
Exporters: China, Hong Kong SAR, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, United States.
Importers: EU, Japan, Asia, North America.
IIT: Authors' calculations. See Section IV for details.

Table 1b. Estimation Results of the Export Equation [Fixed Effects (Within)]

	Textiles	Pulp and Paper	Metal Products	General Machinery	Electrical Machinery	Precision Instruments
Dependent Variable: logQEX	**Estimated Coefficient**					
logGDPex(t)	0.150 *	1.229 ***	0.981 ***	2.640 ***	1.388 ***	2.792 ***
	-1.92	(8.17)	(12.26)	(14.48)	(11.69)	(4.17)
logGDPex(t-1)						-1.430 **
						(-2.19)
logGDPex(t-2)						
logGDPim(t)	3.884 ***	6.096 ***	0.709 ***	1.476	1.239 ***	1.142 ***
	-4.4	(3.71)	(5.91)	-0.6	(7.92)	(6.76)
logGDPim(t-1)	-1.960 **	-4.201 ***		-3.203		
	(-2.27)	(-2.60)		(-0.91)		
logGDPim(t-2)				2.777		
				(1.43)		
logRER(t)	-1.455 ***	-1.378 ***	-1.722 ***	-0.146	-0.667	-1.615 ***
	(-5.43)	(-2.92)	(-4.94)	(-0.23)	(-1.61)	(-3.97)
logRER(t-1)	-0.377	-0.223	-0.846 **	-0.099	-0.567	-0.294
	(-1.09)	(-0.37)	(-2.09)	(-0.13)	(-1.09)	(-0.62)
logRER(t-2)	-0.911 ***	-1.885 ***	-1.044 ***	-1.698 ***	-2.100 ***	-0.917 **
	(-3.97)	(-4.47)	(-3.46)	(-3.44)	(-5.92)	(-2.39)
logRER(t)*GDPpcgap(t)	0.026 ***	0.041	-0.033 *	0.037 *	-0.011	0.099 ***
	-3.06	(1.62)	(-1.77)	(1.78)	(-0.81)	(2.96)
logRER(t-1)*GDPpcgap(t-1)	0.027 ***	0.030	0.007	-0.018	0.008	0.050 *
	-2.68	(1.55)	(0.57)	(-0.76)	(0.47)	(1.76)
logRER(t-2)*GDPpcgap(t-2)	-0.003	0.004	0.013 **	0.001	-0.011 ***	-0.012 *
	(-0.43)	(0.69)	(2.47)	(0.12)	(-3.29)	(-1.92)
logRER(t)*IIT(t)	7.247 **	8.939 ***	8.671 ***	1.736	2.048 *	6.789 ***
	-2.6	(3.08)	(5.19)	(0.76)	(1.87)	(3.59)
logRER(t-1)*IIT(t-1)	-1.411	-1.850	2.232	-0.160	1.364	0.391
	(-0.42)	(-0.50)	(1.18)	(-0.06)	-1	(0.15)
logRER(t-2)*IIT(t-2)	3.405	10.566 ***	3.659 ***	2.830	3.973 ***	3.205
	-1.51	-4.2	(2.62)	-1.6	(4.08)	(1.47)
GDPgappc(t)	-0.132 ***	-0.209	0.156	-0.176 *	0.038	-0.477 ***
	(-3.10)	(-1.57)	(1.65)	(-1.76)	(0.57)	(-2.77)
GDPpcgap(t-1)	-0.141 ***	-0.151	-0.034	0.093	-0.058	-0.258 *
	(-3.03)	(-1.57)	(-0.58)	(0.77)	(-0.66)	(-1.74)
GDPpcgap(t-2)	0.011	-0.014	-0.051 **	-0.004	0.038 ***	0.049 *
	(0.37)	(-0.66)	(-2.55)	(-0.13)	(2.91)	(1.96)
IIT(t)	-36.006 ***	-41.296 ***	-38.830 ***	-4.557	-9.117 *	-30.225 ***
	(-2.82)	(-3.10)	(-5.03)	(-0.43)	(-1.79)	(-3.44)
IIT(t-1)	6.232	8.643	-9.982	0.742	-6.188	-1.282
	-0.4	-0.5	(-1.14)	(0.06)	(-0.96)	(-0.11)
IIT(t-2)	-16.173	-48.201 ***	-16.724 **	-12.333	-18.199 ***	-15.438
	(-1.56)	(-4.14)	(-2.58)	(-1.51)	(-3.96)	(-1.58)
_cons	8.068 ***	6.021 ***	13.153 ***	-4.687 **	7.586 ***	5.780 ***
	-8.37	(5.77)	(12.81)	(-2.46)	(7.63)	(5.02)
Number of obs.	953	931	912	915	913	896
R-sq: within	0.738	0.742	0.791	0.746	0.799	0.752
between	0.442	0.658	0.520	0.427	0.604	0.432
overall	0.639	0.710	0.708	0.673	0.750	0.697
Hausman Test	chi2(17) =16.71	chi2(15) =4.18	chi2(15) =3.93	chi2(17) =111.80	chi2(16) =5.93	chi2(17) = 17.77
	P>chi2 = 0.4739	P>chi2 = 0.9971	P>chi2 = 0.9980	P>chi2 = 0.0000	P>chi2 = 0.9888	P>chi2 = 0.4038
Long-Run Steady State: X = X(t-k)	X=logGDPex, logGDPim, logRER, (logRER)*GDPpcgap, (logRER)*IIT, GDPpcgap, IIT k=0,1,2					
logGDPex	0.150 *	1.229 ***	0.981 ***	2.640 ***	1.388 ***	1.362 ***
logGDPim	1.924 ***	1.895 ***	0.709 ***	1.050 ***	1.239 ***	1.142 ***
logRER	**-2.743** ***	**-3.486** ***	**-3.612** ***	**-1.942** ***	**-3.334** ***	**-2.825** ***
(logRER)*GDPpcgap	0.050 ***	0.075 ***	-0.014	0.020	-0.014	0.136 ***
(logRER)*IIT	9.240 ***	17.655 ***	14.562 ***	4.406 ***	7.386 ***	10.385 ***
GDPpcgap	-0.261 ***	-0.375 ***	0.071	-0.087	0.019	-0.686 ***
IIT	-45.947 ***	-80.854 ***	-65.536 ***	-16.148 **	-33.504 ***	-46.945 ***
(1+ave.IIT)*logRER	**-1.910** ***	**-1.729** ***	**-1.440** ***	**-1.164** **	**-1.185** ***	**-0.910** ***
IIT Average	0.090	0.100	0.149	0.177	0.291	0.184
Min.	0.001	0.000	0.000	0.000	0.000	0.000
Max.	0.444	0.495	0.519	0.734	0.938	0.665
Std. Dev.	0.075	0.091	0.102	0.144	0.193	0.124

*, **, ***: 10%, 5%, 1% significance of P>|t|, and P>F for the long-run analysis.

Note: The numbers in parentheses are t-values from heteroskedasticity-robust standard errors.
Exporters: China, Hong Kong SAR, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, United States.
Importers: EU, Japan, Asia, North America.
IIT: Authors' calculations. See Section IV for details.

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