# TRADE INVOICE CURRENCY AND PRICING-TO-MARKET: EVIDENCE FOR THE LIMITED USE OF THE JAPANESE YEN IN THE EAST ASIAN REGION

*Kiyotaka Sato*
*Research Associate, ICSEAD*

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***Kiyotaka Sato***
Research Associate
The International Centre for the Study of East Asian Development (ICSEAD)

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***Abstract:***

This paper examines currency invoicing of Japan's exports to the East Asian region by applying the theory of pricing-to-market (PTM). Contrary to the results of previous literature, we reveal that Japanese exporters of integrated circuits (ICs) and magnetic disks are likely to prefer U.S. dollar-invoiced transactions even in exports to the East Asian region. Given a large presence of the electronics industry for trade and investment between Japan and the East Asian countries, it is hard to expect further internationalization of the Japanese yen in the near future.

***Key words***: Trade invoice currency, Pricing-to-market (PTM), Internationalization of the yen, Semiconductors and integrated circuits (ICs)

***JEL classification***: F3, F4.

*Corresponding author:*
11-4 Otemachi, Kokurakita, Kitakyushu, 803-0814, Japan
Tel: +81-93-583-6202, Fax: +81-93-583-4602
e-mail: sato@icsead.or.jp

# TRADE INVOICE CURRENCY AND PRICING-TO-MARKET: EVIDENCE FOR THE LIMITED USE OF THE JAPANESE YEN IN THE EAST ASIAN REGION

*Kiyotaka Sato*[*]

## I. INTRODUCTION

Stimulated by the onset of the euro in Europe, renewed attention has been given to the internationalization of the Japanese yen, particularly in the East Asian region.[1] The Japanese government of late embarked on the further development of the domestic money market (e.g. the introduction of public auctions of financial bills) to boost the international presence of the yen. In addition, the Japanese government started to advocate the introduction of the "tri-polar currency basket system" (the U.S. dollar, euro, and yen) to the emerging economies to prevent a currency crisis.

Previous studies on the international use of the Japanese yen, among others Frankel (1993), Ito (1993), Fukuda and Ji (1994), Iwami (1995, Chapter 5), Fukuda (1996), and Kawai (1996), have shown that yen has not been used, or held, widely in the East Asian region for both trade and financial transactions. The evidence reported

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[1] This paper focuses on East Asia in examining the use of the Japanese yen in trade transactions. East Asia includes the following 9 countries (or areas): the Asian NIEs (Korea, Taiwan, Hong Kong, and Singapore), ASEAN4 (Indonesia, Malaysia, Philippines, and Thailand), and China. It must be noted, however, that the statistics on trade invoice currency (*Yushutsu (Yunyu) Kessai Tsukadate Doko Chosa*) published by MITI (Ministry of International Trade and Industry) report the data on Southeast Asia rather than East Asia. In the MITI data, Southeast Asia is defined to include 22 countries (or areas). See notes in Table 1.

in the above studies is quite interesting, because the presence of the Japanese economy has increased significantly in the region for the last several decades. Given the increasing importance of the Japanese economy for the East Asian countries, it is natural to expect that the role of the Japanese yen will also increase over time. We must note, however, that the use of the Japanese yen as an invoice currency in Japan's trade with the East Asian countries has somewhat declined from the mid-1990s, as will be mentioned below (Tables 1 and 2).

The purpose of this paper is to investigate the question as to why the role of the Japanese yen has not been growing despite the recent increase in interdependence between Japan and East Asia, focusing on the role of a trade invoice currency. Sato (1999) have examined empirically currency invoicing of Japan's exports to the East Asian countries for three specific commodities by applying the theory of pricing-to-market (henceforth, PTM). This paper advances the above research by increasing the sample of commodities and by expanding the sample period. The problems of the data for empirical tests are also described in detail. We perform three types of regressions in a rigorous way to support the results of the above research. Error-correction regression analysis is also performed and the results are reported in the Appendix.

The main findings of this paper are as follows. Japanese exporting firms of integrated circuits (ICs) and magnetic disks tend to stabilize their export prices even in the East Asian markets by invoicing in U.S. dollars. The currency invoicing of the electronics industry, especially the semiconductor and IC industry, is particularly important, because the recent expansion of Japan's investment and trade with the East Asian region has been promoted largely by this industry. Given the currency invoicing of this industry, the limited use of the yen can be expected to continue in the region for years to come.

This paper is organized as follows. Section II briefly summarizes the theory of trade invoice currency and discusses why Japan's trade invoicing pattern is so unique. The data on the Japan's trade invoicing pattern are also described. Section III presents the theoretical model applying PTM to trade invoicing practice. In Section IV, three types of empirical estimations are performed in order to reveal currency invoicing patterns of Japan's exports to the East Asian countries. Section V concludes the paper.

## II. LITERATURE SURVEY: THEORY AND EVIDENCE

### *2.1 Empirical Regularities of Trade Invoicing Patterns*

There are a large number of studies, both theoretically and empirically, on the trade invoice currency.[2] These studies reveal the several regularities of trade invoicing patterns.[3]

(1) Trade in manufactured products between developed countries tends to be invoiced in the exporter's currency, the regularity of which is called "Grasman's Law" (Grassman, 1973).
(2) Trade between developed and developing countries tends to be invoiced in the currency of the developed country.
(3) Trade in primary products is generally invoiced in the international currency (formerly in the pound sterling, but currently in U.S. dollars).

[2] For example, Grassman (1973) (1976), McKinnon (1979), Page (1981), Tavlas and Ozeki (1992), Ito (1993), Kawai (1996).

[3] See, for example, Tavlas and Ozeki (1992) and Tavlas (1997) for overviews.

(4) Exports to and imports from the United States are typically invoiced in U.S. dollars. Contrary to the Grasman's Law, this is the case even when a developed country exports to the United States.

The regularity (1)-(3) can be explained by the McKinnon's Hypothesis: McKinnon suggests that trade in specialized manufactured products tends to be invoiced in the exporter's currency and trade in primary products tends to be invoiced in a major international currency.[4] Producers of manufactured products in a developed country appear to have some market power over their products due to the distinctive character of the products, which enables them to control their market price. Since producers generally wish to stabilize their profits in terms of their own currency, they prefer invoicing their exports in their national currency. In contrast, primary products are relatively homogeneous and one producer's output can be precisely graded and compared to that of others. In addition, these products are neither firm-specific nor country-specific. Owing to such homogeneous characteristics of these products, the producers do not have a particular market power over their products, and the products tend to be registered at a centralized commodity exchange in a particular country whose currency is used internationally. Accordingly, trade in the primary products tends to be invoiced mainly in U.S. dollars.

Interestingly, Japan shows a different pattern of currency invoicing (see Tables 1 and 2).[5] First, the yen-invoiced ratio is quite low (36 percent as of March 1998) in Japan's exports to the world, and the corresponding ratio of imports is much lower (21.8

[4] See McKinnon (1979), Chapter 4.

[5] For a comparison of Japan's currency invoicing pattern with other developed countries (the United States and European countries), see Sato (1999), Tavlas (1997), and Iwami (1995).

percent). Second, the U.S. dollar is largely used in Japan's exports to and imports from the United States. This is the case even in exports of manufactured products to the United States. According to Table 3, about 80 percent or more of Japan's exports to the United States are invoiced in U.S. dollars. Third, about half of Japan's exports to Southeast Asia are invoiced in U.S. dollars, which is contrary to the regularity (2). Fourth, more than 70 percent of Japan's imports from Southeast Asia are also invoiced in U.S. dollars. This observation leads to the following question: Why is Japan's trade invoicing pattern so unique?

### *2.2 Factors Preventing Yen-Invoiced Trade Transactions*

It is generally agreed that the following factors prevent the Japanese yen from being used in trade transactions.[6]

(1) Relatively small size of the short-term capital markets in Japan.
(2) Japan's unique trade structure: the heavy reliance of Japan's exports to the United States and the high importing share of raw materials and fuels.
(3) Dominance of the US dollar as a vehicle currency.

Whereas the first two factors are undoubtedly important in accounting for the low level of yen-invoiced trade, the dominant role of the U.S. dollar as a vehicle currency is particularly important when we consider the role of the yen in East Asia.[7]

[6] See Tavlas and Ozeki (1992), Kawai (1996), Fukuda (1996).

[7] Sato (1999) discusses the first two factors (1 and 2) in detail.

In addition, the additional factor must also be considered: most East Asian countries had in effect pegged their currencies to the U.S. dollar at least up to the Asian currency crisis.

The U.S. dollar accounts for a dominant share in foreign exchange market transactions. According to Table 4, 94.8 percent and 93.0 percent of transactions are carried out against the U.S. dollar in Singapore and Hong Kong, respectively, in April 1998. The very high share of the U.S. dollar in foreign exchange markets indicates that the U.S. dollar plays a role of a vehicle currency. Once a currency becomes a dominant vehicle currency, the currency typically continues to be used, owing to low transaction costs based on economies of scale. The dominant vehicle role in mediating exchanges of various currencies facilitates dollar-denominated transactions in both foreign trade and capital transactions.[8] In contrast, the share of yen transactions in foreign exchange markets is in practice significantly low in Singapore and Hong Kong (23.3 percent and 27.1 percent as of April 1998, respectively), compared to the share of U.S. dollar transactions. There is no sign that the Japanese yen is playing a vehicle role in Asian foreign exchange markets. In addition, East Asian countries had long pegged their currencies to the U.S. dollar. The stability of their currencies against the U.S. dollar induced a strong incentive to prefer U.S. dollar-denominated transactions, though some of the East Asian countries began to adopt a more flexible exchange rate system after the currency crisis.

Whereas the U.S. dollar's vehicle role and nominal anchor role are important factors in preventing the use of the yen in trade, another line of work has recently gained much more attention: applying the theory of PTM to trade invoicing practice. Many studies, such as Hamada and Horiuchi (1987), Osugi (1990), Tavlas and Ozeki

[8] See Krugman (1984).

(1992), and Ito (1993) have pointed out that the low level of Japan's yen-invoiced exports has to do with the PTM behavior of Japanese exporters. Giovannini (1988) have shown theoretically that the selection of the trade invoice currency depends on the shape of the firm's profit function in each foreign market: firms set their export prices in the foreign (domestic) currency if the profit function is concave (convex) in the exchange rate. Fukuda and Ji (1994) have applied Giovannini's result and examined the currency invoicing of Japanese exporters empirically, comparing the PTM behavior of Japan's exports to the United States with that of exports to East Asia. They have shown that Japanese exporters tend to pass through changes in currency values to East Asian importers, by invoicing their export products in the yen. According to Table 1, however, yen-invoiced exports to Southeast Asia have not increased, or rather decreased from 1993, which contradicts the result of Fukuda and Ji.[9] Accordingly, the main purpose of this paper is to explore what impedes yen-invoiced transactions in Japan's exports to the East Asian countries.[10]

## III. MODEL SPECIFICATION

Most studies on PTM behavior of Japanese firms have not explicitly recognized that currency invoicing of exporting firms does affect the exchange rate pass-through. These studies implicitly assume that exporting firms invoice their products in their own

[9] Again, the MITI statistics (Tables 1 to 3) do not report the data for East Asia but for Southeast Asia, whereas we focus on trade invoicing pattern in the East Asian countries. See also footnote 1. We will hereafter use "the East Asian countries" instead of "Southeast Asia" when we mention the data in Tables 1 to 3.

[10] This paper mainly focuses on the currency invoicing of Japan's exports. For the consideration of the currency invoicing of Japan's imports, see Sato (1999).

country's currency. In contrast, this section explicitly discusses the selection of the invoice currency and shows that currency invoicing of export prices is an important choice variable of the firms in the framework of the PTM model. Such lines of work have been presented by Giovannini (1988) and Fukuda and Ji (1994). Fukuda and Ji have applied the result of Giovannini's work to the issues of the trade invoicing practice of Japanese exporting firms in their exports to the United States and the East Asian countries. The model discussed in this section is mainly based on these two works and this exposition is a somewhat simplified version of their model.[11]

Let us consider a monopolistically competitive firm in the *i*th industry that produces in the domestic country and sells in both domestic and *n* separate foreign markets (indexed by *j*). We assume that imperfect arbitrage between markets allows prices to differ in each market, which means that the firm can generally set an independent price in each market.

In exports to the foreign market, the firm can charge an export price ( $p_{ij}^{f}$ ) in terms of the domestic currency (that is, it can invoice its products in the domestic currency). In this case, the decision variable is $p_{ij}^{f}$ and the firm sells at an export price ( $p_{ij}^{f} / S_j$ ) in the foreign market, where $p_{ij}^{f} / S_j = p_{ij}^{*}$ and $S_j$ is the exchange rate expressed as the domestic currency price of the foreign (country *j*'s) currency. When the firm sets an export price in the foreign currency (that is, when it invoices its products in the foreign currency), it sells at a price $p_{ij}^{*}$ in the foreign market, in which case $p_{ij}^{*}$ is the decision variable.

[11] The earlier version of this section is presented in the appendix of Sato (1999).

The central assumption here is that prices are set before the realization of all variables affecting demand and cost, in other words, the exporter selects the invoice currency and charges the price before the exchange rate is known. We also assume that the firm is risk neutral and that there are two periods. Domestic and foreign markets are open only in period 2. In period 1, the firm decides the selling price in the domestic market ( $p_i$ ) and the export prices ( $p_{ij}^f$ or $p_{ij}^*$ ) in each foreign market in order to maximize expected profits. Given the prices set in period 1, the firm adjusts production to fulfill realized demands in period 2. No inventories are left over at the end of period 2.

Let $E_1$ denote the conditional expectation operator based on the information set in period 1. When export prices are invoiced in the domestic currency, the firm's problem in period 1 is:[12]

$$\underset{\{p_i, p_{ij}^f\}}{Max}\, E_1\left\{ p_i h(p_i; P_i, Z_i) + \sum_{j=1}^{n} p_{ij}^f f\left(p_{ij}^f / S_j; P_{ij}^*, Z_{ij}^*\right) - c\cdot[h(\cdot) + \sum_{j=1}^{n} f(\cdot)]\right\}, \quad (1)$$

where

$p_i, p_{ij}^* =$ the domestic and foreign currency prices of the firm's output,

$P_i, P_{ij}^* =$ two vectors of the domestic and foreign prices of domestic and foreign substitutes,

$Z_i, Z_{ij}^* =$ vectors of variables shifting demand in the domestic and foreign markets. The demand function is assumed to be $h_i = h(p_i; P_i, Z_i)$ in the domestic market and

[12] The forward currency contract is not included in the model, because we implicitly assume that the forward market rate is kept equal to the expected future spot rate by uncovered arbitrage of risk-neutral firms. For a theoretical consideration of the model including forward currency contracts, see Friberg (1998).

$f_{ij} = f(p_{ij}^*; P_{ij}^*, Z_{ij}^*)$ in the foreign market. Since we assume that this is a partial equilibrium model, $P_i, P_{ij}^*, Z_i$, and $Z_{ij}^*$ are exogenous. For analytical simplicity, the production cost function is assumed to be linear in the amount of output, and hence, the marginal cost of production is constant over time and is equal to $c$.[13]

The associated first-order conditions are:

$$E_1\{h_i + p_i h' - ch'\} = 0, \tag{2}$$

$$E_1\{f_{ij} + p_{ij}^f \cdot (f'/S_j) - c \cdot (f'/S_j)\} = 0, \tag{3}$$

where $h' \equiv \partial h_i / \partial p_i$ and $f' \equiv \partial f_{ij} / \partial p_{ij}^*$. Rearranging (2) and (3), we obtain:

$$p_i = c - (E_1 h_i / E_1 h'), \tag{2a}$$

$$p_{ij}^f = c - \{E_1 f_{ij} / E_1 (f'/S_j)\}. \tag{3a}$$

When export prices are invoiced in the foreign currency, the problem is:

$$\underset{\{p_i, p_{ij}^*\}}{Max}\, E_1\left\{ p_i h(p_i; P_i, Z_i) + \sum_{j=1}^{n} S_j p_{ij}^* f(p_{ij}^*; P_{ij}^*, Z_{ij}^*) - c \cdot [h(\cdot) + \sum_{j=1}^{n} f(\cdot)] \right\}. \tag{4}$$

The associated first-order conditions are:

$$E_1\{h_i + p_i h' - ch'\} = 0, \tag{5}$$

$$E_1\{S_j f_{ij} + S_j p_{ij}^* f' - cf'\} = 0. \tag{6}$$

If only the exchange rate in period 2 is uncertain in period 1, we obtain from (5) and (6) that:

$$p_i = c - h_i / h', \tag{5a}$$

$$(E_1 S_j) p_{ij}^* = c - \{(E_1 S_j) f_{ij} / f'\}. \tag{6a}$$

[13] This follows Fukuda and Ji (1994). The cost function may in practice be affected by the exchange rate through changes in import prices of intermediate inputs. This simplification, however, can be reasonable because our analysis focuses on the effects of different demand conditions in different markets.

We will show that which pricing (or invoicing) behavior of exporting firms gives the highest expected profits depends on how expected profits are affected by exchange rate uncertainty. Assuming that all the variables except $S_j$ are non-stochastic, we will compare the choice of invoicing in the foreign or domestic currency under risk neutrality.

First, when invoicing in the foreign currency, the first-order condition (6) is a linear function of the exchange rate $S_j$. Applying the mean preserving spread to the exchange rate distribution neither affects (6) nor the expected profits when $p_{ij}^*$ is given. Hence, invoicing in the foreign currency is preferred to invoicing in the domestic currency if expected profits decrease with increasing risk.

Second, when invoicing in the domestic currency, the first-order condition (3) will not be a linear function of the exchange rate. Which currency invoicing behavior leads to the highest expected profits depends on the curvature of the profit function. Let $\pi$ denote the profit function and $\tilde{p}$ and $\tilde{p}^f$ be the profit-maximizing prices of $p$ and $p^f$ in the absence of risk, respectively. Suppose that $\pi$ is concave in $S$ for every $p$ and $p^f$, then the following inequality holds:

$$\pi(\tilde{p}, \tilde{p}^f, \tilde{S}) \geq \pi(p, p^f, \tilde{S}) = E\{\pi(p, p^f, \tilde{S})\} \geq E\{\pi(p, p^f, S)\},$$

where $\tilde{S}$ is the exchange rate in the absence of risk. This inequality implies that if the profit function is concave in the exchange rate, expected profits decrease with exchange rate risk when invoicing in the domestic currency. Since stabilizing the selling price leads to higher expected profits in this case, it is preferable to invoice in the foreign currency when the profit function is concave.

It is typically not easy to say whether the profit function is concave or convex in the exchange rate. The first and second partial derivatives of the expected profits with respect to $S_j$ when invoicing in the domestic currency are given by:

$$\partial E_1\pi/\partial S_j = E_1\{[f'/(S_j)^2]\cdot p^f\cdot(c-p^f)\},$$

$$\partial^2 E_1\pi/\partial(S_j)^2 = E_1\left\{[p_{ij}^f(p_{ij}^f-c)/(S_j)^4](p_{ij}^f f''+2S_j f')\right\}.$$

If we assume that demand function in the foreign market ($f_{ij}$) is concave in $p_{ij}^*$, and hence, $f''<0$, then the profit function (1) is strictly concave in $S_j$ since the second derivative is negative.[14] Thus, the shape of the profit function depends on whether the demand function in the foreign market ($f_{ij}$) is concave or convex in $p_{ij}^*$. Assume further that the exchange rate follows the random walk process so that $E_1S_j = S_j^1$ ($S_j^1$ is the exchange rate in period 1).[15] Then, the following proposition suggested by Fukuda and Ji (1994) holds:

*Proposition:* Suppose that the demand function in the foreign market is concave. Then the exporting firm invoices its exports in the foreign currency, which leads to the positive correlation between the exchange rate in terms of the domestic currency and the export price in terms of the domestic currency ($S_j^1 p_{ij}^*$).

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[14] This is verified by using the first-order condition: (3) or (3a) which implies that $p_{ij}^f > c$ since $f'<0$.

[15] Previous studies, such as Giovannini (1988), Marston (1990), and Fukuda and Ji (1994), also assume the random walk process for at least a first approximation.

*Proof.* Since the profit function (1) is strictly concave in the exchange rate $S_j$ when the demand function $f_{ij}$ is concave in $p_{ij}^*$, the firm invoices its exports in the foreign currency, as discussed above. Then, given the export price $p_{ij}^*$, differentiating (6a) with respect to $E_1 S_j$ leads to the following result:

$$\partial\{(E_1 S_j) p_{ij}^*\} / \partial(E_1 S_j) = \{p_{ij}^* (f')^2 - f(f' + p_{ij}^* f'')\} / \{2(f')^2 - f f''\},$$

where $f' \equiv \partial f_{ij} / \partial p_{ij}^* < 0$ and $f'' \equiv \partial^2 f_{ij} / \partial p_{ij}^{*2}$. Since demand function $f_{ij}$ is assumed to be concave (i.e., $f'' < 0$) and the exchange rate follows random walk process (i.e., $E_1 S_j = S_j^1$), we obtain that $\partial(S_j^1 p_{ij}^*) / \partial S_j^1 > 0$. □

PTM implies that exporting firms discriminate between the domestic selling price and the export price when the exchange rate fluctuates. Accordingly, it is more useful to examine how exporting firms change the export price relative to the domestic selling price of the same commodity rather than the export price alone (Marston, 1991). To the extent that Proposition holds true, the degree of correlation between the exchange rate and the export price tends to be high and positive when invoicing in the foreign currency. Since $\partial(S_j^1 p_{ij}^*) / \partial S_j^1 > 0$ and $dp_i / dS_j^1 = 0$, we obtain the following condition:

$$\partial\{(S_j^1 p_{ij}^*) / p_i\} / \partial S_j^1 = (1/p_i^2)\left\{p_i [\partial(S_j^1 p_{ij}^*) / \partial S_j^1] - S_j^1 p_{ij}^* (dp_i / dS_j^1)\right\} > 0.$$

This condition indicates that the "relative export price" (i.e., the export price relative to the domestic selling price) in terms of the domestic currency is positively correlated with the exchange rate when invoicing in the foreign currency. Then, the following empirical specification can be used:

$$\ln\left(\frac{p_{ij}^{f}}{p_i}\right)_t = const. + \alpha \cdot \ln S_{j,t} \qquad (7)$$

where $p_{ij}^{f}$ and $p_i$ are the commodity $i$'s export prices to country $j$ and the corresponding domestic selling price respectively both of which are in terms of the yen. $\ln\left(p_{ij}^{f} / p_i\right)_t$ is the natural logarithm of the relative price of commodity $i$'s exports to country $j$ at time $t$, and $\ln S_{j,t}$ is the natural logarithm of the exchange rate expressed as the yen price of the country $j$'s currency at time $t$. $\alpha$ can be interpreted as the elasticity of the relative export price with respect to exchange rate or what may be called the PTM elasticity (Marston, 1990). One advantage of examining the relative export price rather than the export price alone is that the effects of exchange rate changes through marginal costs are likely to have less influence on the former.[16]

In summary, our model implies that when invoicing in the foreign (domestic) currency, relative export prices are positively (ambiguously) correlated with the exchange rate. Accordingly, our task in the next section is to examine the following hypothesis empirically.

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[16] Whereas changes in marginal costs generally affect export prices and domestic prices individually, they are not likely to affect the ratio of the two prices. Given that the export price and the domestic selling price are determined by the markup rule, these prices are expressed as follows:

$$Sp^* = m^* \cdot MC \text{ and } p = m \cdot MC,$$

where $m^*$ and $m$ are markup factor of the export price and the domestic selling price, respectively. $MC$ denotes marginal costs which are assumed to be identical across the destinations of the products. Substitute the above equations into the PTM elasticity:

$$\partial \ln(Sp^* / p)/\partial \ln S = \partial \ln Sp^*/\partial \ln S - \partial \ln p/\partial \ln S$$
$$= \partial \ln(m^* \cdot MC)/\partial \ln S - \partial \ln(m \cdot MC)/\partial \ln S = \partial \ln m^*/\partial \ln S - \partial \ln m/\partial \ln S.$$

The PTM elasticity will be positive to the extent that $\partial \ln m^*/\partial \ln S > 0$ and $\partial \ln m/\partial \ln S = 0$. When the PTM elasticity is positive, the exporter adjusts the markup to offset some of the effect of exchange rate fluctuations on price in terms of the importer's currency. The condition for $\partial \ln m^*/\partial \ln S > 0$ is that demand curves are less convex than the constant elasticity curve (Marston, 1990, Gagnon and Knetter, 1995).

*Hypothesis:* When invoicing in the foreign currency, the PTM elasticity is positive and statistically significant. When invoicing in the domestic currency, the PTM elasticity is insignificantly different from zero.

Noting that the U.S. dollar is largely used in Japan's exports to the United States (Table 3), we can expect that the PTM elasticities are positive and statistically significant. On the other hand, since yen-invoiced exports are relatively large in Japan's exports to the East Asian countries, the PTM elasticities may not be significantly different from zero, as suggested by Fukuda and Ji (1994). We will test the hypothesized relationship in the following section.

## IV. EMPIRICAL ANALYSIS

### *4.1 Data*

In this section, we will examine empirically the correlation between export prices and the exchange rate in Japan's exports to the United States, East Asia, the Asian NIEs, and ASEAN. Before turning to the empirical test, several points concerning the data for empirical tests must be described.

We test the following five types of commodities: automobiles, piston engines (henceforth engines), hybrid integrated circuits (henceforth ICs), horizontal lathes (henceforth lathes), and magnetic disks.[17] These products are chosen from the three major machinery industries: general machinery, electric machinery, and transport equipment. The exports of these three industries accounted for 68.9 percent of Japan's

[17] See Appendix A for details.

overall exports in 1998.[18] Fukuda and Ji (1994) have examined the PTM behavior of Japanese exporters for four types of commodities (TVs, VCRs, and two types of automobiles) and reported a quite interesting result that Japanese exporters are likely to prefer yen-invoiced transactions in their exports to the East Asian countries. This paper develops their study further by testing the PTM behavior of Japanese exporting firms using other commodities with longer sample periods.

The data source for the export commodities is *Japan Exports & Imports (Commodity by Country)*, published by the Japan Tariff Association, which reports the quantities and values of Japan's exports by both commodity and country. Each export value is based on the FOB (free on board) value in terms of the yen. The average export price is calculated by dividing each export value by its export quantity, which can be regarded as an approximation of the actual export price of each commodity to each country. Then, the relative export price is computed by dividing the average export price of the specific commodity by the corresponding domestic wholesale price index. The data sources for the domestic wholesale price index are *Price Index Annual* and *Price Index Monthly*, published by the Bank of Japan.

It must be noted that there are two problems when we use the data from *Japan Exports & Imports (Commodity by Country)*. First, since the commodity classification was changed drastically in January 1988, it is very difficult to use a consistent series of data ranging from the pre-1988 period to the present.[19] We attempted to attain a

[18] Computed from the Japan Tariff Association, *The Summary Report on Trade of Japan*, December 1998.

[19] Up until the end of 1987, the commodity classification of *Japan Exports & Imports (Commodity by Country)* was based upon the Customs Co-operation Council Nomenclature (CCCN). Since the beginning of 1988, the classification has been based upon Harmonized Commodity Description and Coding System (HS).

concordance between HS and CCCN categories in order to use pre-1988 observations. This could be done for only four of the commodities (automobiles, engines, ICs, and lathes). Hence, for those items, the sample period is from January 1985 to April 1999. The sample period for magnetic disks is from January 1990 to April 1999.

Second, the commodity classification is also often changed in the data from January 1988 to the present, which causes another difficulty in choosing a consistent series of data. As for the IC category, for example, DRAM (dynamic random access memories) nowadays accounts for a large share in Japan's total IC exports, and hence, it would be preferable to use DRAM for empirical tests. Because of the short product cycle in the semiconductor industry, however, the DRAM data is available only from January 1996 in *Japan Exports & Imports (Commodity by Country)*.[20] Since a longer time span is preferred for the time series analysis, we choose the hybrid integrated circuits which account for a relatively large share from January 1988 to the present.[21] All the data are seasonally adjusted for empirical tests.[22]

Whereas the destinations of Japan's exports are East Asia, the Asian NIEs, and ASEAN as well as the United States, the data for nominal yen-dollar exchange rate is used in this analysis. Most East Asian countries had adopted the currency basket system and in effect pegged their currencies to the U.S. dollar at least up to the outbreak

[20] Another way is to pick up several commodities which account for the largest share for each period and then to connect them to make a consistent series of the data. However, since the gap of the average price is often so large between them, it is very difficult to use such series for analysis.

[21] From January 1985 to December 1987, integrated circuits are divided into only the two category: "integrated circuits, uncased" and "integrated circuits, n.e.s." where "n.e.s." denotes "not elsewhere specified or included." We use the latter (integrated circuits, n.e.s.) for our analysis.

[22] We use the Census X-11 (multiplicative) command in the Eviews 3.1 software package for seasonal adjustment.

of the currency crisis.[23] As long as East Asian currencies are tied strongly to the U.S. dollar, it seems reasonable to assume that exporters and importers in the East Asian countries are exposed to less exchange rate risk when their imports and exports are invoiced in U.S. dollars. After Asian currency crisis, the above assumption may not be plausible for some of the currencies, such as the Thai Baht, Korean Won, and Indonesia Rupiah. However, our main concern is whether Japan's exports to the East Asian countries are invoiced in U.S. dollars or in other currencies (mainly the yen), because East Asian currencies are not typically used in foreign trade. Accordingly, we use the yen-dollar exchange rate for our analysis.

### *4.2 Testing for Unit Roots*

The first task in empirical tests is to determine whether the variables are stationary or not. We test the null hypothesis that the variable has a unit root by using the augmented Dickey-Fuller (ADF) test and the Phillips-Perron test. This hypothesis is tested by regressing the difference of a variable on a constant, its own lagged value, lagged differences, and possibly a time trend. Under the null hypothesis, the coefficient of the lagged value should be insignificantly different from zero.

The results of the unit root test are reported in Table 5.[24] Looking first at the result of the ADF test, we cannot reject the null hypothesis of a unit root in the level for the exchange rate and all the relative export prices except for lathes (East Asia and the

[23] See Frankel (1993), Frankel and Wei (1994), and Kwan (1994).

[24] We tried preliminary tests of the null hypothesis of a unit root in the level with three types of models (with constant and time trend, with constant only, and without constant and trend), and we got a similar result from the three tests. According to the visual inspection, we report a unit root test in the level either with constant only or without constant and trend. For a unit root test in the first-difference, the test without constant and trend is performed. The number of lags for the ADF test is chosen so that the AIC statistics are minimized. For the Phillips-Perron test, we choose the lags suggested by Newey and West (1994).

NIEs). On the other hand, the result of the Phillips-Perron test is to reject the null hypothesis of a unit root in the level for ICs (the United States at the 10 percent level) and lathes (all cases). Otherwise we cannot reject the null. Turning to the results of a unit root test in the first-difference, we reject the null hypothesis for all cases, and all the test statistics are highly significant. Whereas there is a conflict in the test results of engines, ICs, and lathes between the ADF test and the Phillips-Perron test, we hereafter assume that all the variables are I(1) except for the relative prices of lathes exported to East Asia and the NIEs.

### *4.3 Estimation and Results*

*A. Simple Regression*

As reported above, most of all the variables for empirical analysis are I(1). For the time series analysis with I(1) variables, we typically choose either of two alternatives: the level regression to estimate a long-run cointegrating relationship of PTM or the first difference regression which captures only short-run PTM behavior. We perform the first difference regression in this section, because the short-run response of relative export prices against exchange rate fluctuations is likely to fully capture the automatic change in the yen-value of relative export prices when invoicing in the foreign currency (the U.S. dollar). We also perform the cointegration test and the error-correction regression, the results of which are presented in Appendix B.

The first difference regression is often used in the analysis of PTM or the exchange rate pass-through (for instance, Marston, 1990, Khosla, 1991, Fukuda and Ji, 1994). We estimate the following equation:

$$\Delta \ln\left(\frac{p_{ij}^{f}}{p_i}\right)_t = const. + \alpha \cdot \Delta \ln S_t, \qquad (8)$$

where $\Delta$ is the first difference operator, $\Delta \ln\left(p_{ij}^{f} / p_{i}\right)_{t}$ is the first difference of the natural logarithm of the relative price of commodity *i*'s exports to country *j* at time *t*, and $\Delta \ln S_{t}$ is the first difference of the nominal yen-U.S. dollar exchange rate at time *t*. The constant term is also included in the above equation in order to capture trend effects such as any changes in demand and competition in the market over time.

The results of the regression analysis are reported in Table 6. The equation is estimated by the maximum likelihood method in order to correct the serial correlation of error terms.[25] First, as for exports to the United States, all the estimates of $\alpha$ (the PTM elasticity) are positive and statistically significant. The point estimate of 0.93 for exports of magnetic disks to the United States, for example, implies that a 10 percent depreciation (appreciation) of the yen against the U.S. dollar would lead to a 9.3 percent increase (reduction) in export prices in terms of the yen. In this case, the U.S. dollar price of magnetic disks would remain almost unchanged and the pass-through is incomplete, which implies that they are likely to be invoiced in U.S. dollars.

It must be noted that while 82 to 91 percent of Japan's exports of manufactured products (general machinery, electric machinery, and transport equipment) to the United States are invoiced in U.S. dollars (Table 3), all the estimates of $\alpha$ are not close to unity. The estimates of automobiles and engines are only 0.49 and 0.43, respectively.[26] In contrast, for exports of electronics components, the estimates are larger and closer to

[25] The results of the OLS estimation indicate that the Durbin-Watson (DW) test rejects the null hypothesis of no autocorrelation, even though we transform all the variables by first differencing. Since the error structure may be more complicated, we use the maximum likelihood procedure for the first difference equation (Eq.8).

[26] Such low level of estimates for transport equipment (automobiles) and general machinery is commonly observed in, for example, Marston (1990), Khosla (1991), and Tange (1997).

one: 0.93 for magnetic disks as mentioned above, though the estimate of ICs is over unity (1.51).

One possible explanation for such wide range of estimates is the data inconsistency. Since we produce a longer series of data by combining HS category with CCCN category, there may be some inconsistency in the data for empirical tests.[27] Another possible explanation may be the difference in firms' pricing strategy between the yen appreciation and depreciation period.[28] Japanese exporting firms of differentiated manufactured products may raise the yen price of their exports during the yen depreciation period in order to compensate the loss of profit margins sacrificed during the yen appreciation period, which may lead to lower estimates of $\alpha$ for automobiles and engines.[29] On the other hand, electronic components, especially semiconductors and ICs are less differentiated products than automobiles and engines, and the markets of semiconductors and ICs are highly competitive. Owing to such characteristics, exporters of ICs and magnetic disks have to fully adjust export prices to the exchange rate fluctuations irrespective of the direction of the yen's movements, and hence, the estimates of $\alpha$ are likely to be closer to unity.

It must be emphasized, however, that even though the estimates of $\alpha$ range from 0.43 to 1.51, the regression results do indicate the significant correlation between

[27] There is one more problem in using the Japan Tariff Association statistics for empirical tests. The data on monthly export values in terms of the yen are available in the Japan Tariff Association statistics. However, the monthly yen-denominated export values are in practice compiled by converting exports denominated in foreign currencies into yen-denominated values every week with the weekly "official conversion rate." Since we perform empirical tests using the monthly averaged exchange rate as an exchange rate variable, this may cause some error of estimation.

[28] Interestingly, Marston (1990), Khosla (1991), and Klitgaard (1999) shows that Japanese exporters behave in the same fashion both in the yen appreciation and depreciation periods. Whereas this issue is not treated here in detail, further investigation should be necessary.

[29] Even if they continue to invoice in U.S. dollars, Japanese exporters can change the export prices in terms of the U.S. dollar by adjusting profit margins (or markups).

relative export prices and the exchange rate. U.S. dollar invoicing by Japanese exporters is likely to elicit a certain degree of stabilization of export prices in terms of the U.S. dollar in the U.S. market.

Second, as for exports of automobiles, engines, and lathes to East Asia, the NIEs, and ASEAN, the estimates of $\alpha$ are negative or close to zero and not significantly different from zero except for exports of lathes to ASEAN. This result is consistent with the observation that yen-invoiced transactions are relatively large in exports of general machinery and transport equipment to the East Asian countries (Table 3).[30] On the other hand, in the case of ICs and magnetic disks, the estimates of $\alpha$ are positive, close to one, and significantly different from zero in exports to the East Asian region. This evidence is particularly prominent in exports of ICs to East Asia, the NIEs, and ASEAN, with the estimates of $\alpha$ at the 1 percent significance level. The estimates of $\alpha$ for exports of magnetic disks to East Asia are also close to one, though it is significant only at the 10 percent level. This result implies that the two commodities categorized into the electric machinery industry are likely to be invoiced in U.S. dollars even for exports to the East Asian countries, which is also consistent with the observation that U.S. dollar-invoiced ratio is relatively high in Japan's exports of electric machinery, especially ICs to the East Asian countries (Table 3).

*B. Regression with polynomial lags*

When we discuss the correlation between export prices and the exchange rate, the effect of the lagged exchange rate is another important issue to be considered. Generally speaking, export prices in terms of the foreign currency can be sticky in the

[30] See footnote 9.

short run when trade is invoiced in foreign currency and trade contracts are not easily renegotiated. The contracts of currency invoicing are typically conditional on the negotiating power between exporters and importers: if importers have strong bargaining power, for instance, exporters may fail to reduce exchange rate risks by renegotiating contracts when the exporters' currency appreciates.[31]

The polynomial distributed lags are also often used in the empirical studies, such as Marston (1990), Khosla (1991), Fukuda and Ji (1994), and Tange (1997).[32] We also incorporate the lagged exchange rate effects into our empirical analysis, using the following model:

$$\Delta \ln\left(\frac{p_{ij}^{f}}{p_i}\right)_t = const. + \sum_{k=0}^{2} \beta_k \cdot \Delta \ln S_{t-k} \,. \qquad (9)$$

In Eq.(9), distributed lags are assumed to follow quadratic forms and $\beta_3$=0 is also assumed.[33] Table 7 shows the results which are also estimated by the maximum likelihood method.

The results are almost the same as those reported in Table 6. The estimates of $\sum \beta_k$ for all commodities are significantly different from zero in exports to the United States. The estimates of $\sum \beta_k$ for ICs are significant in exports to East Asia and NIEs,

[31] This discussion is based on interviews at MITI on January 13, 1994. See also Kawai (1990).

[32] When we allow for the lagged exchange rate effects, the problem is how to determine the lags because the results of the regression analysis are subject to the choice of the lags. Most studies in practice choose the number of lags in an arbitrary way. For example, Tange "applied two to six lag lengths on the exchange rates and then selected most adequate results, judging from the signs and significance of the estimates and also goodness of fit in regression" (Tange, 1997, p.201). As will be mentioned below, we use the same assumption as Fukuda and Ji (1994) for comparison with their results.

[33] This assumption is the same as Fukuda and Ji (1994).

but are not significant in exports to ASEAN. In exports of magnetic disks to East Asia and the NIEs, the estimates of $\sum \beta_k$ are not significant, though they are close to one.[34]

### *4.4 An Alternative Empirical Test*

We have so far examined the degree of correlation between relative export prices and the yen-U.S. dollar exchange rate. The advantage of using Eq. (7) is that changes in marginal costs are unlikely to affect relative export prices. In this section, we try to test the validity of the Hypothesis by using other types of empirical specifications which allow for the effects of changes in production costs. The following specification can be used to the extent that export prices are determined by the markup rule:

$$\Delta \ln p^f_{ij,t} = const. + a \cdot \Delta \ln S_t + \sum_{k=0}^{2} b_k \cdot \Delta \ln IP_{i,t} \ , \qquad (10)$$

where $\ln IP_{i,t}$ is the natural logarithm of the gross-weighted input prices at time $t$.[35] Polynomial lags of the input prices are used to allow for the stickiness of changes in

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[34] $t$-statistics are slightly lower than the 10 percent significance level in exports of magnetic disks to the NIEs.

[35] We can derive Eq.(10) relying on the model of Gagnon and Knetter (1995). Suppose the following simpler version of the firm's profit function (4):

$$\pi = p \cdot h(p) + \sum S \cdot p^* \cdot f(p^*) - C[h(\cdot) + f(\cdot)] ,$$

where $C(\cdot)$ is the total cost function. To the extent that the export price is determined by the markup rule, we obtain the following first-order condition with respect to the export price by using the condition $p^* = p^f / S$:

$$Sp^* = MC \cdot \left( \frac{\eta(p^f / S)}{\eta(p^f / S) - 1} \right),$$

where $\eta(\cdot)$ is the absolute value of the elasticity of demand in the foreign market with respect to changes in price. Taking the natural logarithm of the first-order condition and using the first-order Taylor series approximation of the function $\ln\{\eta(p^f / S)/[\eta(p^f / S) - 1]\}$, we obtain:

$$\ln(Sp^*) = \mu + (1 - \beta) \ln MC + \beta \ln S ,$$

where $\beta = \dfrac{\partial \ln \eta}{\partial \ln(p^f / S)} \left( \eta - 1 + \dfrac{\partial \ln \eta}{\partial \ln(p^f / S)} \right)^{-1}$ and $\mu$ denotes a constant which captures the

input prices. As a proxy for production costs, we use the gross-weighted input price indexes which show the general price trends of raw materials and fuel & energy consumed in current production processes including materials traded within the same sector.[36]

When invoicing in U.S. dollars, we expect that export prices in terms of the yen are positively correlated with the yen-U.S. dollar exchange rate but ambiguously correlated with input prices. On the other hand, when invoicing in the yen, we expect that export prices in terms of the yen may be significantly correlated with input prices.

The results of the regressions estimated by the maximum likelihood method are reported in Table 8.[37] First, the estimates of *a* (the coefficient of the exchange rate) are positive and statistically significant for exports of all commodities to the United States. The same is true not only of exports of ICs to East Asia, the NIEs, and ASEAN but also of exports of lathes to ASEAN. The estimates of *a* are not statistically significant for exports of magnetic disks to East Asia, the NIEs, and ASEAN, though the estimate is slightly lower than the 10 percent significance level in exports to East Asia. These results are quite similar to those of the empirical tests in the previous section. Second, the estimates of $\sum b_k$ are not statistically significant for all the cases except exports of engines to the NIEs. These results are contrary to the hypothesis that export prices are

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constant terms of the Taylor series.

[36] The data sources of the input price indexes are *Price Index Annual* and *Price Index Monthly*, published by the Bank of Japan. For engines and lathes, the gross-weighted input price index of general industrial machinery is used. For ICs and magnetic disks, the index of electric & communication equipment is used. For automobiles, the index of motor vehicles is used.

[37] In this regression analysis, taking the first difference of variables is assumed to be enough to produce stationary series.

adjusted to reflect changes in production costs and to the results reported by Khosla (1991) and Fukuda and Ji (1994).[38]

In summary, whereas we cannot find evidence that Japanese exporters adjust their export prices in terms of the yen to changes in input prices, export prices are significantly correlated with the exchange rates. Japanese exporters are likely to prefer U.S. dollar-invoiced transactions in their exports of ICs to the East Asian region as well as those of all commodities to the United States.

## V. CONCLUDING REMARKS

There have been a number of studies on the PTM behavior of Japanese exporters. However, owing to data constraints, it is difficult to study the PTM practice of Japan's exports in specific countries or areas. In addition, only a few attempts have so far been made at examining the effects of currency invoicing on PTM. Fukuda and Ji's seminal work have applied the theory of PTM to the issue of currency invoicing of Japan's exports and concluded that pricing behavior of Japanese machinery exports differs markedly between the U.S. and East Asian markets. By increasing the sample of commodities and by expanding the sample period, this paper advances previous research and contrary results to Fukuda and Ji's work are obtained.

The main points that have been made in the above empirical examinations can be stated as follows. First, the estimates of PTM elasticities (Eqs.8 and 9) including *a*

[38] Whereas our main concern is the effects of exchange rate changes on export prices, there is room for further consideration of the empirical specification explicitly including cost variables. We tried an estimation with longer lags (say, 6 month lags), but the results are similar to those reported herein. We also tried the estimation with the domestic wholesale price index as a proxy for domestic cost shocks, as in Fukuda and Ji (1994). The result is that some of the estimates for cost effects are statistically significant, though the estimated values are marginal.

of Eq.(10) are positive and statistically significant in exports of all commodities to the United States. The results imply that relative export prices of Japan's exports to the United States in terms of the yen are positively correlated with the yen-U.S. dollar exchange rate. Since the results are consistent with currency invoicing patterns of Japan's exports to the United States, Japanese exporting firms are likely to stabilize the export prices in the U.S. market by invoicing in U.S. dollars.

Second, the estimates of PTM elasticities are not statistically significant in Japan's exports of automobiles, engines, and lathes to the East Asian region except for exports of lathes to ASEAN. This result is consistent with Japan's currency invoicing pattern that yen-invoiced transactions are relatively large in exports of general machinery and transport equipment to the East Asian countries (Table 3).

Third, contrary to the results of Fukuda and Ji (1994), the estimates of PTM elasticities are positive and statistically significant in Japan's exports of ICs to the East Asian region. The estimates are also significantly positive in Japan's exports of magnetic disks to East Asia. This result is consistent with the high level of dollar-invoiced ratios in exports of electric machinery, especially ICs, to the East Asian countries (Table 3). Japanese exporting firms are likely to prefer invoicing in U.S. dollars in exports of ICs, and possibly magnetic disks, to the East Asian region.

Our model implies that the relatively high invoicing ratios of the U.S. dollar can be explained by the shape of the demand and profit functions in foreign markets. More specifically, semiconductors and ICs are less differentiated products than other leading machinery products and the markets of the former are highly competitive. Owing to such characteristics, Japanese exporters have a strong tendency to invoice their products

in U.S. dollars to stabilize export prices even in the East Asian markets.[39] The currency invoicing of the electric machinery industry, especially the semiconductor and IC industry, is particularly important in considering Japan's overall trade invoicing pattern, because increasing interdependence between Japan and East Asia in recent years is largely due to the active investment and trade of the industry.[40] Given the current market structure of semiconductors and ICs and the relatively large weight of exports of these commodities, one cannot expect a further increase in yen-invoiced trade in the near future.

[39] For a further discussion of this point, see Sato (1999).

[40] As of 1997, the share of the electric machinery exports is 30 percent of the Japan's overall exports to East Asia, and the exports of semiconductors etc. (including ICs) account for 44 percent of the electric exports to East Asia (computed from the Japan Tariff Association, *The Summary Report on Trade of Japan*, December 1997). Furthermore, the semiconductors and ICs are also important export products for the East Asian countries. According to the World Trade Organization, *Annual Report 1997*, Volume II, "office and telecommunication equipment" (SITC divisions 75, 76 and group 776) account for half or more of total machinery and transport equipment exports to the world for Korea, Taiwan, Hong Kong and Singapore.

**Appendix A: Data for Empirical Tests**

The export price data are based on *Japan Exports & Imports (Commodity by Country)*, various issues, published by the Japan Tariff Association. In the empirical analysis, five kinds of commodities are examined: (a) Automobiles = Passenger motor cars, with engines of a piston displacement of more than 1,000$cm^3$ not more than 2,000$cm^3$ (CCCN Code: 87.02-192 (1985:01-1987:12)), Motor cars and other motor vehicles principally designed for the transport of persons with spark-ignition internal combustion reciprocating piston engine, of a cylinder capacity exceeding 1,500 cc but not exceeding 2,000 cc, excluding those unassembled or disassembled (HS Code: 8703.23-910 (1988:01-1999:04)). (b) Engines = Internal combustion piston engines for motor vehicles, n.e.s. (CCCN Code: 84.06-390 (1985:01-1987:12)), Spark-ignition reciprocating internal combustion piston engines of a kind used for the propulsion of vehicles (other than railway or tramway rolling-stock, and parts and accessories thereof), of a cylinder capacity exceeding 1,000 cc, other than those for motorcycles (HS Code: 8407.34-900 (1988:01-1999:04)). (c) ICs = Integrated circuits, n.e.s. (CCCN Code: 85.21-419 (1985:01-1987:12)), Hybrid integrated circuits (HS Code: 8542.20-000 (1988:01-1995:12), 8542.40-000 (1996:01-1999:04)). (d) Lathes = Lathes of a kind operated by numerical control system (CCCN Code: 84.45-121 (1985:01-1987:12)), Horizontal lathes, for removing metal, numerically controlled (HS Code: 8458.11-000 (1988:01-1999:04)). (e) Magnetic disks = Magnetic Disk Units (HS Code: 8471.70-300 (1990:01-1999:04)).

The domestic price indexes are based on *Price Indexes Annual* and *Price Indexes Monthly* (Bank of Japan), various issues. In automobiles, the price index of small passenger cars (up to 2,000 cc) is used. In the engine category, the price index of

internal combustion engines for general use (1985:01-1989:12) and that of industrial internal combustion engines-gasoline (1990:01-1999:04) are used. In ICs, the price index of ICs is used. In the lathe category, the price index of NC lathes (1985:01-1994:12) and that of lathes (1995:01-1999:04) are used. In the magnetic disk category, the price index of magnetic disk is used.

The yen-dollar exchange rate is the monthly average (nominal) exchange rate, based on *International Financial Statistics* (IMF, CD-ROM edition).

**Appendix B: Cointegration Test and Error-Correction Regression**

This appendix investigates the trade invoicing practice of Japanese exporters using the error-correction model. Gagnon and Knetter (1995) and Klitgaard (1999) consider the effects of the choice of invoice currency on the PTM practice of Japanese exporting firms, using the error-correction model. They show that export prices react almost one for one to the exchange rate fluctuations in the short run possibly because a substantial portion of Japan's exports are invoiced in foreign currency (mainly in U.S. dollars). For a further check on the robustness of the results in the text, we perform the error-correction regression. We will first begin to test whether there is a cointegrating relationship in the level regression.

As shown in Section 4.2, all the relative export prices are I(1) except for the prices of lathes directed to East Asia and the NIEs. We perform the Engle and Granger (1987) cointegration test for Eq.(7) to examine whether relative export prices are cointegrated with the yen-dollar exchange rate. We regress the log of the relative export price on the log of the yen-dollar exchange rate, a constant, and a trend term. The trend term is included to capture trend effects such as any changes in demand and

competition in the market over time. The number of lags is selected so that the AIC statistics are minimized.

The results of the cointegration test are reported in Table B-1. First, the coefficient of the yen-dollar exchange rate (henceforth, the long-run PTM) is positive and significant for exports of automobiles, engines, and lathes to the United States and for exports of ICs and magnetic disks to all regions.[41] Second, for exports of ICs and lathes to the United States, the test statistics are at the 5 percent significance level, implying that the result rejects the null hypothesis that there is no cointegrating relationship between relative export prices and the yen-dollar exchange rate. Third, the test statistics of exports of automobiles and magnetic disks to the United States are somewhat lower than the 10 percent significant level, and the corresponding statistics of engines are substantially lower than the 10 percent significance level. These results indicate that we cannot reject the null hypothesis of no cointegration.

Fourth, for the cointegration tests of IC exports to East Asia, the NIEs, and ASEAN, dummy variables are included to allow for structural changes. Our preliminary tests without dummy showed that the test results could not reject the null hypothesis of no cointegration in exports of ICs to these three regions. However, visual inspection revealed a close correlation between relative export prices and the exchange rate in the 1990s. Therefore, the CUSUM test is performed to find structural break points. A dummy variable is then included for the level regression in the first step of the Engle-Granger cointegration test.[42] The result rejects the null hypothesis of no

[41] Although the coefficients of the exchange rate are also significant for the NIEs in automobiles and ASEAN in engines, the signs of coefficients are negative.

[42] The structural break point is January 1993 for East Asia, June 1993 for NIEs, and January 1991 for ASEAN.

cointegration at the 1 percent significance level for East Asia and the NIEs and at the 5 percent significance level for ASEAN.[43]

Engle and Granger (1987) show that if two variables are cointegrated, then there must exist an error-correction formulation, and conversely that error-correction formulation generates cointegrated series. Since both relative export prices and the yen-dollar exchange rate are I(1) and they are cointegrated for lathes (United States) and ICs (all the destinations), we perform the error-correction regression for these commodities.

We also perform the error-correction regression for automobiles, engines, and magnetic disks, though the Engle-Granger cointegration test cannnot reject the null hypothesis of no cointegration for these commodities. The reason why we perform the error-correction regression even for these commodities is that the residual-based tests (such as the Engle-Granger cointegration test) have been found to have low power, whereas they are very popular and often used. The low power of the residual-based test is attributed to ignoring equation dynamics in the level regression (the first step of the Engle-Granger cointegration test) and to concentrating on error dynamics. Kremers *et al.* (1992) and Zivot (1996) etc. suggest using the test by the error-correction model instead of residual-based tests.[44] Thus, owing to the low power problem of the Engle-Granger cointegration test, we also report the results of error-correction regression for automobiles, engines, and magnetic disks. We first perform the level regression to get

[43] Minotani (1997) also performs the Engle-Granger cointegration tests including dummy variables in the level regression. We must note first that the result of the stability test such as the CUSUM test and the Chow test etc. may not be reliable for the level regression of the cointegration test because all the variables in the level regression are non-stationary. Second, it is not clear whether the residual-based test is reliable when dummy variables are included in the level regression. There seems to be room for further consideration of these points.

[44] For a good summary of this issue, see Maddala and Kim (1998).

estimates of the long-run PTM (the coefficient of the yen-dollar exchange rate), and then perform the error-correction regression using the residuals of the level regression.

The error-correction regression is first performed including three lags for each variable, and then the longest lags are eliminated if they are not statistically significant at the 5 percent level. The results of the regressions are reported in Table B-2.[45] The error-correction term measures the response of relative export prices to a deviation from its long-run equilibrium value in the previous period. In other words, the estimated coefficients of the error-correction term can be interpreted as the fraction of the last period's error that is corrected this period. The estimated coefficients are negative and statistically significant for all the cases, which may imply that there be a long-run cointegrating relationship in the level regression equation.

Our main concern is the first differenced exchange rate term which indicates the short-run response of relative export prices to the exchange rate. All the coefficients of the first differenced exchange rate term are significant in exports to the United States. For ICs, the coefficient is close to one and statistically significant in exports to East Asia, the NIEs, and ASEAN. For magnetic disks, it is statistically significant in exports to East Asia and the NIEs, while the coefficients are somewhat larger than one. This result implies that these exports are likely to be invoiced largely in U.S. dollars, which conforms to the results of the first difference regression in the text.

[45] We do not report the results for automobiles (East Asia, the NIEs, and ASEAN) and engines (the same as above) because the estimates are not statistically significant.

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*Table 1. Currency Invoicing of Japan's Exports, by Region*
*(% in Transactions Values)*

| | *Exports to:* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | World | | United States | | EU (EC) | | Southeast Asia | |
| *Year* | Yen | Dollar | Yen | Dollar | Yen | Dollar | Yen | Dollar |
| 1970 | 0.9 | 90.5 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1975 | 17.0 | 78.5 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1980 | 28.9 | 66.3 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1981 | 31.8 | 62.8 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1982 | 33.8 | 60.9 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1983 | 42.0 | 50.2 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1984 | 39.5 | 53.1 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1985 | 39.3 | 52.2 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1986 | 36.5 | 53.5 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1987 | 33.4 | 55.2 | 15.0 | 84.9 | 44.0 | 8.2 | 41.1 | 56.5 |
| 1988 | 34.3 | 53.2 | 16.4 | 83.5 | 43.9 | 7.6 | 41.2 | 56.0 |
| 1989 | 34.7 | 52.4 | 16.4 | 83.5 | 42.2 | 7.0 | 43.5 | 53.6 |
| 1990 | 37.5 | 48.8 | 16.2 | 83.7 | 42.1 | 6.4 | 48.9 | 48.1 |
| 1991 | 39.4 | 46.8 | 16.5 | 83.4 | 42.0 | 6.8 | 50.8 | 45.9 |
| S1992 | 40.1 | 46.6 | 16.6 | 83.2 | 40.3 | 11.1 | 52.3 | 41.6 |
| M1993 | 42.8 | 45.6 | 18.0 | 81.6 | 42.7 | 7.2 | 52.4 | 44.4 |
| S1993 | 39.9 | 48.4 | 16.5 | 83.3 | 41.0 | 7.5 | 52.5 | 44.3 |
| M1994 | 40.7 | 48.6 | 19.4 | 80.5 | 40.9 | 8.5 | 52.0 | 45.1 |
| S1994 | 39.7 | 48.3 | 19.0 | 80.8 | 36.6 | 9.0 | 49.0 | 47.9 |
| M1995 | 37.6 | 51.5 | 17.5 | 82.3 | 37.2 | 11.3 | 47.2 | 49.9 |
| S1995 | 36.0 | 52.5 | 17.0 | 82.9 | 34.9 | 12.2 | 44.3 | 53.4 |
| M1996 | 35.9 | 53.1 | 15.9 | 83.9 | 36.1 | 12.5 | 44.1 | 53.5 |
| S1996 | 35.2 | 53.3 | 14.5 | 85.4 | 33.3 | 12.4 | 46.3 | 51.3 |
| M1997 | 35.8 | 52.8 | 16.6 | 83.2 | 34.3 | 13.4 | 45.5 | 51.7 |
| S1997 | 35.8 | 52.1 | 15.3 | 84.5 | 34.2 | 12.3 | 47.0 | 50.2 |
| M1998 | 36.0 | 51.2 | 15.7 | 84.1 | 34.9 | 13.2 | 48.4 | 48.7 |

*Notes*:
1. S refers to September and M refers to March.
2. Southeast Asia includes the following 22 countries (or areas): Asian NIEs (Korea, Taiwan, Hong Kong and Singapore), ASEAN 4 (Indonesia, Malaysia, Philippines and Thailand), Brunei, Cambodia, Laos, Myanmar, India, Pakistan, Sri Lanka, Maldives, Bangladesh, East Timor, Macao, Afghanistan, Nepal and Bhutan.

*Sources:*
BOJ, *Yushutsu Shinyojo Tokei* (Export Letter of Credit Statistics).---Data for 1970-1982.
MITI, *Yushutsu Kakunin Tokei* (Export Confirmation Statistics).---Data for 1983-1991.
MITI, *Yushutsu Hokukosho Tukadate Doko* (Export Currency Invoicing Report).
---Data for S1992-S1993.
MITI, *Yushutsu Kessai Tsukadate Doko Chosa* (Export Settlement Currency Invoicing).
---Data for M1994-M1998.

*Table 2. Currency Invoicing of Japan's Imports, by Region*
*(% in Transactions Values)*

| | *Imports from:* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | World | | United States | | EU (EC) | | Southeast Asia | |
| *Year* | Yen | Dollar | Yen | Dollar | Yen | Dollar | Yen | Dollar |
| 1970 | 0.3 | 80.0 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1975 | 0.9 | 89.9 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1980 | 2.4 | 93.1 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1981 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1982 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1983 | 3.0 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1984 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1985 | 7.3* | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1986 | 9.7* | 83.2* | 7.8* | 91.9* | 28.9* | 21.2* | 9.2* | 89.8* |
| 1987 | 10.6 | 81.7 | 9.2 | 90.6 | 27.3 | 19.5 | 11.5 | 87.6 |
| 1988 | 13.3 | 78.5 | 10.0 | 89.9 | 26.9 | 21.0 | 17.5 | 81.2 |
| 1989 | 14.1 | 77.3 | 10.2 | 89.5 | 27.7 | 19.5 | 19.5 | 79.0 |
| 1990 | 14.6 | 75.5 | 11.6 | 88.2 | 26.9 | 16.3 | 19.4 | 78.8 |
| 1991 | 15.6 | 75.4 | 11.2 | 88.7 | 31.4 | 15.9 | 21.6 | 76.5 |
| S1992 | 17.0 | 74.5 | 13.8 | 86.6 | 31.7 | 17.9 | 23.8 | 73.9 |
| M1993 | 18.2 | 75.0 | 16.2 | 83.6 | 35.7 | 24.2 | 23.4 | 74.8 |
| S1993 | 20.9 | 72.4 | 13.8 | 86.1 | 45.0 | 18.2 | 25.7 | 72.0 |
| M1994 | 21.6 | 72.1 | 12.4 | 87.5 | 44.1 | 19.4 | 30.1 | 67.4 |
| S1994 | 19.2 | 73.9 | 13.3 | 86.4 | 38.6 | 21.9 | 23.6 | 74.2 |
| M1995 | 24.3 | 68.9 | 18.4 | 80.9 | 40.6 | 20.2 | 34.1 | 64.2 |
| S1995 | 22.7 | 70.2 | 21.5 | 78.4 | 44.8 | 16.1 | 26.2 | 71.9 |
| M1996 | 20.5 | 72.2 | 17.5 | 82.7 | 40.9 | 15.3 | 23.9 | 74.1 |
| S1996 | 20.6 | 72.4 | 16.4 | 83.2 | 46.1 | 12.5 | 24.0 | 73.8 |
| M1997 | 18.9 | 74.0 | 14.2 | 85.6 | 41.3 | 17.0 | 23.3 | 74.9 |
| S1997 | 22.6 | 70.8 | 22.0 | 77.8 | 49.3 | 13.1 | 25.0 | 73.0 |
| M1998 | 21.8 | 71.5 | 16.9 | 83.0 | 44.3 | 14.3 | 26.7 | 71.6 |

*Notes:*
1. S refers to September and M refers to March.
2. * denotes fiscal year data.

*Sources:*
MITI, *Yunyu Shonin Todokede Hokokusho* (Import Approval Notification Report).
--Data for 1970-1980.
MITI, *Hokokushorei ni Motozuku Hokoku* (Report Based on Report Guidance).
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MITI, *Yunyu Hokoku Tokei* (Import Report Statistics).---Data for 1986-1991.
MITI, *Yunyu Hokukosho Tukadate Doko* (Import Currency Invoicing Report).
---Data for S1992-S1993.
MITI, *Yunyu Kessai Tsukadate Doko Chosa* (Import Settlement Currency Invoicing).
---Data for M1994-M1998.

*Table 3. Currency Invoicing of Japan's Exports and Imports, by Commodity and Region, in March 1998 (% in Transactions Values)*

*A. Japan's Exports:*

| | To World | | To United States | | To EU | | To South-east Asia | |
|---|---|---|---|---|---|---|---|---|
| Commodity | Yen | Dollar | Yen | Dollar | Yen | Dollar | Yen | Dollar |
| All commodities | 36.0 | 51.2 | 15.7 | 84.1 | 34.9 | 13.2 | 48.4 | 48.7 |
| Food Stuff | 52.7 | 42.9 | 17.6 | 82.4 | 37.9 | 21.1 | 59.2 | 35.6 |
| Textiles | 35.7 | 59.0 | 16.3 | 83.3 | 59.8 | 8.8 | 28.2 | 70.8 |
| Chemicals | 29.7 | 61.5 | 29.0 | 70.5 | 38.3 | 20.4 | 29.8 | 68.5 |
| Non-metallic mineral manufs. | 41.8 | 50.9 | 18.4 | 81.3 | 40.7 | 11.6 | 53.1 | 43.1 |
| Metal products | 21.3 | 74.3 | 11.2 | 88.8 | 34.2 | 31.2 | 23.2 | 76.2 |
| General machinery | 38.1 | 50.2 | 17.7 | 82.1 | 32.6 | 22.9 | 59.7 | 37.7 |
| Electric machinery | 32.4 | 55.6 | 13.6 | 86.4 | 37.4 | 9.7 | 42.7 | 53.4 |
| ICs (Integrated circuits) | 21.4 | 68.9 | 9.3 | 90.5 | 16.2 | 15.9 | 26.7 | 70.8 |
| Telecom equipment | 24.8 | 59.2 | 10.8 | 89.2 | 38.0 | 6.1 | 34.0 | 48.6 |
| Transport equipment | 43.4 | 40.4 | 12.6 | 87.4 | 36.9 | 3.6 | 81.3 | 15.4 |
| Passenger motor cars | 37.6 | 40.7 | 13.6 | 86.4 | 37.8 | 0.1 | 87.7 | 2.6 |
| Parts of motor vehicles | 39.3 | 53.8 | 12.4 | 87.6 | 51.2 | 0.1 | 81.1 | 17.8 |
| Precision instruments | 37.1 | 45.6 | 20.9 | 78.9 | 34.5 | 6.2 | 61.5 | 37.1 |
| Others | 27.2 | 55.6 | 16.6 | 83.2 | 23.8 | 13.0 | 40.3 | 54.9 |

*B. Japan's Imports:*

| | From World | | From United States | | From EU | | From South-east Asia | |
|---|---|---|---|---|---|---|---|---|
| Commodity | Yen | Dollar | Yen | Dollar | Yen | Dollar | Yen | Dollar |
| All commodities | 21.8 | 71.5 | 16.9 | 83.0 | 44.3 | 14.3 | 26.7 | 71.6 |
| Food stuff | 27.4 | 66.7 | 21.4 | 78.6 | 31.7 | 19.0 | 30.7 | 68.8 |
| Raw materials | 6.8 | 91.3 | 1.2 | 98.7 | 27.6 | 53.0 | 14.8 | 84.6 |
| Mineral fuels | 1.3 | 98.6 | 4.5 | 95.5 | 38.0 | 42.8 | 1.0 | 98.7 |
| Crude oil | 0.5 | 99.3 | 0.0 | 100.0 | - | - | 4.6 | 93.3 |
| Petroleum products | 0.9 | 98.9 | 1.7 | 98.3 | 29.8 | 52.7 | 1.0 | 99.0 |
| Manufactured goods | 28.2 | 62.2 | 16.9 | 83.0 | 46.5 | 12.3 | 33.7 | 63.9 |
| Chemicals | 32.1 | 61.2 | 14.8 | 85.1 | 76.8 | 7.6 | 22.8 | 71.5 |
| Textile | 18.5 | 72.5 | 11.1 | 88.6 | 41.8 | 6.0 | 16.6 | 82.0 |
| Metals | 27.2 | 69.7 | 14.4 | 85.6 | 35.1 | 43.1 | 51.6 | 46.9 |
| Machinery & equipment | 31.2 | 57.3 | 19.8 | 80.3 | 35.2 | 10.1 | 37.7 | 60.1 |
| Office machinery | 31.9 | 65.4 | 32.6 | 67.3 | 16.5 | 62.1 | 34.9 | 63.1 |
| Semiconductors etc. | 51.6 | 47.4 | 23.2 | 76.8 | 44.4 | 32.1 | 54.3 | 45.6 |
| Motor vehicles | 43.0 | 14.2 | 26.0 | 73.9 | 45.7 | 0.2 | 90.5 | 7.6 |
| Others | 20.8 | 67.4 | 14.7 | 85.2 | 31.0 | 15.3 | 24.5 | 72.7 |

*Source:*

MITI, Yushutsu (Yunyu) Kessai Tsukadate Doko Chosa (Export and Import Settlement Currency Invoicing).

*Table 4. Currency Compositions of Foreign Exchange Market Activity in April 1992, April 1995, and April 1998: Average Daily Turnover*

(Percent; Billions of U.S. Dollars in Parentheses)

| *Market:* | *Year:* | *Currency:* U.S. Dollar | Deutsche Mark | Japanese Yen | Pound Sterling | ECU | Local Currency | Others | Total |
|---|---|---|---|---|---|---|---|---|---|
| Japan | 1992 | 92.4 | 18.6 | 73.9 | 5.6 | 0.4 | – | 9.1 | 200.0 (252.2) |
| | 1995 | 93.7 | 15.9 | 81.1 | 2.2 | 0.2 | – | 6.8 | 200.0 (322.6) |
| | 1998 | 91.8 | 12.1 | 83.5 | 3.6 | 0.1 | – | 8.9 | 200.0 (297.2) |
| Singapore | 1992 | 90.4 | 36.6 | 31.5 | 14.7 | 0.9 | 3.2 | 22.7 | 200.0 (151.7) |
| | 1995 | 90.9 | 31.9 | 27.9 | 7.6 | 0.5 | 5.6 | 35.6 | 200.0 (210.8) |
| | 1998 | 94.8 | 20.2 | 23.3 | 5.8 | 0.2 | 12.7 | 43.2 | 200.0 (278.0) |
| Hong Kong | 1992 | 90.2 | 32.4 | 28.0 | 13.5 | 0.5 | 14.5 | 20.9 | 200.0 (121.8) |
| | 1995 | 93.3 | 28.5 | 31.1 | 7.9 | n.a. | 17.0 | 22.2 | 200.0 (180.4) |
| | 1998 | 93.0 | 22.8 | 27.1 | 10.6 | n.a. | 23.8 | 22.8 | 200.0 (157.1) |

*Notes:*

1. Data for April 1992, April 1995, and April 1998 are based on reported foreign exchange market turnover by country and currency net of local inter-dealer double-counting.
2. Because two currencies are involved in each transaction, the sum of transactions in individual currencies comes to twice the reported turnover. Therefore, the total currency composition adds up to 200 percent, and total amounts in parentheses also equal twice total transactions.

*Sources:*

BIS, *Central Bank Survey of Foreign Exchange Market Activity in April 1992*, Basle, March 1993.
BIS, *Central Bank Survey of Foreign Exchange and Derivative Market Activity 1995*, Basle, May 1996.
BIS, *Central Bank Survey of Foreign Exchange and Derivative Market Activity 1998*, Basle, May 1999.

*Table 5. Results of Unit Root Tests*

| | *Level* | | | | | *First-difference* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ADF test | | Phillips-Perron test | | | ADF test | | Phillips-Perron test | | |
| | Test stat. | No. lags | Test stat. | No. lags | Type | Test stat. | No. lags | Test stat. | No. lags | Type |
| Automobiles | | | | | | | | | | |
| US | -0.25 | 1 | -0.27 | 4 | Const | -14.63 ** | 0 | -14.68 ** | 4 | No Const |
| EA | -1.26 | 1 | -1.53 | 4 | Const | -17.47 ** | 0 | -17.92 ** | 4 | No Const |
| NIEs | -1.73 | 1 | -1.90 | 4 | Const | -15.46 ** | 0 | -15.91 ** | 4 | No Const |
| ASEAN | -1.01 | 13 | -1.23 | 4 | Const | -3.15 ** | 12 | -22.27 ** | 4 | No Const |
| Engines | | | | | | | | | | |
| US | -0.04 | 5 | -0.14 | 4 | No Const | -7.73 ** | 4 | -16.19 ** | 4 | No Const |
| EA | -0.05 | 2 | -0.08 | 4 | No Const | -12.44 ** | 1 | -20.16 ** | 4 | No Const |
| NIEs | -0.06 | 11 | -0.94 | 4 | No Const | -5.94 ** | 10 | -20.87 ** | 4 | No Const |
| ASEAN | 0.17 | 4 | 0.09 | 4 | No Const | -8.53 ** | 3 | -20.09 ** | 4 | No Const |
| ICs | | | | | | | | | | |
| US | -0.96 | 3 | -2.70 # | 4 | Const | -11.01 ** | 2 | -23.77 ** | 4 | No Const |
| EA | -1.97 | 1 | -1.97 | 4 | Const | -19.21 ** | 0 | -18.77 ** | 4 | No Const |
| NIEs | -2.02 | 1 | -2.01 | 4 | Const | -19.03 ** | 0 | -18.56 ** | 4 | No Const |
| ASEAN | -2.23 | 2 | -1.93 | 4 | Const | -13.21 ** | 1 | -21.42 ** | 4 | No Const |
| Lathes | | | | | | | | | | |
| US | -0.42 | 7 | -3.68 ** | 4 | Const | -7.09 ** | 6 | -24.15 ** | 4 | No Const |
| EA | -4.15 ** | 2 | -9.12 ** | 4 | Const | -4.59 ** | 10 | -27.93 ** | 4 | No Const |
| NIEs | -11.59 ** | 0 | -11.74 ** | 4 | Const | -8.34 ** | 6 | -30.90 ** | 4 | No Const |
| ASEAN | -1.04 | 21 | -10.32 ** | 4 | Const | -5.38 ** | 20 | -26.32 ** | 4 | No Const |
| Magnetic Disks | | | | | | | | | | |
| US | -0.86 | 0 | -0.68 | 4 | Const | -12.39 ** | 0 | -12.42 ** | 4 | No Const |
| EA | -0.79 | 14 | -1.58 | 4 | Const | -15.98 ** | 0 | -19.39 ** | 4 | No Const |
| NIEs | -0.73 | 17 | -1.46 | 4 | Const | -15.69 ** | 0 | -18.31 ** | 4 | No Const |
| ASEAN | -1.99 | 1 | -2.38 | 4 | Const | -13.61 ** | 0 | -15.91 ** | 4 | No Const |
| Yen-U.S. dollar exchange rate | | | | | | | | | | |
| | -1.54 | 5 | -1.59 | 4 | No Const | -5.71 ** | 4 | -9.03 ** | 4 | No Const |

*Notes*:

1. ADF test denotes the unit root test of the augmented Dickey-Fuller test.
2. Double asterisks (**), a single asterisk (*), and a sharp (#), respectively, indicate that the statistics are significant at the 1, 5 and 10 % levels, based on MacKinnon (1994).
3. The number of lags (No. lags) for ADF test are chosen so that the AIC statistics are minimized. For Phillips-Perron test, we choose the lags suggested by Newey and West (1994).
4. "Const" denotes the unit root test with drift, and "No Const" denotes the unit root test without drift and trend.

*Table 6. Regressions of the Relative Export Price on the Exchange Rate: Eq.(8)*

| Commodity | Export Destination | Constant | α | Rho | Adj.R-sq. /DW |
|---|---|---|---|---|---|
| Automobiles | United States | 0.005 * | 0.49 ** | -0.31 ** | 0.22 |
| | | (0.002) | (0.07) | (0.07) | 2.07 |
| | East Asia | 0.004 | -0.09 | -0.28 ** | 0.08 |
| | | (0.006) | (0.21) | (0.07) | 2.02 |
| | NIEs | 0.005 | -0.04 | -0.17 * | 0.02 |
| | | (0.007) | (0.24) | (0.08) | 2.02 |
| | ASEAN | 0.005 | 0.08 | -0.44 ** | 0.19 |
| | | (0.004) | (0.15) | (0.07) | 2.13 |
| Engines | United States | 0.002 | 0.43 ** | -0.22 ** | 0.10 |
| | | (0.003) | (0.11) | (0.08) | 2.12 |
| | East Asia | -0.001 | -0.20 | -0.37 ** | 0.14 |
| | | (0.006) | (0.24) | (0.07) | 2.12 |
| | NIEs | -0.764 | -0.24 | -0.38 ** | 0.14 |
| | | (0.009) | (0.33) | (0.07) | 2.05 |
| | ASEAN | 0.000 | -0.31 | -0.36 ** | 0.13 |
| | | (0.009) | (0.33) | (0.07) | 2.09 |
| ICs | United States | 0.013 | 1.51 ** | -0.47 ** | 0.27 |
| | | (0.009) | (0.34) | (0.07) | 2.23 |
| | East Asia | 0.013 * | 0.77 ** | -0.42 ** | 0.22 |
| | | (0.005) | (0.19) | (0.07) | 2.02 |
| | NIEs | 0.012 * | 0.72 ** | -0.41 ** | 0.20 |
| | | (0.005) | (0.20) | (0.07) | 1.97 |
| | ASEAN | 0.013 * | 0.66 ** | -0.45 ** | 0.20 |
| | | (0.007) | (0.25) | (0.07) | 2.05 |
| Lathes | United States | 0.005 | 0.66 ** | -0.49 ** | 0.27 |
| | | (0.004) | (0.17) | (0.07) | 2.26 |
| | East Asia | 0.001 | 0.46 | -0.44 ** | 0.19 |
| | | (0.011) | (0.43) | (0.07) | 2.35 |
| | NIEs | -0.001 | -0.15 | -0.47 ** | 0.22 |
| | | (0.015) | (0.57) | (0.07) | 2.37 |
| | ASEAN | 0.004 | 1.22 * | -0.37 ** | 0.15 |
| | | (0.014) | (0.53) | (0.07) | 2.17 |
| Magnetic Disks | United States | 0.010 | 0.93 ** | -0.24 * | 0.12 |
| | | (0.007) | (0.27) | (0.09) | 1.91 |
| | East Asia | 0.009 | 0.94 # | -0.41 ** | 0.17 |
| | | (0.014) | (0.55) | (0.09) | 2.39 |
| | NIEs | 0.008 | 0.82 | -0.40 ** | 0.16 |
| | | (0.014) | (0.53) | (0.09) | 2.41 |
| | ASEAN | 0.002 | 0.02 | -0.25 ** | 0.05 |
| | | (0.021) | (0.79) | (0.09) | 2.06 |

*Notes:*

1. Numbers in parentheses are standard errors.
2. Double asterisks (**), a single asterisk (*), and a sharp (#), respectively, indicate that the statistics are significant at the 1, 5, and 10 % levels.

*Source:* See Appendix A.

*Table 7. Regressions of the Relative Export Price on the Exchange Rate: Eq.(9)*

| Commodity | Export Destination | Constant | $\Sigma \beta_k$ | Rho | Adj.R-sq. /DW |
|---|---|---|---|---|---|
| Automobiles | United States | 0.005 ** | 0.60 ** | -0.30 ** | 0.25 |
| | | (0.002) | (0.09) | (0.07) | 2.04 |
| | East Asia | 0.006 | 0.37 | -0.30 ** | 0.10 |
| | | (0.006) | (0.26) | (0.07) | 2.04 |
| | NIEs | 0.006 | 0.33 | -0.18 * | 0.03 |
| | | (0.007) | (0.31) | (0.08) | 2.04 |
| | ASEAN | 0.006 | 0.23 | -0.44 ** | 0.19 |
| | | (0.004) | (0.19) | (0.07) | 2.14 |
| Engines | United States | 0.001 | 0.35 * | -0.23 ** | 0.11 |
| | | (0.003) | (0.14) | (0.08) | 2.09 |
| | East Asia | 0.000 | -0.04 | -0.38 ** | 0.13 |
| | | (0.006) | (0.30) | (0.07) | 2.07 |
| | NIEs | -0.004 | 0.22 | -0.39 ** | 0.13 |
| | | (0.009) | (0.41) | (0.07) | 1.97 |
| | ASEAN | 0.000 | -0.02 | -0.36 ** | 0.13 |
| | | (0.009) | (0.41) | (0.07) | 2.07 |
| ICs | United States | 0.011 | 1.22 ** | -0.47 ** | 0.27 |
| | | (0.009) | (0.42) | (0.07) | 2.23 |
| | East Asia | 0.012 * | 0.65 ** | -0.42 ** | 0.22 |
| | | (0.005) | (0.24) | (0.07) | 2.02 |
| | NIEs | 0.011 * | 0.62 * | -0.41 ** | 1.99 |
| | | (0.005) | (0.25) | (0.07) | 1.97 |
| | ASEAN | 0.013 # | 0.46 | -0.41 ** | 0.20 |
| | | (0.007) | (0.31) | (0.07) | 2.16 |
| Lathes | United States | 0.004 | 0.46 * | -0.49 ** | 0.26 |
| | | (0.004) | (0.21) | (0.07) | 2.26 |
| | East Asia | 0.000 | 0.65 | -0.44 ** | 0.20 |
| | | (0.011) | (0.53) | (0.07) | 2.36 |
| | NIEs | -0.002 | 0.37 | -0.47 ** | 0.21 |
| | | (0.015) | (0.70) | (0.07) | 2.32 |
| | ASEAN | 0.004 | 1.02 | -0.35 ** | 0.14 |
| | | (0.015) | (0.67) | (0.07) | 2.20 |
| Magnetic Disks | United States | 0.012 | 1.04 ** | -0.25 ** | 0.12 |
| | | (0.007) | (0.34) | (0.09) | 1.95 |
| | East Asia | 0.012 | 0.99 | -0.42 ** | 0.17 |
| | | (0.015) | (0.69) | (0.09) | 2.45 |
| | NIEs | 0.010 | 1.05 | -0.40 ** | 0.14 |
| | | (0.014) | (0.69) | (0.09) | 2.41 |
| | ASEAN | 0.010 | 0.49 | -0.30 ** | 0.05 |
| | | (0.021) | (0.97) | (0.10) | 1.99 |

*Notes:*

1. Numbers in parentheses are standard errors.
2. Double asterisks (**), a single asterisk (*), and a sharp (#), respectively, indicate that the statistics are significant at the 1, 5, and 10 % levels.

*Source:* See Appendix A.

*Table 8. Regressions of the Export Price on the Exchange Rate and the Production Cost: Eq.(10)*

| Commodity | Export Destination | Constant | $a$ | $\Sigma b_k$ | Rho | Adj.R-sq. /DW |
|---|---|---|---|---|---|---|
| Automobiles | United States | 0.004 | 0.46 ** | 1.33 | -0.29 ** | 0.22 |
| | | (0.002) | (0.07) | (1.00) | (0.07) | 2.09 |
| | East Asia | 0.006 | -0.18 | 4.35 | -0.26 ** | 0.08 |
| | | (0.006) | (0.21) | (3.23) | (0.07) | 2.01 |
| | NIEs | 0.006 | -0.11 | 3.51 | -0.16 * | 0.02 |
| | | (0.007) | (0.24) | (3.82) | (0.08) | 2.03 |
| | ASEAN | 0.004 | 0.05 | 0.79 | -0.44 ** | 0.18 |
| | | (0.004) | (0.15) | (2.31) | (0.07) | 2.14 |
| Engines | United States | 0.002 | 0.47 ** | -1.28 | -0.25 ** | 0.11 |
| | | (0.003) | (0.11) | (1.35) | (0.08) | 2.10 |
| | East Asia | 0.000 | -0.14 | -1.24 | -0.39 ** | 0.14 |
| | | (0.006) | (0.24) | (2.78) | (0.07) | 2.08 |
| | NIEs | -0.002 | -0.31 | 11.66 ** | -0.41 ** | 0.16 |
| | | (0.009) | (0.32) | (3.77) | (0.07) | 2.00 |
| | ASEAN | 0.000 | -0.32 | -2.18 | -0.37 ** | 0.12 |
| | | (0.009) | (0.33) | (3.89) | (0.07) | 2.08 |
| ICs | United States | 0.007 | 1.43 ** | 1.78 | -0.46 ** | 0.26 |
| | | (0.012) | (0.36) | (2.84) | (0.07) | 2.22 |
| | East Asia | 0.001 | 0.78 ** | -0.56 | -0.46 ** | 0.25 |
| | | (0.006) | (0.19) | (1.48) | (0.07) | 2.09 |
| | NIEs | 0.001 | 0.71 ** | -0.15 | -0.45 ** | 0.22 |
| | | (0.007) | (0.19) | (1.53) | (0.07) | 2.02 |
| | ASEAN | 0.001 | 0.76 ** | -1.21 | -0.44 ** | 0.22 |
| | | (0.008) | (0.25) | (1.96) | (0.07) | 2.18 |
| Lathes | United States | 0.003 | 0.65 ** | -1.93 | -0.50 ** | 0.27 |
| | | (0.004) | (0.17) | (1.91) | (0.07) | 2.29 |
| | East Asia | -0.003 | 0.37 | 1.70 | -0.45 ** | 0.19 |
| | | (0.011) | (0.43) | (5.01) | (0.07) | 2.36 |
| | NIEs | -0.006 | -0.29 | 4.96 | -0.48 ** | 0.21 |
| | | (0.015) | (0.57) | (6.60) | (0.07) | 2.33 |
| | ASEAN | 0.002 | 1.13 * | -1.45 | -0.35 ** | 0.13 |
| | | (0.014) | (0.54) | (6.33) | (0.07) | 2.21 |
| Magnetic Disks | United States | -0.006 | 0.92 ** | -0.22 | -0.35 ** | 0.15 |
| | | (0.012) | (0.27) | (4.28) | (0.09) | 1.92 |
| | East Asia | 0.000 | 0.86 | 2.90 | -0.46 ** | 0.21 |
| | | (0.024) | (0.56) | (8.69) | (0.09) | 2.48 |
| | NIEs | -0.001 | 0.76 | 3.50 | -0.46 ** | 0.19 |
| | | (0.023) | (0.53) | (8.25) | (0.09) | 2.49 |
| | ASEAN | 0.004 | 0.59 | 5.02 | -0.26 ** | 0.05 |
| | | (0.035) | (0.78) | (12.51) | (0.10) | 2.12 |

*Notes:*
1. Numbers in parentheses are standard errors.
2. Double asterisks (**), a single asterisk (*), and a sharp (#), respectively, indicate that the statistics are significant at the 1, 5, and 10 % levels.

*Source:* See Appendix A.

*Table B-1. Engle-Granger Cointegration Tests:*
*Japan's Exports to the USA, East Asia, the NIEs, and ASEAN*

| | Const. | Time | EXR | Tim*D | EXR*D | Adj.R-sq. / DW | Test Stat. / (Lags) |
|---|---|---|---|---|---|---|---|
| Automobiles | | | | | | | |
| USA | 5.65 ** | 0.006 ** | 0.68 ** | | | 0.94 | -3.19 |
| | (0.13) | (0.000) | (0.02) | | | 0.43 | (1) |
| East Asia | 9.33 ** | 0.002 ** | -0.07 | | | 0.26 | -1.94 |
| | (0.56) | (0.000) | (0.11) | | | 0.19 | (1) |
| NIEs | 10.62 ** | 0.001 | -0.30 * | | | 0.12 | -1.94 |
| | (0.64) | (0.001) | (0.12) | | | 0.17 | (1) |
| ASEAN | 0.90 ** | 0.004 ** | -0.04 | | | 0.69 | -2.13 |
| | (0.37) | (0.000) | (0.07) | | | 0.32 | (12) |
| Engines | | | | | | | |
| USA | 5.67 ** | 0.002 ** | 0.33 ** | | | 0.21 | -1.63 |
| | (0.29) | (0.000) | (0.06) | | | 0.20 | (5) |
| East Asia | 6.80 ** | 0.001 ** | -0.06 | | | 0.10 | -2.45 |
| | (0.53) | (0.000) | (0.10) | | | 0.33 | (2) |
| NIEs | 6.02 ** | 0.001 | 0.13 | | | 0.00 | -1.05 |
| | (0.76) | (0.001) | (0.15) | | | 0.32 | (11) |
| ASEAN | 8.03 ** | 0.001 | -0.36 ** | | | 0.17 | -3.14 |
| | (0.63) | (0.001) | (0.12) | | | 0.42 | (1) |
| ICs | | | | | | | |
| USA | -2.83 ** | 0.009 ** | 0.72 ** | | | 0.82 | -4.01 * |
| | (0.41) | (0.000) | (0.08) | | | 1.37 | (3) |
| East Asia | -4.00 ** | 0.021 ** | 0.69 ** | -0.016 ** | 0.26 ** | 0.92 | -4.81 ** |
| | (0.45) | (0.001) | (0.09) | (0.001) | (0.03) | 0.57 | (7) |
| NIEs | -4.27 ** | 0.021 ** | 0.74 ** | -0.018 ** | 0.33 ** | 0.91 | -4.58 ** |
| | (0.53) | (0.001) | (0.10) | (0.002) | (0.04) | 0.43 | (7) |
| ASEAN | -2.45 ** | 0.024 ** | 0.41 ** | -0.016 ** | 0.12 ** | 0.88 | -4.24 * |
| | (0.50) | (0.001) | (0.09) | (0.001) | (0.02) | 0.72 | (1) |
| Lathes | | | | | | | |
| USA | 9.15 ** | 0.004 ** | 0.48 ** | | | 0.72 | -4.15 * |
| | (0.22) | (0.000) | (0.04) | | | 1.17 | (2) |
| ASEAN | 11.86 ** | -0.001 ** | -0.04 | | | 0.05 | -5.11 ** |
| | (0.54) | (0.000) | (0.10) | | | 1.64 | (12) |
| Magnetic Disks | | | | | | | |
| USA | -0.29 | 0.014 ** | 1.26 ** | | | 0.87 | -3.18 |
| | (0.61) | (0.001) | (0.12) | | | 0.33 | (0) |
| East Asia | 0.46 | 0.015 ** | 1.03 ** | | | 0.78 | 1.68 |
| | (0.88) | (0.001) | (0.18) | | | 0.90 | (7) |
| NIEs | -0.30 | 0.016 ** | 1.19 ** | | | 0.76 | -2.24 |
| | (0.93) | (0.001) | (0.19) | | | 0.75 | (7) |
| ASEAN | 0.04 | 0.015 ** | 1.10 ** | | | 0.70 | -2.19 |
| | (1.09) | (0.001) | (0.22) | | | 0.90 | (10) |

*Notes:*
1. Double asterisks (**), a single asterisk (*), and a sharp (#), respectively, indicate that the statistics are significant at the 1, 5 and 10 % levels. *P*-values of the test statistics are based on MacKinnon (1994).
2. "Time*D" denotes time trend times dummy variable. "EXR*D" denotes the exchange rate times dummy variable. The dummy takes the value 0 for January 1985 to December 1992 for East Asia, for January 1985 to May 1993 for the NIEs, and for January 1985 to December 1990 for ASEAN. Otherwise, it takes the value 1.

*Table B-2. Error-Correction Regressions*

| | | *Long-run* | *Error-Correction Regression* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *PTM (EXR)* | Const. | ΔEXR | ΔEXR(-1) | ΔREP(-1) | ΔREP(-2) | EC(-1) | Adj.R-sq. | D.alt. |
| Automobiles | | | | | | | | | | |
| | USA | 0.68 ** | 0.006 ** | 0.33 ** | 0.42 ** | -0.23 ** | | -0.13 ** | 0.31 | 0.70 |
| | | (0.02) | (0.002) | (0.08) | (0.09) | (0.07) | | (0.05) | | |
| Engines | | | | | | | | | | |
| | USA | 0.33 ** | 0.002 | 0.45 ** | | -0.16 * | | -0.08 * | 0.12 | -3.32 |
| | | (0.06) | (0.004) | (0.12) | | (0.07) | | (0.03) | | |
| ICs | | | | | | | | | | |
| | USA | 0.72 ** | 0.018 | 1.70 ** | | -0.29 ** | -0.15 * | -0.47 ** | 0.41 | -1.77 |
| | | (0.08) | (0.012) | (0.38) | | (0.09) | (0.08) | (0.10) | | |
| | East Asia | 0.69 ** | 0.016 * | 0.88 ** | | -0.32 ** | | -0.15 ** | 0.24 | 0.00 |
| | | (0.09) | (0.007) | (0.23) | | (0.07) | | (0.05) | | |
| | NIEs | 0.74 ** | 0.016 * | 0.82 ** | | -0.33 ** | | -0.13 ** | 0.21 | 0.30 |
| | | (0.10) | (0.007) | (0.24) | | (0.07) | | (0.05) | | |
| | ASEAN | 0.41 ** | 0.021 * | 0.85 ** | | -0.38 ** | -0.15 * | -0.17 ** | 0.26 | -0.37 |
| | | (0.09) | (0.009) | (0.29) | | (0.08) | (0.08) | (0.06) | | |
| Lathes | | | | | | | | | | |
| | USA | 0.48 ** | 0.008 | 0.93 ** | | -0.39 ** | -0.15 * | -0.36 ** | 0.39 | 0.20 |
| | | (0.04) | (0.006) | (0.20) | | (0.09) | (0.07) | (0.09) | | |
| | ASEAN | -0.04 | 0.001 | 0.41 | | 0.06 | | -0.85 ** | 0.40 | -0.63 |
| | | (0.10) | (0.016) | (0.53) | | (0.08) | | (0.10) | | |
| Magnetic Disks | | | | | | | | | | |
| | USA | 1.26 ** | 0.010 | 1.04 ** | | | | -0.16 ** | 0.13 | 2.24 |
| | | (0.12) | (0.009) | (0.30) | | | | (0.05) | | |
| | East Asia | 1.03 ** | 0.020 | 1.63 ** | | -0.50 ** | -0.43 ** | -0.19 * | 0.40 | -0.51 |
| | | (0.18) | (0.018) | (0.59) | | (0.10) | (0.09) | (0.09) | | |
| | NIEs | 1.19 ** | 0.012 | 1.39 * | | -0.26 ** | | -0.29 ** | 0.23 | -5.20 |
| | | (0.19) | (0.019) | (0.63) | | (0.09) | | (0.08) | | |
| | ASEAN | 1.10 ** | 0.004 | 0.96 | | -0.01 | | -0.51 ** | 0.24 | -0.66 |
| | | (0.22) | (0.024) | (0.79) | | (0.09) | | (0.10) | | |

*Notes:*

1. Double asterisks (**) and a single asterisk (*) indicate that the statistics are significant at the 1 and 5 % levels, respectively.
2. Log-run PTM (EXR) denotes the estimate of the exchange rate coefficient in the Engle-Granger cointegration test (quoted from Table B-1).
3. EC(-1) denotes the first lag of the error-correction term.
4. D.alt. denotes Durbin's alternative except for Magnetic Disk (USA) which is DW statistics.