INSTITUTE OF DEVELOPING ECONOMIES

IDE Discussion Papers are preliminary materials circulated
to stimulate discussions and critical comments

IDE DISCUSSION PAPER No. 155

The Choice of Transport Mode: Evidence from Japanese Exports to East Asia

Kazunobu HAYAKAWA*

May 2008

Abstract
This paper investigates Japanese trade by mode of transport, i.e., air transport versus maritime shipping. Some facts about Japanese machinery exports by mode of transport in the 1990s are examined first. Then it will be shown that products of the machinery sector where international fragmentation prevails are more likely to be exported by air.

Keywords: Transport, Fragmentation, East Asia, Japan
JEL classification: F14, L91, N75

---

* Corresponding author. Kazunobu Hayakawa, Economic Integration Studies Group, Inter-Disciplinary Studies Center, Institute of Developing Economies, 3-2-2 Wakaba, Mihama-ku, Chiba-shi, Chiba 261-8545 Japan. Phone: 81-43-299-9754; Fax: 81-43-299-9763. E-mail: kazunobu_hayakawa@ide.go.jp

The Institute of Developing Economies (IDE) is a semigovernmental, nonpartisan, nonprofit research institute, founded in 1958. The Institute merged with the Japan External Trade Organization (JETRO) on July 1, 1998. The Institute conducts basic and comprehensive studies on economic and related affairs in all developing countries and regions, including Asia, the Middle East, Africa, Latin America, Oceania, and Eastern Europe.

INSTITUTE OF DEVELOPING ECONOMIES (IDE), JETRO

3-2-2, WAKABA, MIHAMA-KU, CHIBA-SHI

CHIBA 261-8545, JAPAN

1. Introduction

With the ongoing globalization, logistics play an important role in the strategy of multi-country corporations. A smooth and effective transportation system is essential particularly for corporations that adopt efficient production systems, such as the just-in-time (JIT) production system and supply chain management (SCM). Since the absence of key components idles an entire assembly plant, a delay in transportation affects the entire supply chain, resulting in a loss of commercial opportunity. Hence, it is important for such corporations to streamline transportation management.

Despite the importance of transportation, the changes in international trade depending upon the mode of transport, e.g., maritime shipping or air transport, have remained unknown in economics. From the theoretical point of view, however, there seems to be a clear trade-off in transport modal choice. A key element is shipping time. As indicated in the relationship between sea transportation and air transportation, faster delivery is more expensive. Further, such costs crucially depend not only on distance to destination but also on product weight and bulk. The lightness and smallness of a shipped product make the cost less sensitive to shipping time. On the other hand, shipping time also affects the prices of products such as perishable goods (e.g., fresh foods) and items with immediate information content, e.g., newspapers (see Hummels, 2001). A lengthy shipping time may lead to a complete loss of commercial opportunity for products and their components that have a quite rapid product life cycle and high demand volatility. This argument is also applicable to parts and components important in the production-process division of labor. The longer the supply chain, the more necessary is speedy delivery between production processes. As a result, products are transported by rapid transportation modes if the benefit in terms of price exceeds the cost.

Empirical studies on trade by mode of transport have never taken center stage in trade analysis. However, there is already a great deal of data on trade values in terms of transport mode. Countries such as the U.S. and Japan not only report such data but also trade values in terms of customs and ports in the countries. In the case of analysis covering a lot of countries, the data on bilateral trade values are often drawn from UN Comtrade. Although UN Comtrade does not report trade values by mode of transport, such data are available in the World Trade Atlas produced by Global Trade Information Inc. Trade data identifying mode of transport would seem to be one of the most useful data sources particularly for analyzing the relationship between trade and time costs. Indeed, Hummels (2001) is one of the studies that uses the data on trade by transport mode and estimates the tariff-equivalent of time costs by examining the relationship between transport modal choices and shipping times.[1]

The purpose of this paper is twofold. First, it will provide some facts about Japanese trade by mode of transport. Since the data on global trade by transport mode is unexploited, only a few facts have been accumulated so far. This paper presents facts about Japanese exports by transport mode in the 1990s. Second, by controlling for product characteristics such as weight and size, it will examine the relationship between air transport and the multi-national division of labor in the production process,

[1] Recently empirical and theoretical studies on time costs have been increasing (see, for example, Deardorff, 2003; Evans and Harrigan, 2005; Djankov, Freund, and Pham, 2006; Harrigan and Venables, 2006; Nordas, Pinali, and Grosso, 2006).

which is also known as international fragmentation. In particular, the paper will investigate this relationship as it concerns Japanese trade with East Asian countries, most of which are motivated by international fragmentation (see, for example, Kimura and Ando, 2003). As Hummels (2001) points out, time costs are one of the most important factors for developing international fragmentation. This paper will show that a recent trend in East Asia is that products of a sector where international fragmentation prevails are more likely to be exported by air freight.

The remainder of this paper is organized as follows: section 2 gives some empirical facts about Japanese exports, while section 3 undertakes a formal empirical analysis using trade data in terms of transport mode. Section 4 presents this study's conclusions.

2. Facts about Japan's Machinery Trade by Transport Mode

This section presents an overview of the changes in the Japanese machinery trade in the 1990s in terms of the mode of transport. To avoid over- or under-evaluation of trade values due to the differences in freight charges among importing countries, f.o.b.-valued export values are used. The data in this section come from the Japanese customs website[2].

Investigating first the changes in total Japanese machinery exports by transport mode from 1988 to 2004, Figure 1 shows the share of air exports in total exports (air exports plus maritime exports) by destination. The share of Japanese air exports to the world has tended to increase though it declined slightly from 2000 to 2001. Looking at the changes by destination[3], it can be seen that air transport is frequently used in exports to East Asia compared with those to the other regions. Particularly since 1998, over half of the exports to East Asia have been by air freight.

== Figure 1 ==

Figure 2 shows the share of air exports by product type, i.e., finished machinery products and machinery parts. The HS code list of parts is drawn from Kimura and Ando (2003). From this figure, we can see striking differences between exports to East Asia and those to the other regions. It can be seen that exports of machinery parts to East Asia are frequently via air transport. The share of parts exported by air has always been larger than that of finished products and has continuously increased. Furthermore, while the share of finished products exported by air has declined since 2000, that of parts has experienced a dramatic rise since the first half of the 1990s. Particularly since 1999, more than 60% of machinery parts have been exported by air. This increase may be due to the development of an international production-process division of labor in East Asia. In the exports to the other regions, on the other hand, the opposite tendency can be observed. While the share of finished products exported by air has risen since 2000, that of parts has declined. Particularly in 2000, the magnitude relation between the shares of finished products and parts exported by air reversed despite the general fact that parts are more likely to be transported by air than

2 http://www.customs.go.jp/toukei/info/index.htm

3 In this section, East Asia means the Republic of Korea, China, Hong Kong, Taiwan, Thailand, the Philippines, Malaysia, Singapore, and Indonesia.

finished products due to their lightness and smallness. Therefore, the higher share of finished products exported by air may indicate that Japan exports to the other regions, such as the OECD countries, products having a quite rapid product cycle and high demand volatility.

== Figure 2 ==

Figure 3 sets forth the results of an examination of Japanese exports to East Asia by machinery sector: electric machinery (Section XVI), transport equipment (Section XVII), and precision machinery (Section XVIII) sectors. Remarkable differences can be seen among the sectors. The most striking feature in Figure 3 is the low level in the share of transport equipment exported by air. The share has been around 1%. As argued in the previous section, the bulk and heftiness of transport equipment make it difficult to transport these products by air. On the other hand, the share in both the electric and precision machinery sectors has been much higher than that in transport equipment and has experienced a certain increase. This increase has been because the products in both of these machinery sectors are often small and light. Furthermore, the dramatic development of the production-process division of labor and rapid product cycles have contributed to the increase in the use of air transport in the electric and precision machinery sectors.

== Figure 3 ==

3. Econometric Analysis

This section undertakes a formal analysis using data on trade by transport mode. It will investigate empirically whether the products within a category in which international fragmentation develops are likely to be exported by air. If time costs are one of the most important factors for developing international fragmentation, we should find that such products tend to be transported by air..

3.1. Data and Methodology

The same dataset as in the previous section is employed in this analysis. The focus will be on the machinery sectors in 1996, 2000, and 2004, and the sample consists of Japanese exports to eight East Asian countries (the Republic of Korea, China, Hong Kong, Thailand, the Philippines, Malaysia, Singapore, and Indonesia[4]) at the HS 4-digit level. We will examine the relationship between international fragmentation and transport modal choice by regressing the following simple equation:

$$\ln\left(A_{it}^{p_4} / \left(A_{it}^{p_4} + S_{it}^{p_4}\right)\right) = const + \beta \cdot \ln VIIT_{it}^{p_4} + \varepsilon_{it}^{p_4},$$

where i, t, and p_4 denote importing country, year, and a HS 4-digit code, respectively. The dependent variable is a log of the share of air exports in total exports. Product and country dummy variables are also added in order to control for the other elements affecting transport modal choice, e.g., product weight and bulk.

A VIIT index is used as a proxy for the degree of international fragmentation:

[4] Taiwan has been dropped from the sample due to the unavailability of data on an independent variable.

$$VIIT_{it}^{p_4} \equiv \frac{2\sum_{p_6 \in P_V^4} \min\left(X_{ijt}^{p_6}, X_{jit}^{p_6}\right)}{\sum_{p_6 \in P_4}\left(X_{ijt}^{p_6} + X_{jit}^{p_6}\right)},$$

$$\text{where} \quad P_V^4 = \left\{ p_6 \middle| p_6 \in P_4, \left(\frac{UV_{ijt}^{p_6}}{UV_{jit}^{p_6}} \leq \frac{1}{1.25}\right) \vee \left(\frac{UV_{ijt}^{p_6}}{UV_{jit}^{p_6}} \geq 1.25\right)\right\}.$$

p_6 and p_4 denote a HS 6-digit code and a HS 4-digit code. $X_{ijt}^{p_6}$ represents exports of country *i* (i.e., Japan) to country *j* at p_6 in year *t*. $UV_{ijt}^{p_6}$ is a unit value of the exports of country *i* to country *j*.

The VIIT index indicates how intensively countries become involved in intra-industry trade with unit price differentials.[5] Such trade occurs not only in international transactions across production stages (see, for example, Jones and Kierzkowski, 1990) but also in the transactions of products whose quality is vertically differentiated (see, for example, Flam and Helpman, 1987). Although the magnitude of the VIIT index does not completely correspond to the degree of international fragmentation, this paper will initially employ this index as a proxy for such fragmentation. Indeed, Wakasugi (2006) has used this index to analyze whether the recent trade expansion in East Asia has been induced by the development of international fragmentation. Later, another index will be used to address this issue. The same threshold (25%) as used in Wakasugi (2006) is employed here as unit price differentials.

The data on trade values and their unit values are drawn from UN Comtrade. The import data of each country has been used for the calculations. Unit values of imports are at the HS 6-digit level and were obtained by dividing import values by the corresponding quantities. To address the problems of discordant units between exports and imports and of no information on the quantity, the strategy adopted here is the same as that in Ando (2006), i.e., when encountering discordances in measuring units of import quantities between two countries, bilateral export data are used, which are multiplied by 1.05 for the adjustment. The HS 6-digit products whose unit price cannot be measured even by these methods have been dropped from the calculation of the VIIT index.

The column "Parts + Finished Products" in Table 1 shows the evolution of the mean value of the VIIT index in each country. Two points are to be noted. First, except for Hong Kong, the VIIT exhibits a steady increase for all countries. This increase would imply the development of international fragmentation in the machinery sectors. Second, the recent value of the VIIT is larger for developing countries than for developed countries, though Korea has a relatively large VIIT. This indicates that, since the international division of labor takes advantages of differences in location advantages, international fragmentation has developed more dramatically between Japan and developing countries.

== Table 1 ==

[5] Regarding this decomposition of the Grubel-Lloyd intra-industry index, see Greenaway, Hine, and Milner (1995).

3.2. Regression Results

The regression results by the ordinary least squares (OLS) are shown in Table 2. Eq (1) presents the basic result. The estimation of the coefficient for the VIIT is significantly positive, although the R-squares is quite low. The positive coefficient implies that the products within the category in which international fragmentation develops are likely to be exported by air. In order to control to some extent for product lightness and smallness, an indicator variable needs to be introduced which takes unity if a product is a part and zero otherwise. The result with this introduced variable is shown in Eq (2). The coefficients for both the VIIT and the indicator variable are significantly positive, meaning that parts and components are more likely to be delivered by air. In Eq (3), to control for importer characteristics, we add not only the above indicator variable but also importer dummy variables. In Eq (4), importer-product dummy variables are introduced, which are expected to control for all the time-invariant product and country characteristics. In both Eqs (4) and (5), the coefficients for the VIIT are again significantly positive. Finally, employing a stricter 40% threshold and regressing the same formulations above, the results are presented in Eq (5) to Eq (8). These again confirm that international fragmentation encourages the air transport of products.

== Table 2 ==

However, there needs to be more robustness checks of the above results, as there are problems in the above-proposed empirical methodology. Firstly, as argued earlier, the VIIT index captures not only the trade based on international fragmentation but also the vertical intra-industry trade based on quality differentials. The latter trade seems to occur mainly in finished products. Thus, to address this problem, the VIIT index (and dependent variable) will be reconstructed using the data on the international trade only in parts and components. The column "Parts" in Table 1 shows the evolution of the mean value of such a VIIT index in each country. Compared with the previous index, which is shown in the column "Parts + Finished Products", the magnitude of the reconstructed index rises slightly particularly in developing countries. The regression results using the newly constructed variable are shown in the second to the fifth column in Table 3. From this table it can be seen that the results of the relationship between air transport and international fragmentation are qualitatively unchanged, although the coefficient for the VIIT decreases a little and is significant at the 10% level in Eqs (4) and (8).

== Table 3 ==

Another problem is that taking a log of the dependent variable implies that the sample used here is restricted to the HS 4-digit products that Japan actually exports by air transport. This restriction gives rise to a sample selection bias. In addition, although the products in this paper are aggregated at the HS 4-digit level, international fragmentation sometimes occurs across HS 4-digit products. Since the way of aggregation affects the magnitude of the VIIT index, it is possible to suffer from some unexpected bias. To simultaneously address these two issues, the products will be aggregated at the HS 2-digit level rather than performing the well-known Heckman's estimation. The results are set forth in the sixth to the ninth column of Table 3 and show that the positive relationship between air transport and international fragmentation still exists. As a result, we can conclude that the products important in the sophisticated production-process division of labor are likely to be transported by air. This result indicates that time costs are one of the most important factors for developing international fragmentation.

4. Concluding Remarks

This paper presented an empirical investigation of the relationship between transport mode and international fragmentation by using the data on trade values based on the mode of transport. Certainly we need to continue building up the empirical facts of the relationship between mode of transport and international trade, and then to examine this relationship more closely. Indeed, the findings in section 3 present some hypotheses to be formally tested: the products with a rapid product cycle and with high demand volatility are likely to be transported by air. However, a worldwide sampling of countries would make the analysis of mode choice more complicated because besides sea and air, we would need to take into consideration other means of transport such as that by truck or railway.

References

Ando, M., 2006, Fragmentation and vertical intra-industry trade in East Asia, *North American Journal of Economics and Finance*, **17(3)**: 257-281.

Ando, M. and Kimura, F., 2003, The Formation of International Production and Distribution Networks in East Asia, in Takatoshi Ito and Andrew Rose, eds., International Trade (NBER-East Asia Seminar on Economics, Volume 14), Chicago: The University of Chicago Press.

Deardorff, Alan V., 2003, Time and Trade: The Role of Time in Determining the Structure and Effects of International Trade, with an Application to Japan, in Robert M. Stern, ed., Analytical Studies in U.S.-Japan International Economic Relations, Cheltenham, U.K. and Northhampton, MA: Edward Elgar Publishing Inc.

Djankov, S., Freund, C., and Pham, C., 2006, Trading on Time, Doing Business, Research Paper, World Bank.

Evans, C. L. and Harrigan, J., 2005, Distance, Time, and Specialization: Lean Retailing in General Equilibrium, *American Economic Review* **95(1)**: 292-313.

Flam, H. and Helpman, E., 1987, Vertical Product Differentiation and North-South Trade, *American Economic Review* **77**: 810-822.

Greenaway, D., Hine, R., and Milner, C., 1995, Vertical and Horizontal Intra-industry Trade: A Cross Industry Analysis for the United Kingdom, *Economic Journal* **105**: 1505-1518.

Harrigan, J. and Venables, A. J., 2006, Timeliness and Agglomeration, *Journal of Urban Economics* **59**: 300-316.

Hummels, D., 2001, Time as a Trade Barrier, *GTAP Working Papers* 1152, Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University.

Jones, R. W. and Kierzkowski, H. 1990, The Role of Services in Production and International Trade: a Theoretical Framework, in R. W. Jones and A. O. Krueger (eds), *The Political Economy of International Trade: Essays in Honor of R. E. Baldwin*, Oxford: Basil Blackwell.

Nordas, H., Pinali, E., and Grosso, M., 2006, Logistics and Time as a Trade Barrier, *OECD Trade Policy Working Paper* No. 35, Organisation for Economic Co-operation and Development.

Wakasugi, R., 2006, The Growth of Trade under Heterogeneity in East Asia: An Empirical Evidence, *G-SEC Working Paper* No.8, Keio University.

Figure 1. The Share of Exports by Air

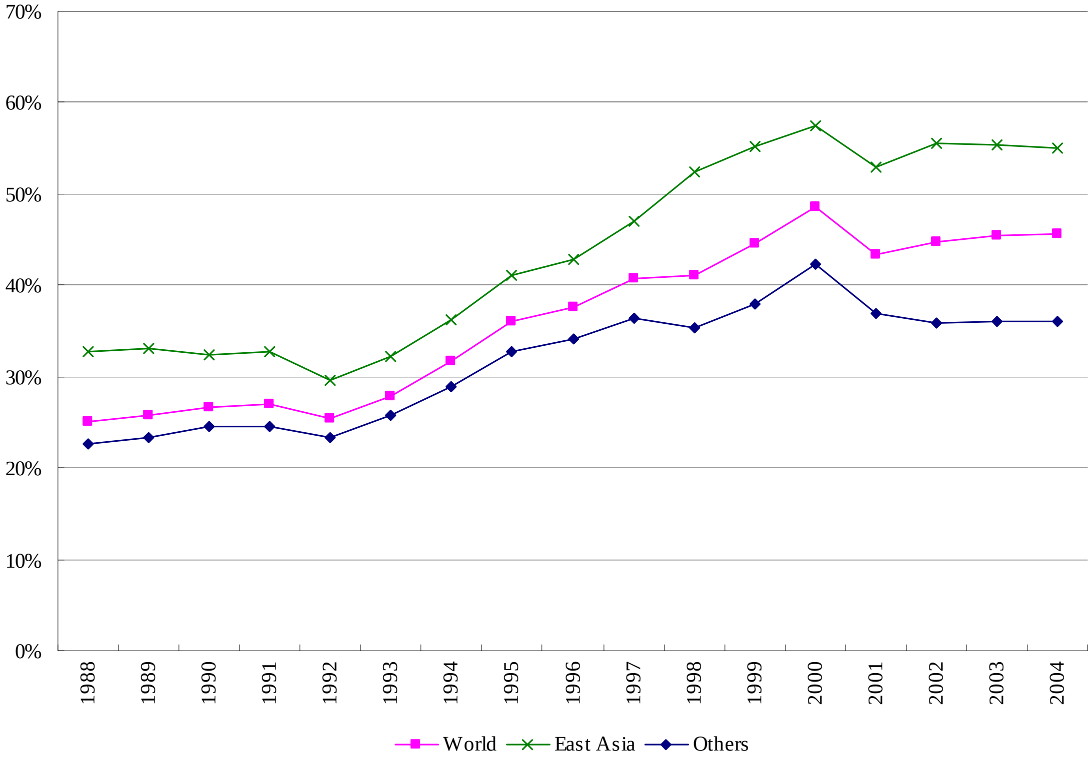

Figure 2. The Share of Exports by Air, Broken down by Product Type

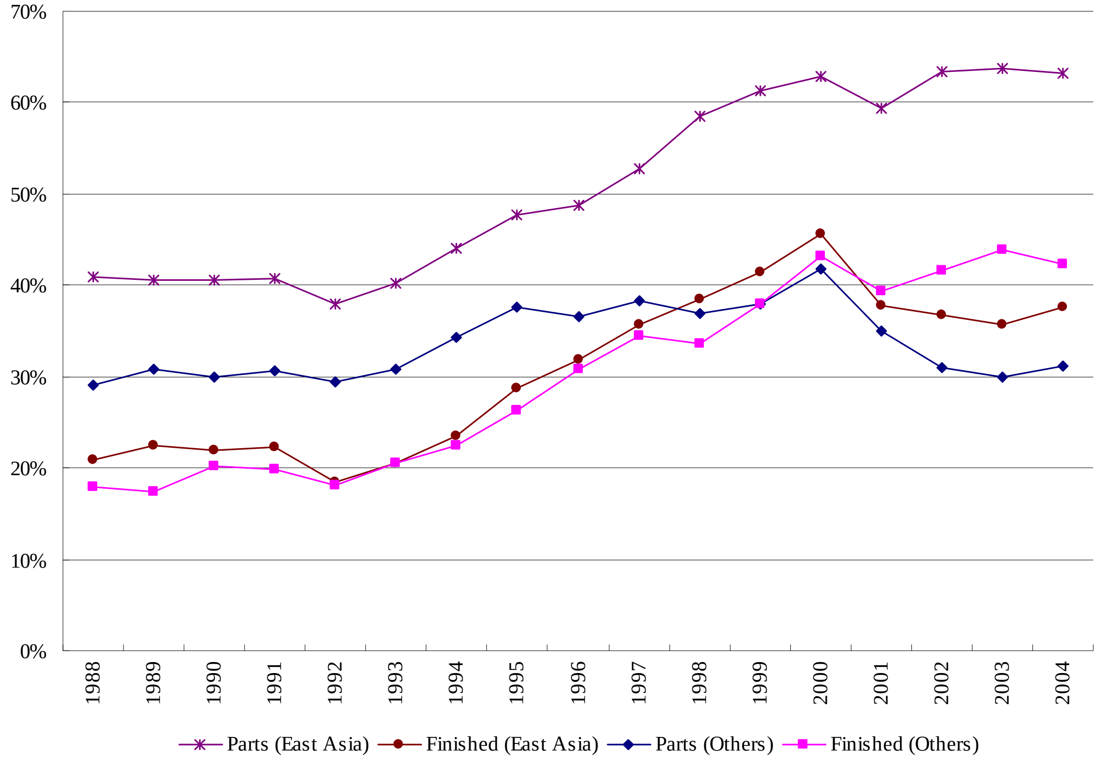

Figure 3. The Share of Exports by Air to East Asia, Broken down by Machinery Type

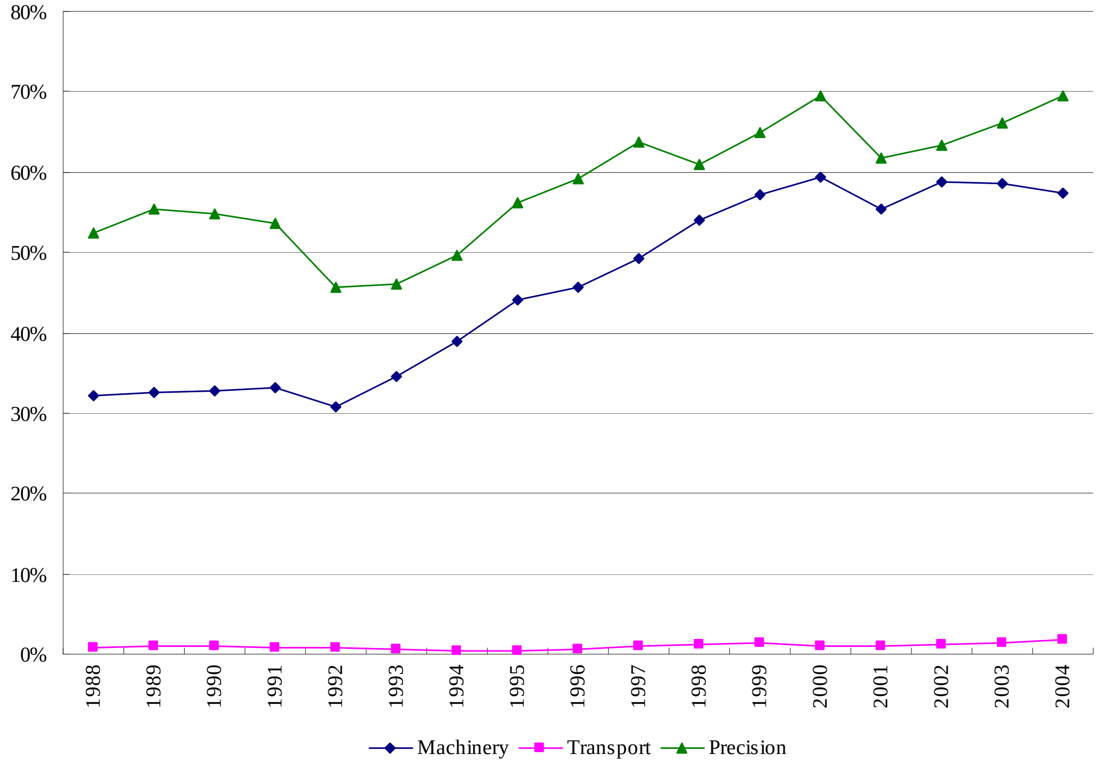

Table 1. Evolution of the VIIT Index

	Parts + Finished Products			Parts		
	1996	2000	2004	1996	2000	2004
China	0.12	0.12	0.14	0.17	0.18	0.22
Hong Kong	0.06	0.06	0.05	0.05	0.05	0.04
Indonesia	0.09	0.10	0.11	0.10	0.11	0.14
Malaysia	0.08	0.09	0.11	0.11	0.11	0.13
Philippines	0.09	0.11	0.14	0.10	0.13	0.16
Korea	0.11	0.12	0.13	0.14	0.15	0.18
Singapore	0.08	0.09	0.09	0.09	0.10	0.09
Thailand	0.09	0.13	0.14	0.10	0.17	0.18

Table 2. Regression Results

	Eq (1)	Eq (2)	Eq (3)	Eq (4)	Eq (5)	Eq (6)	Eq (7)	Eq (8)
VIIT	0.21***	0.21***	0.23***	0.05***	0.21***	0.20***	0.22***	0.04***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
Parts		0.48***	0.47***			0.46***	0.45***	
		(0.06)	(0.06)			(0.06)	(0.06)	
constant	-1.20***	-1.41***	-2.14***	-1.72***	-1.19***	-1.38***	-2.12***	-1.75***
	(0.06)	(0.07)	(0.10)	(0.04)	(0.06)	(0.07)	(0.10)	(0.04)
threshold	25%	25%	25%	25%	40%	40%	40%	40%
estimation	Pool	Pool	Country	Fixed effect	Pool	Pool	Country	Fixed effect
R-sq	0.047	0.066	0.119	0.007	0.048	0.066	0.122	0.005
Obs.	3,343	3,343	3,343	3,343	3,271	3,271	3,271	3,271

Notes: ***, **, and * show 1%, 5%, and 10% significance, respectively. In parenthesis is a White consistent standard error. "Pool", "Country", and "Fixed effect" indicate the pooled OLS estimation, the OLS estimation of the equation with country dummies, and that with fixed effect (country-by-product dummies), respectively.

Table 3. Robustness Checks

	Eq (1)	Eq (4)	Eq (5)	Eq (8)	Eq (1)	Eq (4)	Eq (5)	Eq (8)
VIIT	0.16***	0.03*	0.16***	0.03*	0.56***	0.16*	0.53***	0.17*
	(0.02)	(0.01)	(0.02)	(0.01)	(0.13)	(0.09)	(0.13)	(0.09)
constant	-0.96***	-1.32***	-0.94***	-1.32***	-0.50	-1.56***	-0.53	-1.54***
	(0.06)	(0.04)	(0.06)	(0.04)	(0.37)	(0.24)	(0.38)	(0.25)
threshold	25%	25%	40%	40%	25%	25%	40%	40%
estimation	Pool	Fixed effect	Pool	Fixed effect	Pool	Fixed effect	Pool	Fixed effect
HS	4 digit	4 digit	4 digit	4 digit	2 digit	2 digit	2 digit	2 digit
Products	P	P	P	P	F+P	F+P	F+P	F+P
R-sq	0.0351	0.0044	0.0393	0.0042	0.123	0.033	0.115	0.035
Obs.	2307	2307	2214	2214	167	167	166	166

Notes: See notes in Table 2. “P” means that the sample consists of parts only while “F+P” means that it consists of parts plus finished products