

## Currency Invoicing in Japanese Exports to East Asia: Implications for Yen Internationalization

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The present paper examines currency invoicing in Japanese exports to East Asia by applying the pricing-to-market (PTM) theory. The notable aims of the present paper are to: (i) use a number of sample commodities obtained from the data on monthly series of exports based on the nine-digit Harmonized System; and (ii) examine currency invoicing practices of Japanese exporters by making a distinction between the long-run and short-run PTM under the framework of the error-correction model. Contrary to the results of previous reports, our study shows that Japanese exporters of electric machinery tend to stabilize US Dollar (USD)-denominated export prices in the short run in East Asian markets, implying that electric machinery products tend to be invoiced in USD in exports to East Asia. Given the USD-invoicing practices by Japanese electric machinery exporters, it is hard to expect the further use of the Yen in trade transactions because the electric machinery industry plays a major role in facilitating trade and investment between Japan and East Asia.

*Keywords:* cointegration, error-correction model, internationalization of the Yen, invoice currency, pricing-to-market (PTM).

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## I. Introduction

The choice of invoice currency has important implications for the study of pricing in international markets, whereas most studies of pricing-to-market (PTM) do not explicitly consider the effect of currency invoicing on exchange rate pass through. Specifically, invoicing in the importer's currency causes a 'stickiness' of nominal prices in the local currency, at least in the short run, which might lead to a spurious finding of PTM, while biases are likely to go against finding PTM when invoicing in the exporter's currency (Goldberg and Knetter, 1997). Several recent studies, including Giovannini (1988), Donnenfeld and Zilcha (1991), Johnson and Pick (1997) and Friberg (1998), have made a theoretical examination of the choice of invoice currency. Based on the theoretical model of currency invoicing, Fukuda and Ji (1994) empirically investigated currency invoicing practices in Japanese exports to the USA and East Asia, and Donnenfeld and Haug (2001) examined the determinants of choice of invoice currency in the case of Canadian imports.

Currency invoicing practices by Japanese exporters have particularly important implications for trade aspects of internalization of the Yen. While it is known that the US Dollar (USD) is typically used in East Asian trade as an invoice currency, the Yen plays a certain role as the invoice currency in trade between Japan and East Asia.<sup>1</sup> Table 1 shows that Yen-invoiced exports to South-East Asia increased considerably after 1987 and approximately 52 percent of exports to South-East Asia were invoiced in the Yen in the early 1990s. Many studies, including Hamada and Horiuchi (1987), Tavlas and Ozeki (1992) and Ito (1993), have indicated that such currency invoicing patterns are related to the PTM behavior of Japanese exporters, whereas only few attempts have been made at a rigorous empirical study of this issue. Two exceptions are the studies of Fukuda and Ji (1994) and Fukuda (1996) that estimated pass-through rates of four types of commodities in Japanese exports and found that Japanese exporters tend to pass through changes in exchange rates to East Asian importers while they tend to stabilize their selling prices in terms of the USDs in exports to the USA. Fukuda and Ji (1994) concluded that Japanese exporters choose the invoice currency based on different pricing strategies in each market, resulting in the rising tendency of Yen-invoiced exports to East Asia in addition to the large share of USD-invoiced ratio in exports to the USA (Table 1). However, we must note that the Yen-invoiced ratio in exports to South-East Asia started to decline from the mid-1990s, contrary to the conclusions of previous studies.<sup>2</sup> Hence, a

1. This evidence is pointed out in existing literature of Yen internationalization by Tavlas and Ozeki (1992), Ito (1993) and Iwami (1995), Chapter 5. For detailed data on currency invoicing ratios of Japanese exports and imports, see Kawai (1996) and Sato (1999).

2. Ito (1993) pointed out that the decline of the Yen-invoiced ratio from 1985 to 1987 in exports to the world (Table 1), which corresponds to the rapid Yen appreciation period, might reflect the PTM behavior of Japanese exporters. The point we would like to emphasize is that such co-movements between the Yen-invoiced ratio and the Yen-USD exchange rate can be observed even in exports to South-East Asia (Table 1).

**Table 1** Currency Invoicing Ratios in Japanese Exports (%)

Year	Exports to:							
	World		USA		EU (EC)		South-East Asia	
	Yen	US Dollar	Yen	US Dollar	Yen	US Dollar	Yen	US Dollar
1970	0.9	90.5	NA	NA	NA	NA	NA	NA
1975	17.0	78.5	NA	NA	NA	NA	NA	NA
1980	28.9	66.3	NA	NA	NA	NA	NA	NA
1981	31.8	62.8	NA	NA	NA	NA	NA	NA
1982	33.8	60.9	NA	NA	NA	NA	NA	NA
1983	42.0	50.2	NA	NA	NA	NA	NA	NA
1984	39.5	53.1	NA	NA	NA	NA	NA	NA
1985	39.3	52.2	NA	NA	NA	NA	NA	NA
1986	36.5	53.5	NA	NA	NA	NA	NA	NA
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: S, September; M, March; NA, not available. South-East Asia is defined as the following 22 economies: Asian NIEs (Korea, Taiwan, Hong Kong, and Singapore), ASEAN4 (Indonesia, Malaysia, Philippines, and Thailand), Brunei, Cambodia, Laos, Myanmar, India, Pakistan, Sri Lanka, Maldives, Bangladesh, East Timor, Macao, Afghanistan, Nepal and Bhutan.

Sources: Bank of Japan, *Yushutsu Shinyojo Tokei* (Export Letter of Credit Statistics), various issues; Ministry of International Trade and Industry (MITI), *Yushutsu Kakunin Tokei* (Export Confirmation Statistics), various issues; MITI, *Yushutsu Hokokusho Tsukadate Doko* (Export Currency Invoicing Report), various issues; MITI, *Yushutsu Kessai Tsukadate Doko Chosa* (Export Settlement Currency Invoicing), various issues.

further examination of the exporter's pricing behavior will be necessary to evaluate whether the role of the Yen has increased in Japanese trade with East Asia.<sup>3</sup>

The main purpose of the present paper is to develop an analysis of the previous studies and to make a rigorous empirical examination of currency invoicing

3. This study does not necessarily investigate the sharp increase in Yen-invoiced exports from 1970 to the mid-1980s owing to a lack of the disaggregated trade data during that period. The availability of the disaggregated data allows us to examine the exporter's pricing behavior from 1988 to the present, although it might reflect just the recent cyclical movements in Yen-invoiced exports.

practices in Japanese machinery exports to East Asia and the USA using the commodity- and country-breakdown data on Japanese exports at the nine-digit Harmonized-System- (HS) based level. Moreover, the present paper attempts to distinguish between the short- and long-run PTM behavior of Japanese exporters by using the cointegration technique and the error-correction model. This distinction is particularly important in considering currency invoicing practices by exporters because it is not the long-run but the short-run pass-through rate that captures the effect of currency invoicing on the short-run rigidities of export prices. In contrast, the long-run pass-through rate is determined by the curvature of demand function in the destination markets, as shown by Gagnon and Knetter (1995). We make a comparison of short-run pass-through rates between US and East Asian markets, and draw some implications for the role of the Yen as the invoice currency in East Asia.<sup>4</sup>

The remainder of this paper is organized as follows. Section II briefly reviews the framework of analyzing the choice of invoice currency and presents the basic model for empirical analysis. Section III explains the methodology for empirical analysis and Section IV discusses the data issue. Section V reports the result of unit root tests, cointegration tests and the error-correction regression. Implications for the trade aspects of Yen internationalization in East Asia are also discussed. The final section concludes the paper.

## II. The Framework

### II.1 Basic model

Let us first briefly review the framework developed by the existing literature that shows that the choice of the invoice currency is based on similar conditions to those that govern PTM. We consider a monopolistically competitive firm that produces in the domestic country and sells in both domestic and foreign markets. We assume that imperfect arbitrage between markets allows prices to differ in each market, enabling the firm to set an independent price in each market. The central assumption here is that the risk-neutral firm sets prices and chooses invoice currency before the exchange rate is known. The firm has two choices in currency invoicing: invoicing an export price in the domestic

4. It could be said that if the forward/futures market is perfect, the choice of the invoice currency would have little to do with the firm's exchange rate risk problem and, hence, PTM. However, Japanese firms do not necessarily fully avoid exchange rate risk by hedging through forward/futures markets. Ministry of International Trade and Industry (1996), for example, reports the result of the questionnaire survey (based on multiple answers) on hedging behavior of Japanese firms against exchange rate risks, indicating that 'the shift toward Yen-invoiced transactions' (26.8%) and 'the pass-through of export prices to importers' (16.3%) account for a large share next to 'the hedging through forward markets' (30.2%). It seems reasonable to suppose that the currency invoicing strategy does matter to exporting firms for avoiding exchange rate risks.

currency or invoicing in the foreign currency.<sup>5</sup> The profit function in each case is as follows:

*Case (i): Invoicing in the domestic currency*

$$\pi_t = p_t h(p_t, y_t) + p_t^f f(p_t^f/S_t, y_t^*) - C\{[h(\cdot) + f(\cdot)], w_t, p_t^m\}, \quad (1)$$

where  $p$  denotes the firm's domestic selling price,  $p^f$  denotes the export price in terms of the domestic currency,  $y$  denotes the domestic real income,  $y^*$  denotes the foreign real income,  $w$  denotes the wage price in the domestic currency,  $p^m$  denotes raw material prices in the domestic currency and the subscript  $t$  denotes the time period. The demand function is assumed to be  $h = h(p_t, y_t)$  in the domestic market and  $f = f(p_t^f/S_t, y_t^*)$  in the foreign market.  $C\{\cdot\}$  is the cost function and  $S_t$  is the exchange rate at period  $t$  expressed as the domestic currency price of the foreign currency.

*Case (ii): Invoicing in the foreign currency*

$$\pi_t = p_t h(p_t, y_t) + S_t p_t^* f(p_t^*, y_t^*) - C\{[h(\cdot) + f(\cdot)], w_t, p_t^m\}, \quad (2)$$

where  $p^*$  denotes the firm's export price in terms of the foreign currency, and  $f = f(p_t^*, y_t^*)$  is the demand function in the foreign market when invoicing in the foreign currency.

By solving the firm's maximization problem of the expected profit in each case under the assumption that all variables except  $S$  are non-stochastic, Giovannini (1988) and Fukuda and Ji (1994) have shown that the choice of the invoice currency depends on the shape of the firm's profit function in each market. If the profit function is concave (convex) in the exchange rate, the firm invoices its exports in the foreign (domestic) currency, and the shape of the profit function is, in turn, conditional on the curvature of the demand function. Applying their theoretical results, Fukuda and Ji (1994) have tested the following hypothesized relationship. Invoicing in the foreign currency causes price rigidities in the foreign market, making the export price in terms of the domestic currency positively correlated with the exchange rate in terms of the domestic currency. When invoicing in the domestic currency, changes in exchange rates are passed through to importers, making a correlation more ambiguous between export prices and the exchange rate.

The PTM concerns the relative price of the good destined for different markets: foreign and domestic in this case. Accordingly, the literature on PTM typically examines the response of the export/domestic price ratio to the exchange rate changes. By also taking into consideration that income in domestic and foreign

5. The choice of the third currency is also considered in Johnson and Pick (1997) and Friberg (1998), though we do not explicitly take up the issue.

markets can be expected to affect the export/domestic price ratio, the following equation can be adopted for empirical analysis:<sup>6</sup>

$$\ln(p^f/p)_t = \beta_0 + \beta_1 \ln S_t + \beta_2 \ln y_t^* + \beta_3 \ln y_t, \quad (3)$$

where  $p^f = Sp^*$  denotes the export price in terms of the domestic currency. The existing literature focuses on the sign of  $\beta_1$ , so-called the 'PTM elasticity': when invoicing in the foreign currency, the PTM elasticity will be positive and statistically significant, while when invoicing in the domestic currency, the PTM elasticity is less statistically significant.

## II.2 Error-correction model

While the above theoretical consideration implicitly assumes that the choice of invoice currency is identical to the firm's PTM strategy, there is room for debate of this assumption (Kohsaka, 1996). Specifically, exporters can, in practice, stabilize their export prices in terms of the importer's currency in the following two ways: first, by adjusting profit margins intentionally even when invoicing in their own currency and, second, by invoicing in the importer's currency with the result that export prices are stabilized at least in the short run. Noting these different strategies for stabilizing prices, Gagnon and Knetter (1995) theoretically examine the long-run and short-run PTM behavior of exporters using the error-correction framework to directly capture the effect of the choice of invoice currency on export prices. Assuming a dynamic form of Equation (3) with a lag order of one for both dependent and independent variables and rearranging it, we obtain the following error-correction formulation:

$$\Delta \ln(p^f/p)_t = \gamma_0 + \gamma_1 \Delta \ln S_t + \gamma_2 \Delta \ln y_t^* + \gamma_3 \Delta \ln y_t - \alpha \hat{\epsilon}_{t-1} + u_t, \quad (4)$$

where  $\hat{\epsilon}_t (= \ln(p^f/p)_t - \hat{\beta}_0 - \hat{\beta}_1 \ln S_t - \hat{\beta}_2 \ln y_t^* - \hat{\beta}_3 \ln y_t)$  are the residuals obtained from the OLS estimation. The estimate of  $\alpha$  provides information on the speed of adjustment; and  $u_t$  is the white noise residual.

Equation (4) shows that the level regression might reflect a long-run cointegrating relationship between the export/domestic price ratio, the exchange rate, and foreign and domestic incomes, implying that long-run PTM elasticity ( $\hat{\beta}_1$ ) is determined by the curvature of the demand function in each market. However, the differenced regression captures only the short-run PTM behavior, implying that the short-run PTM elasticity ( $\gamma_1$ ) is significantly positive when exports are invoiced in the importer's currency and not significantly different from zero when invoiced in the exporter's currency. Accordingly, the hypothesis we will examine is as follows:

6. Note that cost factors (wages and raw materials prices) are not included in Equation (3), although they have an influence through marginal costs. However, because we implicitly assume the common marginal costs, changes in marginal costs are unlikely to have significant influences on the export/domestic price ratio (Marston, 1990).

*Hypothesis:* when invoicing in the foreign currency, the short-run PTM elasticity ( $\gamma_1$ ) is positive and statistically significant. When invoicing in the domestic currency, the short-run PTM elasticity is less statistically significant.

In the following section, we first perform the unit root tests to check whether the variables are stationary or not, and then we run the cointegration tests to find any possible cointegrating relationship between the variables. If they are cointegrated, we will run the error-correction regression to distinguish between the short-run and long-run PTM.

### III. Methodology for Empirical Analysis

We employed the time series methodology that allows for possible non-stationarity of the series, long-run equilibrium relationship, and short-run dynamics of export prices in response to exchange rate changes. If we find a cointegrating relationship, we reformulate it into an (vector) error-correction form to allow for short-run dynamics as well as gradual adjustment to a long-term equilibrium.

We use two types of cointegration technique: the Johansen cointegration test and the Hendry's dynamic single equation method for cointegration tests.<sup>7</sup> In implementing the Johansen test, we follow the Hendry's approach of general-to-specific modeling.<sup>8</sup> We initially estimate vector autoregressions (VAR) with twelve lags, and then reduce the longest lag if none is specifically significant for the  $F$ -test of the overall significance in the system of each regressor. After determining the common lag length, we perform the test for reduced rank.

We must note that the results of the Johansen test are very sensitive to misspecification of the lag length and also to the assumption that the errors are independently normal.<sup>9</sup> Taking into account such drawbacks, we also perform the Hendry's dynamic single equation method for cointegration tests that are more powerful and efficient than the Engle and Granger (1987) cointegration tests. Banerjee et al. (1986) show that if the true data generating process involves dynamic terms, the Engle-Granger's estimation of the static model at the first stage of their cointegrating procedure will push more complicated dynamic terms into the residual, which might result in substantial biases in the estimation of long-run relationship in finite samples. Hendry advocated a dynamic regression by adding lagged terms of both dependent and independent variables instead of the static regression of the Engle-Granger's procedure:  $a(L)y_t = b(L)x_t + u_t$ ,

7. For the Johansen test, see Johansen (1998) and Johansen and Juselius (1990). For the Hendry method, see Hendry (1986), Banerjee et al. (1986) and Hendry (1995).

8. See Hendry and Doornik (1994) and Hendry (1995). We use PcFiml version 9 for the Johansen cointegration test.

9. See Maddala and Kim (1998), Chapter 5.

where  $a(L) = 1 - a_1L - a_2L^2 - \dots - a_pL^p$  and  $b(L) = b_0 + b_1L + b_2L^2 + \dots + b_qL^q$ . Evaluating  $a(L)$  at  $L = 1$ , that is,  $a(1) = 1 - \sum_{i=1}^n a_i$ , and given that  $a(1) \neq 0$ , the long-run equation is:  $y = (b(1)/a(1))x = Kx$ .

In the following empirical analysis, we initially run the dynamic regression with twelve lags, and then the non-significant lagged terms are removed sequentially and such sequential reduction is supported by the  $F$ -test. We use *PcGive* version 9 that reports the estimates of the long-run solution and the results of cointegration test.

#### IV. Data Descriptions

One notable feature of this paper is to employ thirteen types of highly disaggregated commodities at the nine-digit HS-based level obtained from the Japan Tariff Association (various issues) that reports the quantities and values of Japanese exports by commodity and country. Each export value is based on the free on board value in terms of the Yen, and the unit values (average export prices) are calculated by dividing each export value by its export quantity. Because they are highly disaggregated, the obtained unit values are regarded as an approximation of the actual export price of each commodity to each country. Then, the ratio of the export price to the domestic selling price (the export/domestic price ratio) is computed by the corresponding domestic wholesale price index (See Appendix I for further details). All the data are monthly and seasonality is adjusted for empirical tests.<sup>10</sup>

We must note that since the Japan Tariff Association statistics drastically changed the commodity classification in January 1988, it is very difficult to use a consistent series of data ranging from the pre-1988 period to the present. In addition, the statistics often revise the classification code even in the post-1988 period, which causes another difficulty in choosing a consistent series of data. We finally chose thirteen commodities from the three major machinery industries (general machinery, electric machinery and transport equipment) and the sample period is from January 1988 to December 1999, although we must be careful in interpreting the estimated results due to the somewhat short sample period for the cointegration analysis.

This paper examines currency invoicing practices in Japanese exports to East Asia as well as the USA, and East Asia is defined as the eight East-Asian economies.<sup>11</sup> The reason why we aggregate eight economies instead of analyzing each economy separately is because of the data problem intrinsic to the unit value series. As Japan does not necessarily export each commodity to each East-Asian economy every month, we encountered data that were not available for

10. We use the Census X-11 (multiplicative) command in the EViews 3.1 for seasonal adjustment.

11. The eight economies are Korea, Taiwan, Hong Kong, Singapore, Malaysia, Indonesia, the Philippines and Thailand. China is not included in East Asia owing to the data availability.



some periods in the unit value series. In addition, the transaction volume is often quite small in exports of some commodities to each East-Asian economy. Noting that different types and qualities of goods might be covered even within the same category of nine-digit classification, the smaller the volume of trade, the larger the fluctuation of the unit value series is and the more severe the measurement error of the unit value series. To avoid these difficulties, we simply assume the aggregated eight economies as one market.<sup>12</sup>

As an exchange rate variable, we use the nominal Yen-USD exchange rate (the exchange rate of the Yen vis-à-vis the USD), even for analysis of pricing behavior in Japanese exports to East Asia. The Yen-USD exchange rate is also used in the previous studies because most East-Asian economies had, in effect, pegged their currencies to the USD at least up to the outbreak of the Asian currency crisis (Frankel and Wei, 1994; Esaka, 2003). As long as the USD pegged exchange rate system is maintained, it seems reasonable to assume that exporters and importers in East Asia are exposed to less exchange rate risk when invoicing in USD. After the currency crisis, the above assumption might not be plausible for some currencies, such as the Thai Baht, Korean Won and Indonesia Rupiah. However, our main interest is whether Japanese exports to the East Asian economies are invoiced in USD or Yen because East-Asian currencies are not typically used in foreign trade.<sup>13</sup> Accordingly, we use the Yen-USD exchange rate for our analysis.

The industrial production index is used as a proxy for real income data because we need a monthly series of data (Appendix I), although the index has a drawback in that it does not cover the service sector.<sup>14</sup> For the East-Asian industrial production index, we construct the weighted average of industrial production for eight East-Asian economies. The weights for each month are based on the corresponding annual averaged share of Japanese exports to each economy.<sup>15</sup> The following two points must be noted for the East-Asian industrial production index. First, for Hong Kong, Indonesia and Thailand, monthly data are

12. Fukuda and Ji (1994) and Fukuda (1996) also assume the aggregated East-Asian economies as one market.

13. According to the interview with an affiliate of one of the major Japanese electronics companies in Singapore (November 20, 2000), the affiliate trades with local companies generally in USD. More interestingly, local companies in South-East Asia typically set prices in USD in their trade with other companies because they manage their operational costs in terms of the USD in order to avoid exchange rate risks. In other words, buyers and sellers have a strong incentive to use one currency, the USD, for their exchange rate risk management, and such an incentive is much stronger after the currency crisis. This might justify our use of the Yen-USD exchange rate for the analysis of pricing behavior in Japanese exports to East Asia.

14. It is desirable to use at least the industry-breakdown data on industrial production index for the empirical analysis. However, as the industry-breakdown data are not readily available, we use the overall industrial production index for the analysis of each commodity concerned.

15. The data on the share of Japanese exports to each East-Asian economy is obtained from International Centre for the Study of East Asian Development (2000).

not published and only quarterly data are available. To make a monthly series of weighted average data, we convert the quarterly series of three economies' industrial production data to the monthly series.<sup>16</sup> Second, China's industrial production data are available only from December 1991. If we include China in East Asia, we have to use a much shorter sample period for empirical analysis. To avoid such a short time span problem, we exclude China from East Asia.

## V. Empirical Results

### *V.1 Testing for unit roots*

The first task for time-series analysis is to examine whether or not the variables are stationary. We use the Phillips-Perron (PP) test and the Kwiatkowski et al. (1992) test (henceforth, the KPSS test) to test the stationarity of the variables. In the PP tests, the null hypothesis is non-stationarity of a variable. However, in the KPSS test, the null is that a variable is stationary and the alternative hypothesis is that a variable has a unit root (Kwiatkowski et al., 1992).

The results of the unit root tests are reported in Table 2.<sup>17</sup> First, the results of the PP test are to reject the null hypothesis of a unit root in level for seven cases in both exports to the USA and to East Asia. Turning to the results of the PP test in the first difference, we strongly reject the null for all cases. Second, the results of the KPSS test in level show that we reject the null hypothesis of the stationarity of a variable for all cases except transistors (the USA) and trucks (East Asia), indicating that these two variables might be stationary in level. The test results in the first difference indicate that the null cannot be rejected in all cases except US industrial production. While there is a conflict in test results between two tests, both unit root tests suggest a level stationarity only in the case of transistors (the USA) and trucks (East Asia). Accordingly, we hereafter assume that all the variables are  $I(1)$  except for transistors (the USA) and trucks (East Asia), and the last two variables are excluded in the following cointegration analysis.<sup>18</sup>

16. Singapore started to publish the monthly data from January 1997. Hence, we use quarterly data for Singapore as well up to December 1996. We used the 'CONVERT (INTERPOL)' command in TSP 4.5 that specifies linear interpolation when converting to a higher frequency.

17. We performed unit root tests in level with trend and constant and in the first difference with constant only for all variables based on the visual inspection on each variable in a graphic analysis. As for the number of lags for the PP and KPSS tests, we choose the lags suggested by Newey and West (1994). We do not report the results of the augmented Dickey-Fuller (ADF) test, since the ADF test is less powerful. Even if taking into account the result of the ADF test, the conclusion in the text will not change.

18. As it is often claimed that there is a poor power problem for these unit-root tests (Maddala and Kim, 1998), we assume that the series is non-stationary in level unless both PP and KPSS tests indicate that it is stationary.

Table 2 Results of Unit Root Tests

Variables	Level		First difference	
	PP test	KPSS test	PP test	KPSS test
Exports to the USA				
Compressors	-2.27	0.39**	-15.18**	0.06
Engines	-3.19	0.31**	-13.47**	0.14
Lathes	-5.41**	0.24**	-20.91**	0.03
Magnetic disk units	-2.67	0.52**	-18.01**	0.14
Facsimiles	-3.98*	0.57**	-15.60**	0.12
Video cassette recorders	-5.92**	0.20*	-20.05**	0.14
Transistors	-5.69**	0.13	-20.11**	0.06
Monolithic integrated circuits	-2.44	0.43**	-14.09**	0.10
Hybrid integrated circuits	-7.45**	0.19*	-23.30**	0.04
Automobile I	-1.52	0.29**	-13.99**	0.21
Automobile II	-2.73	0.16*	-12.83**	0.08
Truck	-3.91*	0.20*	-13.65**	0.05
Motorcycles	-8.40**	0.20*	-22.36**	0.03
Yen-USD exchange rate	-1.89	0.41**	-8.09**	0.08
US industrial production	-1.31	0.65**	-10.52**	0.75**
JP industrial production	-2.69	0.18*	-18.37**	0.11
Exports to East Asia				
Compressors	-5.60**	0.25**	-15.18**	0.06
Engines	-2.68	0.63**	-13.47**	0.14
Lathes	-10.29**	0.18*	-20.91**	0.03
Magnetic disk units	-6.22**	0.21*	-18.01**	0.14
Facsimiles	-4.14**	0.35**	-15.60**	0.12
Video cassette recorders	-4.44**	0.32**	-20.05**	0.14
Transistors	-3.40	0.20*	-20.11**	0.06
Monolithic integrated circuits	-1.85	0.17*	-14.09**	0.10
Hybrid integrated circuits	-2.85	0.21*	-23.30**	0.04
Automobile I	-2.61	0.28**	-13.99**	0.21
Automobile II	-2.94	0.32**	-12.83**	0.08
Truck	-5.91**	0.09	-13.65**	0.05
Motorcycles	-1.08	0.51**	-22.36**	0.03
EA industrial production	-4.55**	0.25**	-8.09**	0.08

Notes: Commodity price data denotes the export/domestic price ratios. All the data are monthly and natural log transformed. Sample period is from January 1988 to December 1999. In the industrial production data, JP represents Japan and EA represents East Asia. Double asterisks (\*\*) and a single asterisk (\*), respectively, indicate that the statistics are significant at the 1 and 5% levels. The critical values are based on MacKinnon (1991) for the Phillips-Perron (PP) test and on Kwiatkowski et al. (1992) for the KPSS test. We use four lags for both PP and KPSS tests, suggested by Newey and West (1994). The unit root tests for level are conducted with trend and constant, and the tests for first difference are conducted with constant only.

**Table 3 Results of Cointegration Tests: The USA**

	<i>Hendry's method (Test statistic)</i>	<i>Johansen cointegration tests</i>				
		<i>Maximum Eigenvalue test</i>			<i>Trace test</i>	
		<i>H<sub>0</sub>: rank = P</i>	<i>Test statistic</i>	<i>5% critical value</i>	<i>Test statistic</i>	<i>5% critical value</i>
Compressors	-6.95**	<i>P</i> = 0	35.53**	27.1	79.92**	47.2
		<i>P</i> ≤ 1	23.81*	21.0	37.39**	29.7
		<i>P</i> ≤ 2	12.92	14.1	13.58	15.4
		<i>P</i> ≤ 3	0.65	3.8	0.65	3.8
Engines	-3.48	<i>P</i> = 0	25.11	27.1	50.50*	47.2
		<i>P</i> ≤ 1	16.02	21.0	25.38	29.7
		<i>P</i> ≤ 2	8.02	14.1	9.36	15.4
		<i>P</i> ≤ 3	1.35	3.8	1.35	3.8
Lathes	-2.51	<i>P</i> = 0	25.52	27.1	47.57*	47.2
		<i>P</i> ≤ 1	13.64	21.0	22.05	29.7
		<i>P</i> ≤ 2	8.06	14.1	8.41	15.4
		<i>P</i> ≤ 3	0.35	3.8	0.35	3.8
Magnetic disk units	-4.06*	<i>P</i> = 0	24.45	27.1	46.12	47.2
		<i>P</i> ≤ 1	14.31	21.0	21.66	29.7
		<i>P</i> ≤ 2	6.58	14.1	7.35	15.4
		<i>P</i> ≤ 3	0.78	3.8	0.78	3.8
Facsimiles	-4.04*	<i>P</i> = 0	21.21	27.1	46.79	47.2
		<i>P</i> ≤ 1	15.27	21.0	25.59	29.7
		<i>P</i> ≤ 2	10.27	14.1	10.31	15.4
		<i>P</i> ≤ 3	0.05	3.8	0.05	3.8
VCRs	-2.10	<i>P</i> = 0	45.01**	27.1	84.07**	47.2
		<i>P</i> ≤ 1	25.93**	21.0	39.06**	29.7
		<i>P</i> ≤ 2	12.88	14.1	13.13	15.4
		<i>P</i> ≤ 3	0.25	3.8	0.25	3.8
Monolithic ICs	-5.15**	<i>P</i> = 0	23.63	27.1	51.44*	47.2
		<i>P</i> ≤ 1	19.52	21.0	27.81	29.7
		<i>P</i> ≤ 2	8.25	14.1	8.29	15.4
		<i>P</i> ≤ 3	0.03	3.8	0.25	3.8
Hybrid ICs	-4.72**	<i>P</i> = 0	34.41**	27.1	53.87*	47.2
		<i>P</i> ≤ 1	11.63	21.0	19.45	29.7
		<i>P</i> ≤ 2	7.31	14.1	7.82	15.4
		<i>P</i> ≤ 3	0.51	3.8	0.51	3.8
Automobile I	-0.96	<i>P</i> = 0	32.48**	27.1	63.17**	47.2
		<i>P</i> ≤ 1	18.16	21.0	30.69*	29.7
		<i>P</i> ≤ 2	9.81	14.1	12.53	15.4
		<i>P</i> ≤ 3	2.72	3.8	2.72	3.8
Automobile II	-1.71	<i>P</i> = 0	26.04	27.1	53.94**	47.2
		<i>P</i> ≤ 1	13.83	21.0	27.90	29.7
		<i>P</i> ≤ 2	9.24	14.1	14.07	15.4
		<i>P</i> ≤ 3	4.83*	3.8	4.83*	3.8
Trucks	-4.77**	<i>P</i> = 0	20.70	27.1	39.59	47.2
		<i>P</i> ≤ 1	10.81	21.0	18.89	29.7
		<i>P</i> ≤ 2	6.59	14.1	8.08	15.4
		<i>P</i> ≤ 3	1.49	3.8	1.49	3.8

Table 3 (Cont'd)

	Hendry's method (Test statistic)	Johansen cointegration tests				
		Maximum Eigenvalue test			Trace test	
		$H_0$ : rank = $P$	Test statistic	5% critical value	Test statistic	5% critical value
Motorcycles	-3.90**	$P = 0$	34.50**	27.1	54.08**	47.2
		$P \leq 1$	12.60	21.0	19.58	29.7
		$P \leq 2$	6.15	14.1	6.98	15.4
		$P \leq 3$	0.82	3.8	0.82	3.8

Notes: Double asterisks (\*\*) and a single asterisk (\*) indicate that the statistics are significant at the 1 and 5% levels, respectively. Critical values for the Hendry's dynamic single equation method for cointegration test are reported by PcGive version 9. Critical values for the Johansen cointegration test are from Osterwald-Lenum (1992). VCRs, video cassette recorders; ICs, integrated circuits.

## V.2 Cointegration tests

The results of cointegration tests in the case of exports to the USA are reported in Table 3. On the basis of the Johansen test statistic, either trace test or maximum eigenvalue test rejects the null hypothesis of zero cointegrating vectors for nine of twelve cases. The null of at most one cointegrating vector is rejected in compressors, video cassette recorders (VCRs) and automobile I. In the case of magnetic disk units, facsimiles and trucks, the test statistic cannot reject the null hypothesis of zero cointegrating vectors. However, taking a careful look at the results of trace statistic, the null is barely accepted at the 5% significance level in the case of magnetic disk units and facsimiles. In addition, on the basis of the Hendry's dynamic regression method of cointegration tests, the null hypothesis that there is no cointegrating relationship is rejected at the 5% level in magnetic disk units and facsimiles. The same is true in the case of trucks. While in some cases there is a conflict between the results of two cointegration methods, we hereafter assume that there is a cointegrating relationship if the null hypothesis of no cointegration is rejected by either test method.

Turning to exports to East Asia (Table 4), the Johansen test statistic rejects the null hypothesis of zero cointegrating vectors in seven cases, where null of at most one cointegrating vector is rejected in two cases: the case of VCRs and monolithic integrated circuits (ICs). Next, on the basis of Hendry's method, the null hypothesis of no cointegration is rejected in eight cases. Neither the Johansen test nor the Hendry's method can reject the null of no cointegration for three cases: compressors, engines and motorcycles. In the other cases, there seems to be a cointegrating relationship. Accordingly, in the case of exports to East Asia, the three commodities (compressors, engines and motorcycles) are excluded and the remaining nine are examined in the next sub-section using an (vector) error-correction model.

**Table 4 Results of Cointegration Tests: East Asia**

	<i>Hendry's method (Test statistic)</i>	<i>Johansen cointegration tests</i>				
		<i>Maximum Eigenvalue test</i>			<i>Trace test</i>	
		<i>H<sub>0</sub>: rank = P</i>	<i>Test statistic</i>	<i>5% critical value</i>	<i>Test statistic</i>	<i>5% critical value</i>
Compressors	-3.14	<i>P</i> = 0	17.24	27.1	35.89	47.2
		<i>P</i> ≤ 1	12.82	21.0	18.64	29.7
		<i>P</i> ≤ 2	3.20	14.1	5.82	15.4
		<i>P</i> ≤ 3	2.63	3.8	2.63	3.8
Engines	-1.09	<i>P</i> = 0	23.11	27.1	41.22	47.2
		<i>P</i> ≤ 1	11.21	21.0	18.11	29.7
		<i>P</i> ≤ 2	6.90	14.1	6.90	15.4
		<i>P</i> ≤ 3	0.00	3.8	0.00	3.8
Lathes	-4.27*	<i>P</i> = 0	28.11*	27.1	48.19*	47.2
		<i>P</i> ≤ 1	17.45	21.0	20.08	29.7
		<i>P</i> ≤ 2	2.19	14.1	2.64	15.4
		<i>P</i> ≤ 3	0.45	3.8	0.45	3.8
Magnetic disk units	-5.29**	<i>P</i> = 0	28.32*	27.1	48.85*	47.2
		<i>P</i> ≤ 1	15.81	21.0	20.52	29.7
		<i>P</i> ≤ 2	4.25	14.1	4.72	15.4
		<i>P</i> ≤ 3	0.46	3.8	0.46	3.8
Facsimiles	-3.80*	<i>P</i> = 0	22.15	27.1	41.74	47.2
		<i>P</i> ≤ 1	16.41	21.0	19.59	29.7
		<i>P</i> ≤ 2	2.84	14.1	3.19	15.4
		<i>P</i> ≤ 3	0.35	3.8	0.35	3.8
VCRs	-8.68**	<i>P</i> = 0	34.31**	27.1	62.28**	47.2
		<i>P</i> ≤ 1	22.29*	21.0	27.97	29.7
		<i>P</i> ≤ 2	5.65	14.1	5.68	15.4
		<i>P</i> ≤ 3	0.04	3.8	0.04	3.8
Transistors	-3.93*	<i>P</i> = 0	25.69	27.1	44.06	47.2
		<i>P</i> ≤ 1	11.50	21.0	18.37	29.7
		<i>P</i> ≤ 2	6.66	14.1	6.87	15.4
		<i>P</i> ≤ 3	0.21	3.8	0.21	3.8
Monolithic ICs	-4.04*	<i>P</i> = 0	36.13**	27.1	66.84**	47.2
		<i>P</i> ≤ 1	25.74**	21.0	30.71*	29.7
		<i>P</i> ≤ 2	4.93	14.1	4.98	15.4
		<i>P</i> ≤ 3	0.05	3.8	0.05	3.8
Hybrid ICs	-4.04*	<i>P</i> = 0	36.86**	27.1	57.33**	47.2
		<i>P</i> ≤ 1	16.43	21.0	20.47	29.7
		<i>P</i> ≤ 2	3.75	14.1	4.04	15.4
		<i>P</i> ≤ 3	0.29	3.8	0.29	3.8
Automobile I	-3.44	<i>P</i> = 0	45.67**	27.1	68.06**	47.2
		<i>P</i> ≤ 1	15.93	21.0	22.39	29.7
		<i>P</i> ≤ 2	6.32	14.1	6.46	15.4
		<i>P</i> ≤ 3	0.14	3.8	0.14	3.8
Automobile II	-4.38*	<i>P</i> = 0	40.22**	27.1	65.03**	47.2
		<i>P</i> ≤ 1	19.59	21.0	24.82	29.7
		<i>P</i> ≤ 2	5.22	14.1	5.22	15.4
		<i>P</i> ≤ 3	0.01	3.8	3.8	3.8

Table 4 (Cont'd)

	<i>Hendry's method (Test statistic)</i>	<i>Johansen cointegration tests</i>				
		<i>Maximum Eigenvalue test</i>			<i>Trace test</i>	
		<i>H<sub>0</sub>: rank = P</i>	<i>Test statistic</i>	<i>5% critical value</i>	<i>Test statistic</i>	<i>5% critical value</i>
Motorcycles	-1.68	<i>P</i> = 0	23.10	27.1	38.10	47.2
		<i>P</i> ≤ 1	8.82	21.0	15.07	29.7
		<i>P</i> ≤ 2	5.69	14.1	6.26	15.4
		<i>P</i> ≤ 3	0.57	3.8	0.57	3.8

Notes: Double asterisks (\*\*) and a single asterisk (\*) indicate that the statistics are significant at the 1 and 5% levels, respectively. Critical values for the Hendry's dynamic single equation method for cointegration test are reported by PcGive version 9. Critical values for the Johansen cointegration test are from Osterwald-Lenum (1992). VCRs, video cassette recorders; ICs, integrated circuits.

V.3 Error-correction analysis

The next step after detecting the long-run cointegrating relationship is to build an (vector) error-correction model. We adopt the following three approaches.

- 1 If we find a cointegrating relationship by the Johansen test, we transform the VAR model into a vector error-correction model. We first conduct the test of restrictions on the cointegration vectors jointly with the test for weak exogeneity of each variable. Our concern here is whether or not the exchange rate variable is weakly exogenous. In the vector error-correction model, only the lagged differenced terms enter into the right-hand side of the equations. However, our major interest is not in the coefficient of the lagged exchange rate ( $\Delta \ln S_{t-i}$ ,  $i = 1, \dots, T$ ) but in that of the current exchange rate ( $\Delta \ln S_t$ ) because the short-run PTM due to the importer's currency invoicing is likely to be captured by the coefficient of the contemporaneous exchange rate. Then we obtain a parsimonious VAR (i.e. a parsimonious vector error-correction model) by removing insignificant regressors and testing whether this reduction in the model is supported by the *F*-test. Then, only if it is weakly exogenous, we condition on the exchange rate so that the current exchange rate ( $\Delta \ln S_t$ ) enters into the right-hand side of the equations.
- 2 If we find a cointegrating relationship not by the Johansen test but by Hendry's dynamic method only, we transform the long-run model into an error-correction model. The error-correction regression is initially run with relevant lag length of first-differenced terms. Then, non-significant lagged terms are removed sequentially and such sequential reduction is supported by the *F*-test.
- 3 If a cointegrating relationship is found by the Johansen test but the exchange rate variable is not weakly exogenous, we can not obtain any information on

the coefficient of the contemporaneous exchange rate. In this case, we use Hendry's method instead by assuming that all variables in the right-hand side of the equation are weakly exogenous and also that there is a single unique cointegration vector, whereas the Likelihood Ratio (LR) test for weak exogeneity in the system suggests that the exchange rate is not weakly exogenous. Hence, we must be careful in interpreting the estimated results in this case. We follow this approach in the following four cases: VCRs, hybrid ICs, automobiles I and II in exports to East Asia.<sup>19</sup>

### *Long-run PTM*

The results for the long-run PTM behavior are reported in Tables 5 and 6. In exports to the USA, the estimates of the long-run PTM elasticity are positive and statistically significant in eight of eleven cases, indicating that mark-up adjustment associated with the exchange rate changes has a stabilizing effect on the export prices in US markets (Table 5). Interestingly, the estimates of long-run PTM elasticity for engines and automobile I are negative and statistically significant, implying that the long-run PTM strategy is not conducted in exports of these commodities whereas it is now widely accepted that Japanese exporters tend to stabilize the export price in US markets.<sup>20</sup>

Turning to the results for exports to East Asia (Table 6), the estimates of long-run PTM elasticity for six commodities are positive and statistically significant. In other words, the long-run PTM behavior is likely to be conducted across three machinery industries even in exports to East Asia. Our finding is particularly interesting because Japanese machinery exporters are typically considered to have strong competitiveness or market power in the East Asian markets and, hence, the exporters are expected to pass through exchange-rate changes to importers in the long run.

Finally, we must note that the coefficients of industrial production indexes indicate unexpected signs in some cases. As for the Japanese industrial production index, we obtain expected negative coefficients in only three cases for exports to East Asia. Otherwise, the coefficients are positive or not statistically significant. For exports to the USA, all coefficients are positive or statistically insignificant. Turning to the foreign industrial production index, we get expected positive coefficients in seven cases for exports to the USA and in five cases for exports to East Asia. Otherwise, the coefficients are negative or statistically insignificant. This observation suggests that the industrial production index is not necessarily a good proxy for income, implying a further consideration of how to handle real income data.

19. Video cassette recorders (USA) are not weakly exogenous either, but we could not obtain any meaningful result using the Hendry's method. Hence, we exclude the result of VCRs from Table 5.

20. It must also be noted that we cannot build any meaningful long-run relationship for trucks, although the result of cointegration test (Hendry's method) in Table 3 suggests that there is a cointegrating relationship for trucks.



Table 5 Long-run and short-run PTM: The USA

Commodity/Test method	Long-run PTM			Error correction model			
	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\gamma_1$	$EC(-1)$	$R^2$	$LM (P \text{ value})$
Compressors (J test)	0.87** (0.05)			0.32** (0.10)	-0.57** (0.11)	0.68	0.12 (0.89)
Engines (J test)	-0.22* (0.10)	0.73** (0.00)		0.37** (0.10)	-0.19** (0.04)	0.39	2.38 (0.10)
Lathes (J test)	0.47** (0.16)	0.82** (0.15)	1.40** (0.50)	0.69** (0.25)	-0.19* (0.08)	0.44	0.56 (0.57)
Magnetic disk units (H test)	1.54** (0.35)	-0.94** (0.33)	0.64 (1.04)	1.20** (0.32)	-0.23** (0.06)	0.43	0.09 (0.91)
Facsimiles (H test)	0.85** (0.18)	0.55** (0.19)	-0.01 (0.60)	0.95* (0.39)	-0.49* (0.11)	0.43	0.73 (0.48)
Monolithic ICs (J test)	0.87** (0.27)	2.81** (0.26)	2.76** (0.85)	0.69** (0.25)	-0.14** (0.05)	0.22	2.14 (0.12)
Hybrid ICs (J test)	0.84** (0.20)	2.21** (0.23)		1.47** (0.52)	-0.43** (0.10)	0.37	1.88 (0.16)
Automobile I (J test)	-1.83** (0.60)			0.19† (0.10)	-0.03* (0.01)	0.56	0.73 (0.49)
Automobile II (J test)	0.48** (0.13)	0.62** (0.14)		0.40** (0.07)	-0.04** (0.02)	0.57	0.59 (0.55)
Trucks (H test)	-0.17 (0.12)			0.36** (0.13)	-0.22** (0.05)	0.29	1.41 (0.25)
Motorcycles (J test)	0.50** (0.09)	0.28** (0.10)		0.90* (0.35)	-0.86** (0.00)	0.53	1.35 (0.26)

Notes: J test, the Johansen test; H test, the Hendry's dynamic single equation method for cointegration test. Double asterisks (\*\*) a single asterisk (\*) and a dagger (†) indicate that the statistics are significant at the 1, 5 and 10% levels, respectively. The numbers in parentheses are standard errors.

Long-run PTM (see Equation (4)): (i) Normalized cointegration vectors are reported for J test and the coefficients of the long-run model are reported for H test; (ii)  $\hat{\beta}_1$  denotes the long-run PTM elasticity (the coefficient of log of the Yen-USD exchange rate).  $\hat{\beta}_2$  and  $\hat{\beta}_3$  denote the coefficients of US industrial production and Japanese industrial production, respectively.

Error-correction model (see Equation (4)): (i)  $\gamma_1$  denotes the short-run PTM elasticity (the coefficient of the first-difference of log-transformed exchange rates) and  $EC(-1)$  denotes error correction term. (ii) For  $R^2$  of J test, the square of the correlation of actual and fitted values in the export/domestic price equation is reported. (iii) LM test denotes the Lagrange-multiplier test for serial correlation of the export/domestic price equation, which is valid for equations and systems with lagged dependent variables. PcFiml reports the  $F$ -statistic and the null hypothesis is no autocorrelation of residuals in the equation concerned.

**Table 6 Long-run and short-run PTM: East Asia**

Commodity/Test method	Long-run PTM			Error correction model			
	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\gamma_1$	$EC(-1)$	$R^2$	LM (P value)
Lathes (J test)	0.37* (0.15)	0.46** (0.10)	-1.56** (0.42)	-0.34 (0.48)	-0.93** (0.09)	0.49	1.61 (0.20)
Magnetic disk units (J test)	1.38** (0.23)	-0.28 (0.18)		1.43* (0.69)	-0.77** (0.14)	0.56	4.07* (0.02)
Facsimiles (H test)	0.03 (0.17)	-1.27** (0.12)	1.26* (0.52)	0.40* (0.16)	-0.26** (0.07)	0.28	1.53 (0.22)
VCR (H test)	1.05** (0.21)	1.63** (0.15)	3.72** (0.61)	2.21** (0.52)	-0.73** (0.08)	0.40	1.63 (0.20)
Transistors (H test)	0.07 (0.20)	-0.61** (0.15)	1.66** (0.55)	1.13** (0.20)	-0.23** (0.07)	0.32	7.46** (0.00)
Monolithic ICs (J test)	0.58** (0.15)	2.00** (0.12)	1.65** (0.47)	0.43* (0.18)	-0.08* (0.04)	0.43	2.11 (0.13)
Hybrid ICs (H test)	0.35 (0.36)	1.23** (0.23)	2.80** (1.05)	0.48† (0.25)	-0.14** (0.04)	0.36	2.65† (0.08)
Automobile I (H test)	1.39** (0.51)		-3.70** (1.38)	-0.63* (0.26)	-0.17** (0.04)	0.33	0.85 (0.43)
Automobile II (H test)	0.47** (0.14)	0.23** (0.09)	-0.80* (0.37)	-0.26† (0.14)	-0.34** (0.06)	0.36	0.82 (0.44)

Notes: J test, the Johansen test; H test, the Hendry's dynamic single equation method for cointegration test. Double asterisks (\*\*) a single asterisk (\*) and a dagger (†) indicate that the statistics are significant at the 1, 5 and 10% levels, respectively. The numbers in parentheses are standard errors.

Long-run PTM (see Equation (4)): (i) Normalized cointegration vectors are reported for J test and the coefficients of the long-run model are reported for H test; (ii)  $\hat{\beta}_1$  denotes the long-run PTM elasticity (the coefficient of log of the Yen-USD exchange rate).  $\hat{\beta}_2$  and  $\hat{\beta}_3$  denote the coefficients of East Asian industrial production and Japanese industrial production, respectively.

Error-correction model (see Equation (4)): (i)  $\gamma_1$  denotes the short-run PTM elasticity (the coefficient of the first-difference of log-transformed exchange rates) and  $EC(-1)$  denotes error correction term. (ii) For  $R^2$  of J test, the square of the correlation of actual and fitted values in the export/domestic price equation is reported. (iii) LM test denotes the Lagrange-multiplier test for serial correlation of the export/domestic price equation, which is valid for equations and systems with lagged dependent variables. PcFiml reports the  $F$ -statistic and the null hypothesis is no autocorrelation of residuals in the equation concerned.

*Short-run PTM*

Let us now consider the results of error-correction regression. In Tables 5 and 6, we report short-run PTM elasticity and the coefficient of the error-correction term only as other coefficients are secondary matters for our analysis. When we obtain a conditional vector error-correction model, the result of the export/domestic price equation (i.e. the equation where the dependent variable is the first difference of the export/domestic price ratios) is reported. The short-run PTM elasticity indicates the short-run response of export/domestic price ratios to changes in the exchange rate, reflecting the choice of invoice currency. The error-correction term,  $EC(-1)$  measures the response of the export prices to a deviation from its long-run equilibrium value in the previous period.

Looking at the results of the short-run PTM elasticity in exports to the USA (Table 5), all the estimated results except for automobile I are positive and statistically significant at least at the 5% level, implying that USD invoicing elicits a certain degree of the short-run stabilization of USD denominated export prices in US markets. This result is consistent with the actual currency invoicing pattern: Japanese machinery exports to the USA are largely invoiced in USD.<sup>21</sup> Another thing we must note is that even in the case of engines and automobile I where the long-run PTM elasticity is negative, the estimates of the short-run PTM elasticity are positive and statistically significant, although the significance level for automobile I is only at the 10% level. All the error-correction terms are negative and the results of goodness-of-fit are reasonable in most cases. The Lagrange-multiplier (LM) test accepts the null of no autocorrelation of residuals in all cases.

Further, turning to the case of exports to East Asia (Table 6), the estimates of the short-run PTM elasticity are positive and statistically significant at least at the 5% level for five cases: magnetic disk units, facsimiles, VCRs, transistors and monolithic ICs.<sup>22</sup> This result implies that the exporters of these commodities (mainly electric machinery products) tend to invoice their exports in USD.<sup>23</sup> In the case of lathes and automobiles I and II that are categorized into

21. Some of the estimated coefficients are equal to or below 0.40 in the case of general machinery and transport equipment industries, though more than 80% of Japanese machinery exports to the USA are invoiced in USD (Sato, 1999; Table 7). This is likely due to the data problem intrinsic to the unit value series. See footnote 23 for the further discussion of this point.

22. We must be careful in interpreting the estimated result for VCRs because, as mentioned earlier, the LR test for weak exogeneity in the system suggests that the exchange rate is not weakly exogenous in this case.

23. The estimates of the short-run PTM elasticity are larger than unity for magnetic disk units, VCRs and transistors. This is true for magnetic disk units and hybrid ICs in exports to the USA as well. The possible reason is the data problem intrinsic to the unit values. As unit values do not account for changes in quality of the commodity concerned unlike the export price index data, the unit value series exhibit substantial variations, even though obvious data input errors were dropped in calculating the unit values for exports to East Asia. Owing to the rapid technological progress in the semiconductor and IC industry and the computer-related industry, the estimated results for these industries might indicate unexpectedly large coefficients.

the general machinery and the transport equipment industry, respectively, the estimates of the short-run PTM elasticity are significantly negative or not significantly different from zero, while the estimates of the long-run PTM elasticity is significantly positive.<sup>24</sup> This result implies that while the exporters of these commodities tend to adjust their mark-up to stabilize the export price in terms of the USD in the long run, they are likely to invoice their exports in Yen. Again, all the error-correction terms are significantly negative and the results of the goodness-of-fit are reasonable in most cases. The LM test accepts the null of no autocorrelation of residuals in all cases except magnetic disk units and transistors.<sup>25</sup>

#### *V.4 Implications for Yen internationalization in East Asia*

We have found a marked difference in the short-run PTM behavior between the electric machinery products and other products. On one hand, the short-run PTM elasticity is positive and statistically significant in the electric machinery exports to East Asia. On the other hand, the PTM elasticity is negative or less statistically significant in general machinery and transport equipment exports to East Asia. These results contrast markedly with the conclusion of the previous literature that states that Japanese machinery exporters tend to pass through exchange-rate changes to East Asian importers with the result that the Yen-invoiced ratio is high in exports to East Asia. Rather, our estimated results are consistent with the currency invoicing patterns of Japanese machinery exports to South-East Asia reported in Table 7 that indicate that the USD-invoiced ratio is higher than the Yen-invoiced ratio in electric machinery exports to South-East Asia.

The strong tendency of USD invoicing for electric machinery exports seems to be explained by the characteristics of these products. Semiconductors and ICs are less-differentiated products than other machinery products such as general machinery and transport equipment products and, hence, exporters of the former might not have a strong market power even in East-Asian markets. In addition, computer-related products such as magnetic disk units that are assembled from electric components (including semiconductors and ICs), tend to be invoiced in USD possibly because USD invoicing is advantageous as long as the electric components are traded generally in USD. It is interesting to note that other electronic products, such as facsimiles and VCRs, are also likely invoiced in USD, implying that the USD might be largely used in the visual apparatus and telecommunication equipment industry as well, although testing

24. Again, we must be careful in interpreting the results for automobiles I and II because we assumed that the exchange rate is weakly exogenous though the LR test for weak exogeneity in the system suggests that the exchange rate is not weakly exogenous.

25. We must note that the result of the LM test indicates the serial correlation of residuals for magnetic disk units and transistors, and a further consideration of the possible misspecification will be necessary.

Table 7 Invoice Currency Ratios in Japanese Exports to South-East Asia

<i>Commodity</i>	<i>M1994</i>	<i>S1994</i>	<i>M1995</i>	<i>S1995</i>	<i>M1996</i>	<i>S1996</i>	<i>M1997</i>	<i>S1997</i>	<i>M1998</i>
<b>Yen-invoiced ratio (%)</b>									
All commodities	52.0	49.0	47.2	44.3	44.1	46.3	45.5	47.0	48.4
General machinery	69.0	65.8	66.8	63.7	59.9	57.9	59.7	61.9	59.7
Electric machinery	41.8	39.7	37.0	35.9	39.7	41.3	37.9	42.0	42.7
Integrated circuits	25.9	28.6	24.2	24.7	24.4	32.6	24.4	22.3	26.7
Telecom equipment	NA	NA	NA	NA	35.8	34.9	28.3	36.0	34.0
Transport equipment	78.4	74.4	71.5	69.3	58.5	68.5	72.3	75.6	81.3
Passenger motor cars	75.0	73.6	66.1	66.4	72.6	72.3	74.1	81.8	87.7
Parts of motor vehicles	NA	NA	NA	NA	60.5	62.3	61.3	72.7	81.1
<b>US Dollars-invoiced ratio (%)</b>									
All commodities	45.1	47.9	49.9	53.4	53.5	51.3	51.7	50.2	48.7
General machinery	29.3	32.6	31.6	34.9	38.7	40.6	38.5	36.4	37.7
Electrical machinery	53.2	54.6	57.6	60.2	56.5	54.5	57.2	53.9	53.4
Integrated circuits	67.8	65.5	71.4	73.2	72.5	63.6	71.7	74.6	70.8
Telecom equipment	NA	NA	NA	NA	55.1	53.8	62.3	52.0	48.6
Transport equipment	18.9	23.3	26.2	28.8	39.7	29.7	25.1	21.4	15.4
Passenger motor cars	14.4	18.8	22.8	26.8	20.8	22.0	16.5	8.2	2.6
Parts of motor vehicles	NA	NA	NA	NA	39.3	37.4	38.4	26.6	17.8

Note: M, March; S, September; NA, not available.

Source: Ministry of International Trade and Industry, *Yushutsu Kessai Tsukadate Doko Chosa (Export Settlement Currency Invoicing)*, various issues.

with more sample commodities will be necessary for the further support of our conclusion.<sup>26</sup>

Currency invoicing practices of electric machinery exporters are particularly important in considering the internationalization of the Yen because recent increase in Japanese trade with East Asia is largely due to the active investment and trade of the electric machinery industry. Given that USD invoicing continues to be preferred in the electric machinery industry, the further use of Yen in trade transactions is unlikely to be realized in East Asia.

## VI. Concluding Remarks

This paper examines the long-run and short-run PTM behavior in Japanese exports to East Asia and the USA based on the theoretical framework of the firm's choice of invoice currency. By using the highly disaggregated data on Japanese exports by destination, we have found that pricing or currency invoicing behavior varies across machinery products in Japanese exports to East Asia. First, it is interesting that the long-run PTM elasticity is positive and statistically significant in six of nine cases in exports to East Asia, contrary to the general view that Japanese exporters have a strong market power in East-Asian markets and, hence, pass through exchange-rate risks to importers. Second, the estimates of the short-run PTM elasticity are significantly positive in electric machinery exports to East Asia, indicating that Japanese exporters tend to stabilize the export price of electric machinery products in the East-Asian markets, at least in the short run. This implies that these products are largely invoiced in USD, even in exports to East Asia, which also contrasts markedly with the previous literature that emphasizes the rising tendency of Yen-invoiced exports to East Asia up to the early 1990s as a possible sign of Yen internationalization.

Our finding has particularly important implications for the role of the Yen in trade invoice currency in East Asia because there is fairly general agreement that Japanese machinery exporters typically conduct Yen-invoiced exports to East-Asian economies, and a further increase in the role of the Yen is expected as trade and investment expands between Japan and East Asia. Noting that the electric machinery industry plays a major role in facilitating trade-investment linkage between Japan and East Asia, it appears difficult to expect the further use of the Yen in East Asia in the near future to the extent that electric machinery products tend to be invoiced in USD in Japanese exports to East Asia.

26. It is also interesting to investigate the parameter constancy of the error-correction estimation, especially for exports to East Asia. We ran the break-point *F*-test over the sample period for four products (magnetic disk units, facsimiles, transistors and monolithic ICs) in exports to East Asia, and the result is that the null hypothesis of constant parameters could not be rejected in all cases. Therefore, we can say that these products tend to be invoiced in USD in Japanese exports to East Asia over the sample period.

## Appendix I: Data for Empirical Tests

In the empirical analysis, the following thirteen commodities are examined. The export price data are obtained from Japan Tariff Association (various issues), *Japan Exports & Imports (Commodity by Country)* and the domestic price indexes are taken from the wholesale price index data of Bank of Japan (various issues), *Price Index Annual* and *Price Index Monthly*.

<i>Commodity</i>	<i>Export price data description</i>
Compressors	HS Code: 8414.30–100 (January 1988 – December 1999). Compressors of a kind used for air conditioning machines of motor vehicles
Engines	HS Code: 8407.34–900 (January 1988 – December 1999). 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
Lathes	HS Code: 8458.11–000 (January 1988 – December 1999). Horizontal lathes, for removing metal, numerically controlled.
Magnetic disk units	HS Code: 8471.70–300 (January 1988 – December 1999). Magnetic disk units
Facsimiles	HS Code: 8517.82–100 (January 1988 – December 1999), 8517.21–000 (January 1996 – December 1999). Facsimile machines
Video cassette recorders	HS Code: 8521.10–000 (January 1988 – December 1999). Video recording or reproducing apparatus, whether or not incorporating a video tuner, of magnetic tape type
Transistors	HS Code: 8541.21–910 (January 1988 – December 1999). Cased Silicon Transistors with a dissipation rate of less than 1 W, other than photosensitive transistors
Monolithic integrated circuits	HS Code: 8542.19–900 (January 1988 – December 1999), 8542.30–900 (January 1996 – December 1999). Cased other monolithic integrated circuits
Hybrid integrated circuits	HS Code: 8542.20–000 (January 1988 – December 1999), 8542.40–000 (January 1996 – December 1999). Hybrid integrated circuits
Automobile I	HS Code: 8703.23–910 (January 1988 – December 1999). 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 1500 cc but not exceeding 2000 cc, excluding those unassembled or disassembled
Automobile II	HS Code: 8703.23–920 (January 1988 – December 1999). 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 2000 cc but not exceeding 3000 cc, excluding those unassembled or disassembled

<i>Commodity</i>	<i>Export price data description</i>
Trucks	HS Code: 8704.22–920 (January 1988 – December 1999). Motor vehicles for the transport of goods with compression-ignition internal combustion piston engine, g.v.w. exceeding 5 tonnes but not exceeding 20 tonnes, of a cylinder capacity exceeding 4500 cc, excluding those unassembled or disassembled
Motorcycles	HS Code: 8711.20–900 (January 1988 – December 1999). Motorcycles and cycles fitted with an auxiliary motor, with engines of a cylinder capacity exceeding 50 cc but not exceeding 250 cc, excluding those unassembled or disassembled

<i>Commodity</i>	<i>Domestic price index data description</i>
Compressors	Air & gas compressors (January 1988 – December 1999) Compressors (January 1990 – December 1999)
Engines	Internal combustion engines for general use (January 1988 – December 1989). Industrial internal combustion engines – gasoline (January 1990 – December 1999)
Lathes	NC lathes (January 1988 – December 1994). Lathes (January 1985 – December 1999)
Magnetic disk units	Electronic machinery (January 1988 – December 1989) Electronic computer-related accessories (January 1990 – December 1999)
Facsimiles	Facsimiles (January 1988 – December 1999)
Video cassette recorders	Video tape recorders (January 1988 – December 1999)
Transistors	Transistors (January 1988 – December 1999)
Monolithic integrated circuits	Integrated circuits (January 1988 – December 1999)
Hybrid integrated circuits	Integrated circuits (January 1988 – December 1999)
Automobile I	Small passenger cars (up to 2000 cc; January 1988 – December 1999)
Automobile II	Passenger cars (over 2000 cc; January 1988 – December 1999)
Trucks	Trucks (over 2000 cc; January 1988 – December 1999)
Motorcycles	Motorcycles (January 1988 – December 1999)

The Yen-US dollar exchange rate is the monthly average (nominal) exchange rate of the Yen vis-à-vis the USD taken from the International Monetary Fund (various issues), *International Financial Statistics, Monthly*, CD-ROM edition. The industrial production price index for the USA, Japan, Korea, Hong Kong, Singapore, Malaysia, Philippines are obtained from International Monetary Fund (various issues). The Taiwan data is from the website of National Statistics of Taiwan, the Republic of China (<http://www.stat.gov.tw/main.htm>). The Indonesia data is from BPS, *Statistics Indonesia*, various years. The Thailand data is taken from the Bank of Thailand website (<http://www.bot.or.th>). All the data are indexed on the 1995 base year (1995 = 100).



## References

- Banerjee, A., J. J. Dolado, D. F. Hendry and G. W. Smith, 1986, Exploring equilibrium relationship in econometrics through static models: Some Monte Carlo evidence. *Oxford Bulletin of Economics and Statistics*, **48**, pp. 253–77.
- Bank of Japan, various issues. *Price Index Annual and Price Index Monthly*. Bank of Japan, Tokyo.
- Donnenfeld, S. and I. Zilcha, 1991, Pricing of exports and exchange rate uncertainty. *International Economic Review*, **32**, pp. 1009–22.
- Donnenfeld, S. and A. Haug, 2001, Currency invoicing in international trade: An empirical investigation. *Review of International Economics*, in press.
- Engle, R. F. and C. W. J. Granger, 1987, Co-integration and error correction: Representation, estimation and testing. *Econometrica*, **55**, pp. 251–76.
- Esaka, T., 2003, Was it really a dollar peg?: The exchange rate policies of East Asian countries, 1980–1997. *Journal of Asian Economics*, **13**, pp. 787–809.
- Frankel, J. A. and S.-J. Wei, 1994, Yen bloc or dollar bloc? Exchange rate policies of the East Asian economies, In: *Macroeconomic Linkage*. (eds Ito T. and A. O. Krueger) pp. 295–329. University of Chicago Press, Chicago.
- Friberg, R., 1998, In which currency should exporters set their prices? *Journal of International Economics*, **45**, pp. 59–76.
- Fukuda, S.-i. and C. Ji, 1994, On the choice of invoice currency by Japanese exporters: The PTM approach. *Journal of the Japanese and International Economies*, **8**, pp. 511–29.
- Fukuda, S.-i., 1996, The structural determinants of invoice currencies in Japan: The case of foreign trade with East Asian countries. In: *Financial Deregulation and Integration in East Asia*. (eds T. Ito and A. O. Krueger) pp. 147–63. University of Chicago Press, Chicago.
- Gagnon, J. E. and M. M. Knetter, 1995, Markup adjustment and exchange rate fluctuations: Evidence from panel data on automobile exports. *Journal of International Money and Finance*, **14**, pp. 289–310.
- Giovannini, A., 1988, Exchange rates and traded goods prices. *Journal of International Economics*, **24**, pp. 45–68.
- Goldberg, P. K. and M. M. Knetter, 1997, Goods prices and exchange rates: What have we learned? *Journal of Economic Literature*, **XXXV**, pp. 1243–72.
- Hamada, K. and A. Horiuchi, 1987, Monetary, financial and real effects of Yen internationalization, In: *Real-Financial Linkage among the Open Economies*. (eds S. W. Arndt and J. D. Richardson) pp. 167–191. MIT Press, Cambridge.
- Hendry, D. F., 1986, Using PC-GIVE in econometrics teaching. *Oxford Bulletin of Economics and Statistics*, **48**, pp. 87–98.
- Hendry, D. F., 1995, *Dynamic Econometrics*. Oxford University Press, Oxford.
- Hendry, D. F. and J. A. Doornik, 1994, Modelling linear dynamic economic systems. *Scottish Journal of Political Economy*, **41**, pp. 1–33.
- International Centre for the Study of East Asian Development (ICSEAD), 2000, *East Asian Economic Perspectives: Recent Trends and Prospects for Major Asian Economies*, Vol. 11. ICSEAD, Kitakyushu.
- International Monetary Fund, various issues, *International Financial Statistics Monthly*, CD-ROM edition. International Monetary Fund, Washington D.C.
- Ito, T., 1993, The Yen and the international monetary system. In: *Pacific Dynamism and the International Economic System*. (eds C. F. Bergsten and M. Noland) pp. 299–322. Institute of International Economics, Washington D.C.
- Iwami, T., 1995, *Japan in the International Financial System*. Macmillan, London.
- Japan Tariff Association, various issues, *Japan exports and imports (commodity by country)*. Japan Tariff Association, Tokyo.
- Johansen, S., 1988, Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, **12**, pp. 231–54.

- Johansen, S. and K. Juselius, 1990, Maximum likelihood estimation and inference on cointegration – With application to the demand for money. *Oxford Bulletin of Economics and Statistics*, **52**, pp. 169–210.
- Johnson, M. and D. Pick, 1997, Currency quandary: The choice of invoicing currency under exchange-rate uncertainty. *Review of International Economics*, **5**, pp. 118–28.
- Kawai, M., 1996, The Japanese Yen as an international currency: Performance and prospects. In: *Organization, Performance, and Equity: Perspectives on the Japanese Economy*. (eds R. Sato, R. Ramachandran and H. Hori) pp. 305–55. Kluwer Academic Publishers, Massachusetts.
- Kohsaka, A., 1996, Comment. In: *Financial Deregulation and Integration in East Asia*, (eds T. Ito and A. O. Krueger) pp. 164–5. University of Chicago Press, Chicago.
- Kwiatkowski, D., P. C. B. Phillips, P. Schmidt and Y. Shin, 1992, Testing the null hypothesis of stationarity against the alternative of a unit root. *Journal of Econometrics*, **54**, pp. 159–78.
- MacKinnon, J. G., 1991, Critical values for cointegration tests. In: *Long-run Economic Relationships: Readings in Cointegration*. (eds R. F. Engle and C. W. J. Granger) pp. 267–76. Oxford University Press, Oxford.
- Maddala, G. S. and I.-M. Kim, 1998, *Unit Roots, Cointegration, and Structural Change*. Cambridge University Press, Cambridge.
- Marston, R. C., 1990, Pricing to market in Japanese manufacturing. *Journal of International Economics*, **29**, pp. 217–36.
- Ministry of International Trade and Industry, 1996, [*White Paper on International Trade and Industry*]. Ministry of Finance Printers, Tokyo (in Japanese).
- Newey, W. and K. West, 1994, Automatic lag selection in covariance matrix estimation. *Review of Economic Studies*, **61**, pp. 631–53.
- Osterwald-Lenum, M., 1992, A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics. *Oxford Bulletin of Economics and Statistics*, **54**, pp. 461–71.
- Sato, K., 1999, The international use of the Japanese Yen: The case of Japan's trade with East Asia. *The World Economy*, **22**, pp. 547–84.
- Tavlas, G. S. and Y. Ozeki, 1992, The Internationalization of Currencies: An Appraisal of the Japanese Yen. Occasional paper 90. International Monetary Fund, Washington D.C.

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