

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

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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 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.

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## 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.

Recently theoretical and empirical studies on time costs have been increasing. Deardorff (2003) presents a comprehensive conceptual framework on relationship between time and trade. Evans and Harrigan (2005) and Harrigan and Venables (2006) construct general equilibrium models with demand and cost uncertainties and examine rigorously the relationship between time and trade/industrial location. Such relationship is explored also in empirical studies. Hummels (2001) estimates the tariff-equivalent of time costs by examining the relationship between transport modal choices and shipping times. Djankov *et al.* (2006) and Nordas *et al.* (2006) investigate impacts of the required time for exports on exports and participation to exporting markets, respectively.

The aim of this paper is to add new facts into not only the time costs literature but also the international fragmentation literature. The fragmentation theory was first proposed by Jones and Kierzkowski (1990) and has been extended and deepened in both theoretical and empirical literature.<sup>1)</sup> We have already known that international fragmentation<sup>2)</sup> has developed dramatically in East Asia since the 1990s. Particularly in the

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<sup>1)</sup> For a theoretical analysis, see Arndt and Kierzkowski (2001) and Cheng and Kierzkowski (2001). For an empirical investigation on fragmentation in East Asia, see Kimura (2006).

<sup>2)</sup> Fragmentation is defined as the splitting of a product process into two or more steps that lead to the same final product. When a fragmented production block is placed beyond a national border, the fragmentation is called “international fragmentation” or “cross-border fragmentation”.

electric machinery sector, we observe remarkable expansion and deepening of international fragmentation, which gradually covers a large number of countries and intensifies its sophistication in the combination of intra-firm and arm's length (inter-firm) transactions. To further explore the mechanics of international fragmentation, this paper examines the relationship between time and international fragmentation, in the context of East Asian machinery sectors.

Specifically, this paper investigates transport modal choice in international fragmentation. In general, there is a clear trade-off in transport modal choice. A key element is shipping time. On the one hand, 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. 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. As a result, products are transported by rapid transportation modes if the benefit in terms of price exceeds the cost. As mathematically demonstrated by Hummels (2001), furthermore, the importance of rapid shipping is magnified in the presence of fragmented production because time costs for first stage value-added begin to accumulate immediately and do not stop until the final good is sold. That is, the importance of time savings in transport rises with each stage because the time savings accrue to successively larger amounts of value-added (Hummels, 2001). Thus, international fragmentation would encourage the use of rapid transportation modes such as air.

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 terms of the mode of transport. At present, there is 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. The data in this section come from the Japanese customs website,<sup>3)</sup> in which the longer period data are available than in the World Trade Atlas database. 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.

Investigating first the changes in total Japanese machinery exports by transport mode from 1988 to 2008, figure 1 shows the share of air exports in total exports (air exports plus maritime exports) by destination. While the share of Japanese air exports to the world rose until 2000, it has been almost unchanged since then. Looking at the changes by destination,<sup>4)</sup> 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, except for 2008.

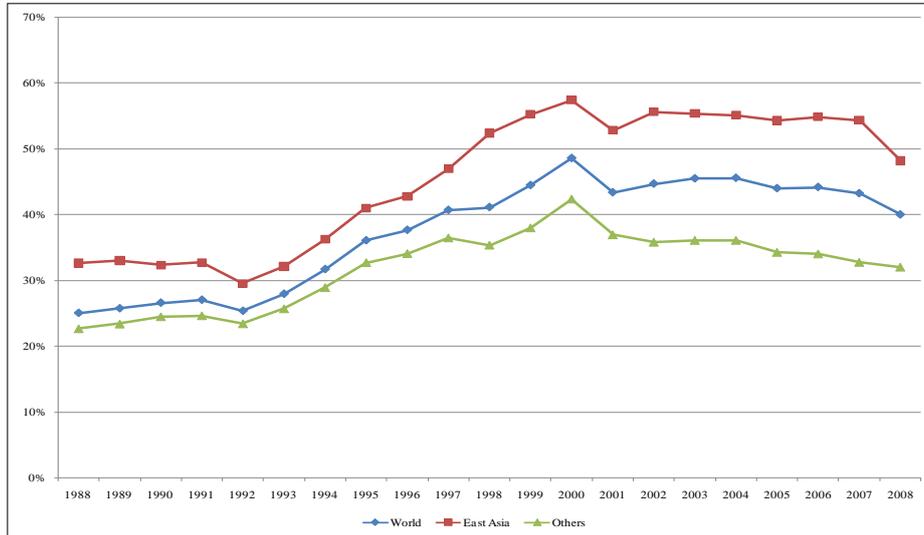
Figure 2 shows the share of air exports by product type, i.e., finished machinery products and machinery parts. The HS code list of parts is drawn from Ando and Kimura (2005). From this figure, we can see striking differences between exports to East Asia and those to the other regions. It can be seen that exports of machinery parts to East Asia are frequently via air

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<sup>3)</sup> <http://www.customs.go.jp/toukei/info/index.htm>

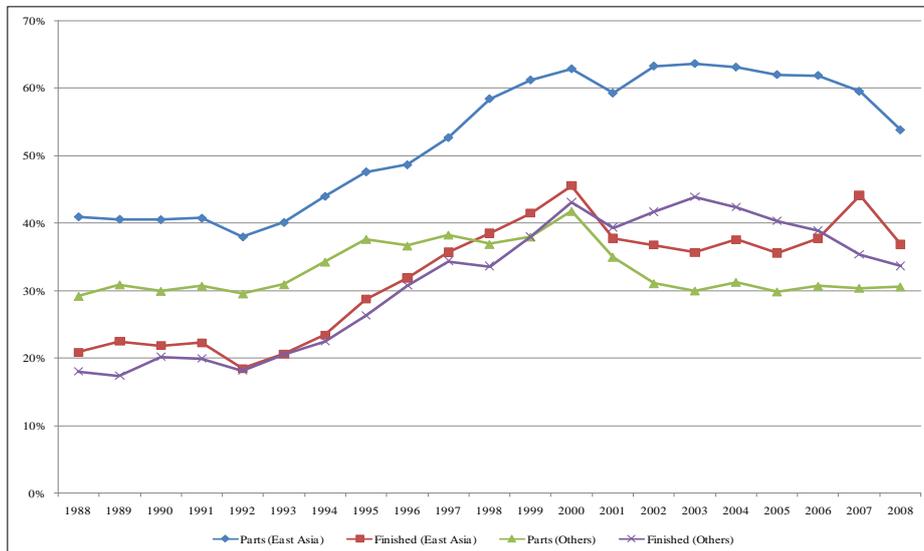
<sup>4)</sup> In this section, East Asia means the Republic of Korea, China, Hong Kong, Taiwan, Thailand, the Philippines, Malaysia, Singapore, and Indonesia.

**Figure 1 The Share of Exports by Air**



Source: Japanese Customs.

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

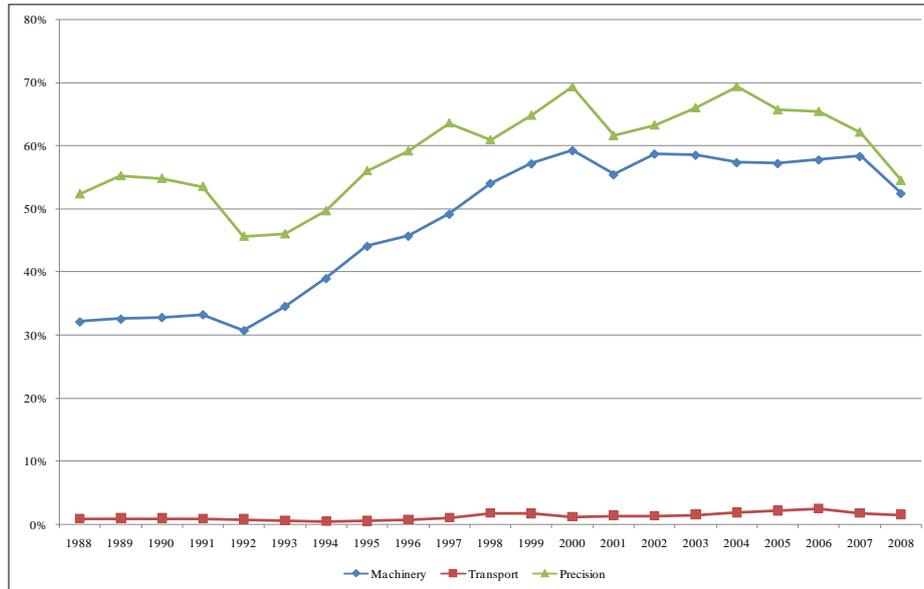


Source: Japanese Customs.

transport. The share of parts exported by air has always been larger than that of finished products. It continuously increased until 2000 and has been stable around 60%. This increase in the share of parts exports by air may be due to the development of international fragmentation in East Asia. In the exports to the other regions, on the other hand, the different tendency can be observed. While the share of parts exports by air has been stable around 30%, the share of finished products exported by air has risen since 2000 though it decreases a little bit in the latter half of the 2000s. 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 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 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 experienced a certain increase until 2000. This increase has been because the products in both of these machinery sectors are often small and light. Furthermore, the dramatic development of the international fragmentation and rapid product cycles have contributed to the increase in the use of air transport in the electric and precision machinery sectors.

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



Source: Japanese Customs.

### 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. As pointed out in the introductory section, 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<sup>5)</sup>) at the HS 4-digit level. We will examine the relationship between international fragmentation and transport modal choice by regressing the following simple equation:

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

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:

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

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

$p_6$  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.<sup>6)</sup> Such trade occurs not

<sup>5)</sup> Taiwan has been dropped from the sample due to the unavailability of data on an independent variable.

<sup>6)</sup> Regarding this decomposition of the Grubel-Lloyd intra-industry index, see Greenaway *et al.* (1995).

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 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

### 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.

**Table 2 Regression Results**

	Eq.(1)	Eq.(2)	Eq.(3)	Eq.(4)	Eq.(5)	Eq.(6)	Eq.(7)	Eq.(8)
VIIT	0.21 <sup>***</sup> (0.02)	0.21 <sup>***</sup> (0.02)	0.23 <sup>***</sup> (0.02)	0.05 <sup>***</sup> (0.01)	0.21 <sup>***</sup> (0.02)	0.20 <sup>***</sup> (0.02)	0.22 <sup>***</sup> (0.02)	0.04 <sup>***</sup> (0.01)
Parts		0.48 <sup>***</sup> (0.06)	0.47 <sup>***</sup> (0.06)			0.46 <sup>***</sup> (0.06)	0.45 <sup>***</sup> (0.06)	
Constant	-1.20 <sup>***</sup> (0.06)	-1.41 <sup>***</sup> (0.07)	-2.14 <sup>***</sup> (0.10)	-1.72 <sup>***</sup> (0.04)	-1.19 <sup>***</sup> (0.06)	-1.38 <sup>***</sup> (0.07)	-2.12 <sup>***</sup> (0.10)	-0.75 <sup>***</sup> (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	0.055
Obs.	3,343	3,343	3,343	3,343	3,271	3,271	3,271	3,271

Notes: <sup>\*\*\*</sup>, <sup>\*\*</sup>, and <sup>\*</sup> 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.

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.

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

**Table 3 Robustness Checks**

	Eq.(1)	Eq.(4)	Eq.(5)	Eq.(8)	Eq.(1)	Eq.(4)	Eq.(5)	Eq.(8)
VIIT	0.16 <sup>***</sup> (0.02)	0.03 <sup>*</sup> (0.01)	0.16 <sup>***</sup> (0.02)	0.03 <sup>*</sup> (0.01)	0.56 <sup>***</sup> (0.13)	0.16 <sup>*</sup> (0.09)	0.53 <sup>***</sup> (0.13)	0.17 <sup>*</sup> (0.09)
Constant	-0.96 <sup>***</sup> (0.06)	-1.32 <sup>***</sup> (0.04)	-0.94 <sup>***</sup> (0.06)	-1.32 <sup>***</sup> (0.04)	-0.50 (0.37)	-1.56 <sup>***</sup> (0.24)	-0.53 (0.38)	-1.54 <sup>***</sup> (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.	2,307	2,307	2,214	2,214	167	167	166	166

Notes: <sup>\*\*\*</sup>, <sup>\*\*</sup>, and <sup>\*</sup> 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. “P” means that the sample consists of parts only while “F+P” means that it consists of parts plus finished products.

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).

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.

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