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Abstract

In this paper, we empirically examine the movement of the exchange rate pass-through to the aggregate import prices in Japan from 1980s through 2001. We demonstrate that the exchange rate pass-through to Japan's import prices lowered in the 1990s, and such a decline occurred mainly during the period from the late 1980s to mid 1990s. In addition, we also show that the decline came mainly from the declines in the exchange rate pass-through in each product, rather than the shift of import share from raw materials to manufactured goods with lower exchange rate pass-through. Moreover, the period of the decline in exchange rate pass-through coincides with the period of the sharp appreciation of yen and resultant structural changes in the economy and international trade. Although advance in globalization of Japanese firms is likely to reduce the exchange rate pass-through to import prices, it should be noted that the decline in exchange rate pass-through does not necessarily imply that exchange rate fluctuations have become less important in connection with macroeconomic fluctuations.

Key words: Exchange rate pass-through, Pricing-to-market, Import structure, Expenditure-switching effect, Firms' sourcing decision.

JEL classification codes: F21, F30, F40.

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Table of Contents

I Introduction

In this paper, we empirically examine the development of the exchange rate pass-through to the aggregate import prices in Japan over time to show when and by how much it has declined since the 1980s. We also throw some lights on the factors behind such a decline in exchange rate pass-through to import prices.

Recently theoretical as well as empirical research on the exchange rate pass-through to aggregate import prices has attracted a renewed attention. In this line of research, the focus has shifted to the exchange rate pass-through to "import" prices measured by "aggregate" price indicators, from the export price setting by individual exporters in the previous studies. In addition, it is emphasized to seek a policy implication to price development in the economy as a whole.

Behind the renewed interests in exchange rate pass-through on import prices lie the following recent development of theoretical studies on the worldwide low inflation and on the relationship between exchange rate fluctuation and its power on adjustment of the macro-economy.

First is Taylor's (2000) conjecture on the recent worldwide decline in exchange rate pass-through. His conjecture is that firms become increasingly difficult to fully pass exchange rate movements on their export prices in the context of recent economic environment, characterized by intensified worldwide competitive pressure and low and stable inflation. In response, the policy implications of a diminished exchange rate pass-through to domestic prices have been widely discussed.

Taylor's conjecture provides an important implication for future price developments. As long as low and stable inflation is maintained, exchange rate pass-through remains low, and inflation, in turn, continues to stay at a very low and stable level. This implies a virtuous circle exists between price development and corporate pricing behavior. If this is the case, a commitment to low and stable price development by a central bank is reinforced by its historical record. To explore the implication of exchange rate pass-through on future inflation from a macroeconomic perspective, recent research has focused not on corporate export price setting, which was vigorously analyzed until the early 1990s, but on countries' import prices to estimate exchange rate pass-through to countries' import prices.

Second is the recent theoretical development in "new open-economy

macroeconomics," starting from Obstfeld and Rogoff (1995).[1] Since this line of researches has micro-foundations, exporters can decide to set their export prices in their currency (producers' currency pricing, PCP) or in consumers' currency (local currency pricing, LCP) in the models. In the PCP model, on the one hand, the exchange rate pass-through on import prices is always perfect, and thus, exchange rate fluctuations works for adjusting the current account imbalance and business cycle.[2] On the other hand, in the case of LCP, the exchange rate pass-through is limited, thus producing only a little expenditure switching effect between domestic and foreign goods.[3] Therefore, these studies show the difference in firms' price setting behavior significantly influence the transmission of monetary policy through changing the degree of exchange rate pass-through.

In this regard, recent studies on the exchange rate pass-through to import prices try to reformulate the argument of "exchange rate pessimism" (Obstfeld [2002]) in the late 1980s to early 1990s. In fact, despite the drastic depreciation of the U.S. dollar following the Plaza Agreement in 1985, U.S. import prices denominated in the U.S. dollar did not rise so much and the subsequent adjustment of current account imbalances in the industrial countries did not progress. This experience reveals that the adjustment mechanisms of exchange rate fluctuations on current account imbalance do not work smoothly, contrary to views prevalent at that time.[4]

In this paper, we estimate exchange rate pass-through to Japan's import prices and examine the movement over time to show when and by how much it has declined since the 1980s. We also investigate the factors behind changes in exchange rate pass-

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1 See Lane (2001) for a survey of recent developments in "new open-economy macroeconomics".

2 Many of these models assume that exporting firms directly sell their products to consumers in the importing country, and import prices are equal to consumer prices. This is equivalent to assume that home inputs are not used for the sales activity of imported goods. In reality, however, domestic inputs are necessary for sales activity of imported goods. Thus, both import prices of goods and domestic input prices of sales activity influence the retail prices consumers face. As a result, the exchange rate pass-through on import prices is generally higher than that on CPI based prices.

3 Research includes Betts and Devereux (2000) and Otani (2002).

4 Krugman (1987) proposed exporters' price-setting behavior as embodied in PTM (pricing-to-market) to provide a theoretical foundation to explain the limited power of exchange rate changes to adjust current account imbalance. A key implication of the PTM behavior of exporters was that they did not change their export prices in local currency terms commensurate with changes in production costs and exchange rates. This was deemed highly consistent with the weak response of their local currency-denominated export prices to exchange rate fluctuations.

through over time. It should be noted that exchange rate pass-through to import prices is larger than that to consumer prices, since CPI contains service prices. Nevertheless, it is important to examine exchange rate pass-through to import prices, considering the increasing globalization of the Japanese economy.

Our major findings in this paper include: First, the decline in exchange rate pass-through occurred mainly during the period from the late 1980s to early 1990s. Second, such decline came mainly from the decline in the exchange rate pass-through in each product, rather than the shift of import share from raw materials to manufactured goods with lower exchange rate pass-through. The latter finding contrasts to that of Campa and Goldberg (2002) that emphasized the effects of changes in trade share.

In drawing the above conclusions, we pay due considerations on the robustness of data series as well as econometric procedures. First, we use the import price series in the corporate goods price index (CGPI) to estimate the exchange rate pass-through on Japanese import prices of eight disaggregated product categories.[5] The CGPI is compiled with careful treatment to control the changes in product quality over time. This enables us to exclude the 'spurious' changes in exchange rate pass-through, possibly caused by the shift in average product quality in response to exchange rate fluctuations. Second, we apply a specification that is simple but flexible enough to capture the exact long-term impacts of exchange rate fluctuations on import prices. In addition, this specification enables us to employ rolling regression analysis to explore in detail when and by how much the long-term exchange rate pass-through has declined since the 1980s.

This paper is structured as follows. Section II briefly reviews the theoretical and empirical research on exchange rate pass-through to export prices from microeconomic and macroeconomic viewpoints. Section III introduces empirical studies using aggregate import prices, and then presents estimation results of exchange rate pass-through to Japanese import prices making comparisons with previous studies. Section IV investigates the factors behind changes in exchange rate pass-through to Japanese import prices. Finally, Section V summarizes the findings of this paper and examines

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[5] The corporate goods price index is renamed from the wholesale price index (WPI) at the time of base-year revision from 1995 to 2000 in December 2002. This is mainly because the percentage of prices surveyed at the production stage has been increased from that under the previous index due to the changes in the selection criteria for price survey stage.

the implication of recent changes in exchange rate pass-through for monetary policy. In addition, Appendix 1 explains a profit maximization model for determining exchange rate pass-through and the sunk-cost model, both of which are mentioned in Section III. Appendix 2 examines the relationship between the decline in exchange rate pass-through and choice of invoice currency.

II Exchange Rate Pass-Through from Macroeconomic Perspectives

Considerable theoretical models on exchange rate pass-through on firms' export prices were proposed in the late 1980s. They focused on microeconomic aspect such as the shape of the demand curve and cost function, or the existence of irreversible investment (sunk-cost). Following these development of theoretical studies, since the end of 1980s through 1990s, a large number of empirical researches estimate the exchange rate pass-through using micro data of firms' export prices.[6,7]

Recently Taylor (2000) has inspired active interest in dynamic changes in exchange rate pass-through from a macroeconomic perspective. He conjectures that exchange rate pass-through has persistently declined in response to changes in the macroeconomic environment such as intensified competitive pressure and worldwide low inflation. Based on his conjecture, in order to derive the implication of changes in exchange rate pass-through on macro-economy, some empirical works attempt to estimate the dynamic movement of exchange rate pass-through on countries' import prices.

In this section, we first introduce the study by Taylor (2000) to examine exchange rate pass-through from macroeconomic perspectives. Then, we overview Campa and Goldberg (2002), one of the leading works on the subject, which estimate exchange rate pass-through to import prices using aggregated data.

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[6] See Appendix 1. for the details of the theoretical and empirical researches for the exchange rate pass-through on firms' export prices.

[7] Recently, some researchers has built structural models of industry behavior based on the industrial organization theory to estimate the exchange rate pass through on export prices using micro data. For example, Kadiyali [1997] and Hellerstein [2002] estimate the exchange rate pass-through of the film industry and the beer industry, respectively.

A. Taylor's (2000) Staggered Pricing Model

As aforementioned, the conjecture raised by Taylor (2000) has triggered the recent upsurge of interest in exchange rate pass-through. His argument is based on the following staggered pricing model.

Let a linear demand curve for a firm's goods be defined as equation (1).

$$y_t = \varepsilon_t - \beta(x_t - p_t), \tag{1}$$

where y_t expresses production of the firm's goods, x_t denotes its price, p_t is the average price of other goods produced by competitive firms, and ε_t is a random shift to demand.[8] β is the inverse of the firm's market power and a higher value of β represents less market power with $\beta \to \infty$ representing perfect competition.

Suppose that the firm pre-sets its price for the next four periods and that it reviews its price every four periods. Let c_t be the firm's marginal cost of producing goods. Then, the firm's expected profit for the four periods at period t when it set its price at x_t can be expressed as follows.[9]

$$\sum_{i=0}^{3} E_t(x_t y_{t+i} - c_{t+i} y_{t+i}), \tag{2}$$

where E_t indicates the conditional expectations operator based on information at period t. The firm maximizes its profit taking the prices of other firms as given. Then, substituting equation (1) to equation (2) and differentiating it with respect to x_t we derive the solution for optimal prices given by the following equation (3).

$$x_t = 0.125\sum_{i=0}^{3}(E_t c_{t+i} + E_t p_{t+i} + E_t \varepsilon_{t+i} / \beta). \tag{3}$$

If we apply equation (3) to a firm that imports products from foreign countries and sells them in the home country, we can derive the following implications for exchange rate pass-through. First, the amount of price change depends on how permanent exchange rate changes are. The changes in exchange rate affect marginal cost, thereby inducing the firm to change its sales price. In this case, however, price is determined by average marginal cost for the next four periods including the current one. If the exchange rate changes are regarded as temporary, price does not change so much as the exchange rate and exchange rate pass-through remains low.

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[8] In the Taylor's model, it is assumed that the expected value of ε_t, a random shift to demand, is not necessarily zero.

[9] For simplicity, the discount factor is assumed to be one.

Second, when prices set by other firms are expected to decline persistently in the future, the firm also has to lower its price. Hence even if the exchange rate depreciates and import cost rises, the firm will try to avoid a price hike as much as possible. Third, weaker market power makes it difficult for the firm to change its product price in response to demand shocks. Thus, the firm is less likely to pass the increased cost due to depreciation on to its product price.

B. Recent Development

Campa and Goldberg (2002) estimate the exchange rate pass-through to the import prices for 25 OECD member countries by using quarterly data from 1975 to 1999. Their estimation is based on the following specification:

$$\Delta imp_t^j = \alpha + \sum_{i=0}^{-4} a_i^j \Delta ner_{t-i}^j + \sum_{i=0}^{-4} b_i^j \Delta mc_{t-i}^j + c^j \Delta gdp_t^j + \varepsilon_t^j \ , \qquad (4)$$

where Δ represents first difference, imp^j import prices of country j denominated in its currency (log-transformed), ner^j denotes nominal effective exchange rate for country j (log-transformed), mc^j is an indicator for marginal cost of all j's trading partners (log-transformed), gdp^j is aggregate output of country j (log-transformed), and ε^j is the error term. Specifically, mc^j is log-transformed value of $MC^j = NER^j \cdot P^j / RER^j$, where RER^j is the real effective exchange rate, and P^j is j's general price.

The short-term exchange rate pass-through is given by the estimated coefficient a_0 that corresponds to the contemporaneous effect of a change in the exchange rate on import prices. The long-term pass-through is given by the sum of the coefficients $\sum_{i=0}^{-4} a_i^j$ that represents the effect of contemporaneous and four-period lagged exchange rate changes on import prices.

Campa and Goldberg (2002) estimate exchange rate pass-through to overall import prices for 25 OECD member countries based on the above specification. They report that the average short-term pass-through for 25 countries is 0.61 and the average long-term pass-through is 0.77 for the full sample period from 1975 to 1999. In addition, to examine whether the pass-through has declined in the 1990s, they compare the estimated coefficients for the full sample with those for sub-sample for 1975-1989. As a result, they find that the short-term and long-term pass-throughs for 25 counties are respectively lower by –0.04 and –0.27 in the former sub-sample than the latter one.

As for their estimation results on Japanese pass-through, they report 0.88 for

short-term pass-through and 1.26 for long-term pass-through for the full sample. These numbers are considerably greater than those of other major industrial countries: the short-term and long-term pass-through are 0.26 and 0.41 for U.S., and 0.29 and 0.79 for Germany. Moreover, their results reveal that Japanese short-term and long-term pass-through become dramatically lower in the 1990s: the estimates for short-term and long-term pass-through are respectively lower by −0.36 and −0.76 for full sample period from 1975 to 1999, compared with the estimates for the sub-sample period of 1975-1989.

Campa and Goldberg (2002) further examine two hypotheses to explain the observed decline in exchange rate pass-through in the 1990s. The first is changes in the macroeconomic environment such as decline in worldwide inflation and exchange rate volatility. The second is changes in world trade structure, such as the decrease in import share of raw materials as well as the increase in share of manufactured products. They pool the estimated pass-through across countries to regress them with money supply, average inflation, exchange rate volatility, real GDP (as the proxy of country size), and an indicator for structural change in imports.[10] They conclude that the decline in pass-through in the 1990s is mainly attributable to the structural change in imports.

III Estimation of Exchange Rate Pass-Through to Japan's Import Prices

As aforementioned, Campa and Goldberg (2002) show that the exchange rate pass-through to import prices declined in the 1990s. Their analysis, however, does not show whether exchange rate pass-through gradually declined throughout the 1990s or whether it declined rapidly during a specific period in the 1990s. To detect changes in exchange rate pass-through over time across industries, we employ the rolling regression method to estimate pass-through with a 72-month sub-sample by using monthly data from January 1978 to October 2002.

[10] Country size may affect exchange rate pass-through because foreign firms are likely to have larger market power in a smaller economy. An indicator for structural change in imports is a weighted-average of the pass-though for five disaggregated import prices (food, energy, raw materials, manufactured goods, and non-manufactured goods).

A. Specification and Data

We estimate exchange rate pass-through based on the following equation (5) including a partial adjustment term to import prices to allow for the possibility of gradual adjustment of import prices to exchange rate fluctuations.[11]

$$\begin{aligned} \Delta imp_t^j &= \phi^j + \varphi^j \Delta imp_{t-1}^j + \gamma^j \Delta ner_t^j + \eta^j \Delta z_t^j + \nu_t^j \\ \lambda^j &= \gamma^j / (1-\varphi^j) \end{aligned}, \qquad (5)$$

where z is other control variables that are specified below and superscript j denotes product categories. γ and λ represent the short-term and long-term pass-through, respectively.[12] Note that this specification enables us to obtain the total effect of the current exchange rate on the current and future import prices, that is, the exact long-term pass-through of current exchange rate.

Data used in our estimation are as follows. First, as for the dependent variable, import prices, we employ import price indexes for each product category from the CGPI. Besides the aggregate series, disaggregated import prices for eight categories are available from CGPI import price indexes: foods, materials, fuels, chemicals, textiles, metals, machinery, and others.[13] Considering large fluctuations in primary commodity prices, we compile two additional series that exclude the import prices of primary commodities from overall import prices: overall excluding fuel and overall excluding fuel and material series.

Second, as for the independent variables, we use the IMF's effective nominal

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[11] We do not use an error correction model (ECM) in this paper, since the existence of cointegration between exchange rate and import prices is rejected by the Engle-Granger test.

[12] Long-term pass-through in equation (5) is a nonlinear function of estimated coefficients. So, standard error of long-term pass-through is estimated as follows.
s.e. = $(\lambda_\gamma^2 Var[\gamma] + \lambda_\varphi^2 Var[\varphi] + 2\lambda_\gamma \lambda_\varphi Cov[\gamma,\varphi])^{1/2}$ where $Var[\cdot]$, $Cov[\cdot]$, λ_γ, and λ_φ are estimated variance, estimated covariance, $\partial\lambda/\partial\gamma$ (=$1/(1-\varphi)$), and $\partial\lambda/\partial\varphi$ (=$\gamma/(1-\varphi)^2$), respectively.

[13] Since the categories reported by CGPI are a little different from those in *The Summary Report on Trade of Japan*, we adjusted them to be consistent with each other as follows.

Materials: natural fiber materials + metalliferous ore and metal scrap + logs + lumber + inedible agricultural, forestry and livestock products + non-metallic crude minerals + pulp + waste paper + ceramic, stone and clay products;

Textiles: textiles - natural fiber materials; Metals: metals and related products – metalliferous ore and metal scrap;

Others: other primary products and manufactured goods + lumber chips + processed wood materials - inedible agricultural, forestry, and livestock products – non-metallic crude minerals – pulp – ceramic, stone and clay products – waste paper.

exchange rates.[14] In addition, we adopt demand shock and marginal cost changes as in Campa and Goldberg (2002). We employ the Index of Industrial Production (IIP) as a proxy for demand shock. As marginal cost, we calculate marginal cost according to the following formula as is used in Campa and Goldberg (2002): $MC = (NER^{JPN}/RER^{JPN})*ULC^{JPN}$, where upper subscript *JPN* implies Japan and, thus, ULC^{JPN} represents unit labor cost in Japan in *Main Economic Indicators* (MEI). Since the IMF's real effective exchange rate is deflated by the unit labor cost of trading partners, the calculated marginal cost obtained by the above formula becomes a weighted average of unit labor cost in trading partner countries.

In estimating the exchange rate pass-through based on equation (5) using aforementioned data, we adopt seemingly unrelated regression in order to improve the efficiency, utilizing the residual correlation among the equations of each product categories.[15]

B. Benchmark Estimation Results

We first examine whether the decline in pass through to overall import prices comes from the import structure changes, as is suggested by Campa and Goldberg (2002). Table 1 summarizes the short-term and long-term pass-through coefficients of overall import prices as well as import prices of product categories. The sample periods divided into the periods before and after 1990.[16]

Looking at the full-sample estimation results in the first column, pass-through coefficients for overall import prices in the short-term and long term are 0.63 and 1.04, respectively, confirming that the pass-through coefficient is larger in the long term by 0.41 than in the short term.[17] The short-term pass-through coefficients are almost the same regardless of including or excluding primary materials: overall, 0.63; overall, excluding fuels 0.64; and overall, excluding fuels and materials 0.61. In contrast, the

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[14] It is expressed in yen term.

[15] The estimations are conducted using the logarithmic first difference of variables to control for the possibility of unit roots in variables included in estimation equations. The results of the augmented Dickey-Fuller test for variables included in the estimated equations reject the existence of unit root in first difference, but do not reject in terms of level.

[16] Durbin's *h* statistics almost rejects the existence of autocorrelation in the error term.

[17] The estimates are a little smaller than those in Campa and Goldberg (2002), partly due to the longer sample period until October 2002 in our estimation, while until 1999 in Campa and Goldberg (2002).

long-term coefficients become low if primary commodities are excluded: overall, 1.04; overall, excluding fuels, 0.84; and, overall, excluding fuels and materials, 0.73.

The estimates differ across product categories, and such differences are more significant with respect to the long-term than the short-term. Looking at short-term coefficients, materials is the highest at 0.76 and textiles the lowest at 0.41, chemicals the second lowest at 0.49, but other categories, such as foods, metals, and machinery, show close estimates around 0.60-0.62. As for long-term coefficients, the estimates differ more significantly across product categories. Fuels, materials and metals show larger estimates of 1.20, 1.15 and 0.94 respectively, while textiles shows smaller estimate at 0.55. Foods, chemicals, machinery, and others exhibit estimates in the middle at 0.81, 0.79, 0.77, and 0.82, respectively.

Comparing the estimates between two sub-sample periods before and after 1990, the declines in pass-through coefficients are observed overall as well as with most product categories in both the short and long term. The pass-through coefficient declines much more overall compared with overall excluding fuels and excluding fuels and materials.[18] Among product categories, fuels exhibit the largest decline in both short-term and long-term estimates. Declines in foods, materials, chemicals, and machinery are smaller, although they are still statistically significant.

The question we have to examine next is what causes such a decline in overall exchange rate pass-through in the 1990s. The above observation of the declines in pass-through in each category suggest two possibilities for the lowered pass-through in the 1990s: (i) a decreased import share of primary commodities with high pass-through and (ii) a declining pass-through in other products. In this context, as aforementioned, Campa and Goldberg (2002) point out that the structural change in imports is the main factor behind the decline in pass-through.

To confirm the above point, we decomposed changes in the pass-through coefficients of overall import prices into contributions of change in import share and change in pass-through rate for each product category. To be more specific, since the

[18] The decline in the long-term pass-through after the 1980s is larger than that in the short-term pass-through because partial adjustment parameter β declines, suggesting that import prices have become less sticky recently than in the 1980s. A possible explanation of this decreased stickiness in import prices is increased competitive pressure in import product markets and weakened market power of businesses, suggested by Taylor (2000).

pass-through coefficient for overall import prices is approximately equal to a weighted average of the pass-through coefficients for product categories, $\bar{\gamma}_t$, the changes in pass-through coefficients between period t and 0 can be written as follows:

$$\begin{aligned}\bar{\gamma}_t - \bar{\gamma}_0 &= \sum_j w_t^j \gamma_t^j - \sum_j w_0^j \gamma_0^j \\ &= \sum_j w_t^j (\gamma_t^j - \gamma_0^j) + \sum_j (w_t^j - w_0^j)(\gamma_0^j - \bar{\gamma}_0), \end{aligned} \tag{6}$$

where w_t^j is the import share of product category j at period t.[19]

Table 2 reports the decomposition results, and clearly demonstrates that the declines in pass-through to overall import prices are largely attributable to declines in pass-through to category import prices in both short-term and long-term estimates. In contrast to Campa and Goldberg's (2002) argument, the change in import share is not so significant.

In the following, we test the robustness of above result in terms of different specification and alternative sets of data used in the estimation.

C. Robustness Checks

In order to check the robustness of the above estimation results, we estimate the exchange rate pass-through based on the different specification than equation (5). We also estimate the same specification of the benchmark estimation, but by using alternative data series of effective exchange rate and import prices.[20]

1. Alternative Specification

As an alternative specification to equation (5), we employ a similar specification as equation (4), used in Camp and Goldberg (2002), as follows:[21]

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[19] The deviation of weighted averaged pass-through from estimated pass-through is not so large.

[20] In addition to these robustness checks, we also conduct the following two types of robustness check. The first is to use the alternative set of control variables. In addition to aforementioned IIP as a proxy of demand shock and marginal cost, we test two alternative sets of control variables. One includes primary commodity market price indexes besides aforementioned two variables. The other does not include any control variables. We got the similar results irrespective of the difference in control variables.

The second is to include a dummy variable for the appreciation of the yen (one during periods when the yen appreciated, and zero otherwise) and trend or exponential trend as the proxy for an increase in productivity in equation (5) as regressors. Nevertheless, the results are almost same with the reported results in this paper.

[21] As is shown in (4), Campa and Goldberg (2002) adds lags of foreign production cost terms to estimation equations. However, we only include a contemporaneous marginal cost term because the

$$\Delta imp_t^j = \alpha^j + \sum_{i=0}^{5} \beta_i^j \Delta ner_{t-i}^j + \delta^j \Delta z_t^j + \varepsilon_t^j , \quad (7)$$

where the short-term pass-through of product category j is given by the estimated coefficient β^j_0 and the long-term pass-through is given by the sum of coefficients of exchange rate terms.

Equation (5) assumes that the impact of changes in nominal effective exchange rate gradually decays in an exponential manner. In contrast, equation (7) allows more flexible pattern in the impact of contemporaneous and lagged changes in exchange rate.

Table 3 summarizes the short-term and long-term exchange rate pass-through. The results on both specifications, equations (5) and (7), exhibit similar results. Therefore, it confirms us that the above result is robust from the perspective of alternative specification.

2. Alternative series of effective exchange rates

We next estimate equation (5), which is the same specification as the benchmark estimation, by using nominal effective exchange rates for each product category with time-varying weight, based on import value from major trading partners.

In computing the effective exchange rates for each product category with time-varying weight, we use one-year average of monthly import of the category from major trading partner countries as a weight.[22] As Campa and Goldberg (2002) point out, it is important to capture changes in import composition in examining the movement of exchange rate pass-through over time. The IMF effective exchange rate, however, is less likely to reflect such changes because of using a fixed weight, in spite of its advantage of the availability of long time-series retroactive to January 1978.

It should be noted that, in this robustness check, it is impossible to test a possible structural breaks in exchange pass-through between the 1980s and 1990s. This is because nominal effective exchange rates with time-varying weight is available only from January 1988 to December 2001 due to the limitation in the availability of import value of individual goods by major trading partners. In addition, we use the weighted-

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coefficients of the lags of marginal cost are not significant.

[22] Import value data is taken from *The Summary Report on Trade of Japan* by the Ministry of Finance. Major trading partners include 33 economies as follows: Korea, Taiwan, Thailand, Philippines, India, Pakistan, Israel, Sweden, Denmark, UK, Ireland, Netherlands, France, Germany, Switzerland, Spain, Finland, Austria, Canada, US, Mexico, Venezuela, Chile, Brazil, South Africa, Australia, EU (Jan. 1999-), China, Malaysia, Saudi Arabia, Belgium, Italy, Norway, and Kuwait.

average of trade partners' producer price indexes (PPI)[23] as a proxy for marginal cost, instead of that based on the IMF effective exchange rate in the benchmark estimation.

Table 4 reports the estimation results of short-term and long-term pass-through coefficients for nominal effective exchange rates with time-varying weight, for the sample period from January 1990 to December 2001.[24] The results show that both pass-through generated from different set of nominal effective exchange rate exhibit similar estimates.

3. Alternative Series of Import Prices

Finally, we also estimate equation (5) by using the unit value indexes (UVI) of imports as an alternative import price series.

Some cautions are in order when using the UVI as import price series. First, the UVI associates the lagged impacts of exchange rate fluctuations. This is because the official exchange rate, used in converting foreign currency denominated values into yen denominated values, is the average exchange rate of last two weeks of the previous month and first two weeks of the current month. To avoid this problem, we employ quarterly data, instead of monthly data, in estimating pass-through by using the UVI. Second, the disaggregated categories of UVI (foods, materials, fuels, and manufactures) do not completely match with those of CGPI.

Table 5 summarizes the estimation result. The estimated long-term pass-through using CGPI and UVI are so similar that it may well to understand that our estimation results do not depend on the choice of import price series. The short-term pass-through using UVI tend to be larger than those of CGPI, since data frequency of CGPI is monthly, while the one of UVI is quarterly. These results suggest that shifts in average quality of import products do not significantly respond to exchange rate fluctuations.

D. Changes in Pass-Through over Time

The above results for robustness checks suggest that our benchmark estimation results are less influenced by the choices of specifications of lag pattern for exchange rates,

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[23] We use WPI when PPI is not available. If WPI is also not available, we use CPI.

[24] Estimation results for the benchmark specification remain almost unchanged, if we shorten the second sub-sample period to up until December 2001.

nominal effective exchange rate series, and import price series. In the following, we examine changes in pass-through coefficients over time by implementing a rolling estimation. In this exercise, we focus on overall pass-through excluding fuels and materials to eliminate the impact of structural changes in imports.

Figure 1 summarizes the estimated coefficients of exchange rate pass-through over time. The short-term pass-through in the upper panel is largely stable, though it exhibits a slight downward trend in the 1980s. The long-term pass-through in the lower panel declines until the sub-sample period ending in 1998. A closer look at the estimation results for the long-term pass-through shows that the downward trend becomes steep during sub-sample periods ending in 1992 to 1998.

We also implement a rolling regression to all product categories to decompose the changes in pass-through coefficients of overall import prices excluding fuels and materials into the contributions of changes in import share and changes in pass-through rate for each product category.

Figure 2 shows the decomposed result for the cumulative changes in overall pass-through excluding fuels and materials from 1984, based on equation (6).[25] This figure indicates that the expansion of the cumulative decline in overall pass-through excluding fuels and materials is mostly attributable to declines in the pass-through to import prices for individual product categories. Therefore, once we exclude the impact of the declining import share of fuels and materials since the mid-1980s, the changes in import shares have minor impact on the decline in overall pass-through.

Estimation results shown in this section are summarized as follows. (i) The exchange rate pass-through declined after the 1980s. (ii) The decline in overall pass-through comes mainly from the decrease in the pass-through to individual product categories, when we adjust for the impact of the declined import share of primary commodities with high exchange rate pass-through. (iii) Overall pass-through declines rapidly during sub-sample periods ending from 1992 to 1998, and levels off thereafter. In the next section, we examine the causes of the decrease in pass-through in detail.

IV Factors behind the Decline in Exchange Rate Pass-Through

In this section, we discuss the factors behind the decline in exchange rate pass-through

[25] We have translated estimated pass-through to a calendar-year basis because of data availability.

bearing Taylor's (2000) conjecture in mind. Factors we examine here include: (i) yen's sharp appreciation and the change in Japanese trade structure, and (ii) the worldwide low inflation environment.[26]

A. Yen's Sharp Appreciation and the Change in Japanese Trade Structure

Large and persistent changes in exchange rates influence a firm's decision making with respect to the international allocation of resources, such as foreign direct investments and expansion of procurements and sales networks in abroad. As a result, such significant changes in exchange rates are likely to induce structural changes in the economy and international trade, thereby altering exchange rate pass-through over the medium-to-lung term.

In fact, Japanese firms conducted massive foreign direct investment in response to the yen's sharp appreciation since the Plaza Agreement in 1985 (Figure 3). As a result, the proportion of the overseas production of Japanese firms increased (Figure 4), and Japan's re-imports also increased in the 1990s (Figure 5). Such advance in globalization of Japanese firms is likely to reduce the exchange rate pass-through to import prices, because firms tend to pass less of a change in exchange rates onto the prices of intra-firm trading across borders than to the prices of inter-firm trading. Empirical evidences in the previous section show that the exchange rate pass-through onto the Japanese import prices has declined especially from later 1980s to the early 1990s. This period of decrease in exchange rate pass-through coincides with that of aforementioned advance in globalization of Japanese firms and rapid changes in Japan's trade structure.

Further, we can point out the possibility that the change in Japan's trade structure increases competitive pressure in Japan's market, which is captured by an increase in the import penetration ratio, and results in the decline in the exchange rate pass-through. Based on Taylor's (2000) staggered pricing model, under the assumption that prices are rigid, this upward pressure in worldwide competition leads to the decline in the exchange rate pass-through on import prices. Therefore, such a change in competitive pressure in the world economy is considered to influence the exchange rate pass-

[26] As is shown in Appendix 2, the decline in the estimated exchange rate pass-through is consistent with the change in the choice of the invoice currency by Japanese firms, suggesting that the choice od invoice currency is closely related with the exchange rate pass-through.

through on Japan's import prices.

Figure 6 is a scattered diagram showing the relationship between exchange rate pass-through and the import penetration ratio since 1990s, when Japan's overseas production, re-import, and import penetration ratios have dramatically risen. It demonstrates that exchange rate pass-through fell as the import penetration ratio rose in the latter 1990s for almost all product categories[27]. It should be noted that the improvement in competitiveness of firms in emerging market economies such as East Asian economies and the increase in the imports from them also contribute to the increase in the import penetration ratio. The increase in foreign direct investment following the Plaza Agreement initiated the high economic growth in East Asian economies and worked to transfer the advanced technology and know-how of efficient production to improve the competitiveness of East Asian firms. As a result, it can be conjectured that the worldwide competitive pressure increases to deteriorate the market power of the existing firms exporting their goods to Japanese market.[28]

B. Worldwide Low Inflation Environment

As is mentioned before, Yen's sharp appreciation and the resulting globalization of Japanese firms is likely to cause a large decline in the exchange rate pass-through in 1990s. In addition, focusing on its development since 1990s, the current worldwide low inflation is also likely to reduce the exchange rate pass-through.

Taylor's (2000) staggered pricing model shows that the product prices are likely to be stable as long as the competitors' prices are stable and that if the exchange rate changes are regarded as temporary, price does not change so much as the exchange rate. In addition, once the worldwide low inflation environment is realized, an economy with inflation as low as the average of its trading partners will be less likely to experience persistent nominal exchange rate changes (Taylor [2000]).

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[27] Since the estimated pass-through for textiles did not decline but rose as mentioned in the previous section, its relationship between the import penetration ratio and exchange rate pass-through is upward sloping.

[28] It should be noted that it is price elasticity that directly shows a firm's market power. If price elasticity was lower, it can be concluded that the upward pressure in worldwide competition led to a deterioration in a firm's market power. Nevertheless, to the best of our knowledge, we do not have enough empirical industrial organization literature on price elasticity.

Therefore, it can be concluded that under an environment of worldwide-sustained low inflation with less persistent exchange rate changes, the exchange rate pass-through to import prices is likely to be low. To investigate its validity, we examine the development of the worldwide inflation and the exchange rate pass through on Japan's import prices. Figure 7 shows the relationship between the worldwide inflation rate and exchange rate pass-through since 1980s. This picture demonstrates that, from the late 1980s to the early 1990s, while the worldwide inflation rate remains almost unchanged, Japan's exchange rate pass-through dramatically declined. In addition, it also shows that the exchange rate pass-through declines to some extent as the worldwide inflation falls since the late 1990s. It implies the possibility that in the midst of intensified worldwide disinflation with a less persistent exchange rate change since the late 1990s, the exchange rate pass-through declined modestly.

It should be noted that the decline in the exchange rate pass-through since the late 1990s is by far smaller than that in the early 1990s when the worldwide inflation remained almost unchanged. This observation leads us to conclude that while the change in Japan's trade structure mainly reduced the exchange rate pass-through, the effect of the fall in the worldwide inflation is considerably smaller than that of the change in the trade structure.

V Concluding Remarks

In this paper, we have examined the changes in exchange rate pass-through on import prices in Japan since the 1980s. Our empirical findings show that exchange rate pass-through to Japan's import prices declined in the 1990s, supporting Campa and Goldberg's (2002) conclusion that import price pass-through declined in major industrial countries, including Japan, in the 1990s.

In addition, we have shown two further empirical findings. First, the decline in exchange rate pass-through occurred mainly during the period from the late 1980s to early 1990s. Second, such decline came mainly from the decline in the exchange rate pass-through in each product, rather than the shift of import share from raw materials to manufactured goods with lower exchange rate pass-through. This finding contrasts to Campa and Goldberg's (2002) finding that emphasized the effects of changes in trade

share.

Our empirical evidence suggests that the decline in exchange rate pass-through to import prices in Japan is associated with the globalization of Japanese firms' activities, responding to the sharp appreciation of yen in the mid-1980s. A rise in the import penetration of foreign products increases competitive pressure in Japan's domestic markets. The foreign direct investment of Japanese firms accelerates the globalization of their production bases. Japanese firms also increase their usage of yen as an invoice currency for their imports. Although all of these movements are most likely to lower exchange rate pass-through to Japan's import prices, empirical investigations using firm-level data are required to draw more decisive conclusions on this point.

It should be noted that the decline in exchange rate pass-through does not necessarily imply exchange rate fluctuations become less important in macroeconomic fluctuations. As Obstfeld (2002) points out, at least two factors can drastically modify the impact of exchange rate fluctuations on the economy in the conclusions of abstracted theoretical models. One is that the exchange rate pass-through to domestic prices is much slower than that to import prices, reflecting the complicated chain of transactions linking the two prices. The other is that the magnitude of the expenditure switching effect crucially depends on a firm's sourcing decisions across borders. In fact, it might be the case that the recent increase in intra-firm trading makes it possible to shift business activities across borders smoothly, thereby enhancing the response to exchange rate changes.

Appendix 1. Theoretical and Empirical Research on Exchange Rate Pass-Through

In the appendix, we first review the two strands of theoretical models to explain the determinants of exchange rate pass-through to corporate export prices, developed during the period from the late 1980s to early 1990s. We then review the empirical researches on exchange rate pass-through of export firms in response to the development of theoretical analysis.

A. Theoretical model

These theoretical models to explain the determinants of exchange rate pass-through to corporate export prices can be classified into two: one is the static profit maximization model of monopolistic firm and the other is the sunk-cost model focusing on hysteresis effect of large changes in exchange rates on export firms' behavior.

1. Static Model of Profit Maximization on the Determination of Exchange Rate Pass-Through

We first review the static profit maximization model of monopolistic firm to examine the determinants of exchange rate pass-through in setting firms' export prices (see Feenstra [1989] and Marston [1990]).

Let us define domestic import demand as $x(p, q, I)$, where p and q are prices of foreign and domestic goods denominated in the home currency, and I denotes income. The firm's cost function is given by $C(x, w^*)$, where w^* represents factor prices in a foreign country. Suppose that the cost function is homogeneous of degree one in factor prices, then it can be written as $C(x, w^*) = \phi(x)w^*$, where ϕ' is the marginal cost and $\phi'' > 0$ (< 0) indicates increasing (falling) marginal cost.

Letting e denote the exchange rate (the home-currency price of foreign currency), the profit maximization problem of a foreign firm exporting its goods to the home market can be written as follows.

$$\underset{p}{Max}[e \cdot p \cdot x(p,q,I) - \phi(x)w^*]. \tag{A-1}$$

The first order condition of this optimization problem is

$$\phi'(x)(w^*/e) = p[1-(1/\eta)] \equiv r(p,q,I), \tag{A-2}$$

where, η is the price elasticity of demand ($\eta = -x_p p/x$) and $r(p, q, I)$ represents marginal revenue.

Moreover, letting w be the home-currency price of foreign factor prices ($w = w^*/e$), total differentiation of equation (A-2) results in the following equation.

$$(dp/dw)(w/p) = 1/[(\phi'' x/\phi')\eta + (r_p p/r)]. \tag{A-3}$$

Since w^* is exogenous and w is expressed as w^*/e, $(dp/dw)(w/p)$ indicates to what extent a foreign firm's export price responds to exchange rate changes, i.e., exchange rate pass-through.

The first derivative of equation (A-2) with respect to p is $r_p p/r = 1 + (p^2/r\eta^2)\,\eta_p$, where η_p and r_p represent first derivatives of η and r with respect to p. This implies that $r_p p/r > 1$ if $\eta_p < 0$ and $r_p p/r < 1$ if $\eta_p > 0$. Also, the sign of $\phi'' x/\phi'$, which is the elasticity of marginal cost with respect to production, is identical with that of ϕ''. Making use of these relations yield the following conditions for the determination of exchange rate pass-through.

(a) $(dp/dw)(w/p) < 1$ if $\eta_p > 0$ and $\phi'' \geq 0$

(b) $(dp/dw)(w/p) = 1$ if $\eta_p = \phi'' = 0$

(c) $(dp/dw)(w/p) > 1$ if $\eta_p \leq 0$ and $\phi'' < 0$

Case (a) shows that if the price elasticity of demand is an increasing function of price p and the marginal cost is a constant or increasing function of production x, the exchange rate pass-through is imperfect and less than one. Case (b) means that if the price elasticity and the marginal cost are constant, the exchange rate pass-through is perfect and equal to one. Case (c) indicates that if the price elasticity of demand is a decreasing function of price p and the marginal cost is also a decreasing function of production x, then the exchange rate pass-through is larger than one.

2. Sunk Cost Model of Hysteresis Effect

We next briefly explain the sunk cost model, proposed by Dixit (1989), that focuses on the hysteresis effect stemmed by entry and exit costs, and provides a rationale for exporters' behavior with respect to imperfect pass-through of exchange rate fluctuations to their export prices. First, we present the intuitive explanation of his theoretical model by assuming all variables are deterministic and, then, discuss the model's implication in case of the uncertainty in exchange rate fluctuations.

The set-up of the model is as follows. Suppose there exist N potential exporting firms in the home country and they sell one unit of goods in a foreign country during a period when they decide to enter the foreign market. q is the volume sold in the foreign market and the goods' price is represented by $p = P(q)$, where its first derivative with respect to q is negative. Let e, C_n, r denote the exchange rate (domestic currency price of foreign currency), marginal cost of firm n, and the discount rate, respectively.

We examine firm n's decision about entry and exit under the assumption that all domestic exporting firms other than the n-th firm export their goods to the foreign market. If firm n decides to enter the foreign market, its present discounted value of

profit denominated in the home currency is given by

$$\pi_n = \sum_{t=1}^{\infty} [1/(1+r)^t][eP(N) - C_n].$$

Suppose that the entry and exit costs, I and E, both of which are not recouped, are incurred to exporters when they enter and exit the foreign market. We also assume $I > E$. The former corresponds to the initial cost such as the cost for sales network construction, and the latter corresponds to the closure cost such as the cost for lay-off of workers.

Firm n makes its decision based on a comparison of the present value of profit π_n with sunk cost, I and E. It decides to enter the foreign market if its present discounted value of profit exceeds entry cost ($\pi_n \geq I$), and exit if exit cost exceeds its present discounted value of profit ($\pi_n \leq E$). Solving these conditions with respect to e yields the exchange rates at which firm n decides to enter and exit the foreign market eh_n and el_n: $eh_n = (r \cdot I + C_n) / P(N)$ and $el_n = (r \cdot E + C_n) / P(N)$. Since we assume $E < I$, firm n makes three decisions as to entry and exit, depending on the level of the exchange rate, as follows.

(a) Firm n enters the foreign market if $e \geq eh_n$.

(b) Firm n exits the foreign firm if $e \leq el_n$.

(c) Firm n has already entered the foreign market, and stays in the foreign market if $el_n < e < eh_n$.

When the exchange rate is in the region of (a) or (b), the number of firms to enter (exit) the foreign market increases as home currency appreciates (depreciates) and exchange rate pass-through becomes positive. On the contrary, when the exchange rate is in the region of (c), the number of firms operating in the foreign market remains unchanged regardless of exchange rate changes, and pass-through is zero. Furthermore, the firm operating in the foreign market at $e = eh_n$ does not exit even if $e < eh_n$ and delays exit until e hits el_n. This asymmetric response to the exchange rate, called the hysteresis effect, generates inertia with respect to the number of firms in the foreign market and on the price of goods.

Next, we examine the effect of the uncertainty in exchange rate fluctuation on firms' entry and exit decision in the foreign market. The introduction of uncertainty in exchange rate fluctuations into the above model broadens the rage of exchange rate, where firms neither enter nor exit the foreign market as well as keeps operating in the

foreign market. In addition, it should be stressed that the more the exchange rate fluctuates, the larger the firms' incentive to adopt such waiting strategy is. That is, as the uncertainty in exchange rate fluctuation becomes larger, firms tend to postpone entering the foreign market until the exchange rate reaches more favorable level to them. On the other hand, the firm having entered the foreign market remains operating in the foreign market until the exchange rate reaches less favorable level to them.

In this case, we can regard this firm's decision-making problem of entry and exit in the foreign market as to exercise the option of entry or exit in the foreign market. Once it exercises this option, it will bear loss as decline in the discounted present value of its profit if the home currency appreciates. However, in case not, even if home currency depreciates, it will lose only a part of an increase in the discounted present value of its profit, since it still has the option to enter the foreign market. Therefore, firms tend to take the waiting strategy in making decision of entry or exit under the exchange rate level where the discounted present value of its profit can just cover the entry cost.

B. Empirical Researches

In response to the above theoretical studies, many economists intensively conducted empirical studies using industry-level data of firms' export prices in industrial countries since the end of 1980s to early 1990s.

Knetter (1989) is among the first to estimate exchange rate pass-through using the micro data. He uses the disaggregated data to SIC (Standard Industrial Classification) seven-digit of U.S. and German exporting firms, such as refrigerators and switches, and shows that pass-through is greater for the U.S. than for Germany. As for the pass-through of Japanese firms, Marston (1990) estimates Japanese firms' exchange rate pass-through for selected products such as automobiles, trucks, and TV sets and shows that it varies across goods, ranging from 33 percent to 69 percent. Ohno (1989) compares exchange rate pass-through on export prices of U.S. and Japanese firms, and concludes that exchange rate pass-through is greater for U.S. exporters than for Japanese exporters.[29] Moreover, Knetter (1993) makes a cross-country study to

[29] Likewise, Gagnon and Knetter (1995) analyze the exchange rate pass-through of Japanese, German, and U.S. automobile industries. They find that the pass-through of Japanese firms is quite small

estimate the exchange rate pass-through of selective exporting firms in the U.S, Germany, the U.K., and Japan. He also shows the aggregate pass-through of these countries: point estimates are 99 percent, 64 percent, 63 percent, and 52 percent, respectively.

The above empirical studies reveal that the exchange rate pass-through of Japanese firms is quite low, compared with those of other industrial countries and that exchange rate pass-through varies across products.

Appendix 2. Estimated Exchange Rate Pass-Through and Choice of Invoice Currency

In section 4, we discussed (i) yen's sharp appreciation and the change in Japanese trade structure, and (ii) the worldwide low inflation environment, as the factors behind the decline in exchange rate pass-through. In this appendix, we examine the relationship between the decline in the exchange rate pass-through and the choice of invoice currency.[30]

The reason why the choice of invoice currency is related with exchange rate pass-through is as follows. Suppose that import prices are pre-set, then exchange rate pass-through to import prices is zero if the home currency is used as the invoice currency, and it is one if a foreign currency is used. Therefore, the higher the ratio of domestic currency-denominated imports to total imports is, the lower the exchange rate pass-through on import prices is. In fact, we can see such relationship from Figure A-1.

This is also the case for Japan over time. As we can see clearly from Figure A-2, our estimates of long-term pass-through and the ratio of yen-denominated imports to total imports in Japan moves in opposite directions each other. The former continuously fell from 1985 to 1995 and leveled off thereafter, while the latter rose continuously from 1985 to 1995, and then leveled off, with missing observations in

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compared with U.S. and German firms.

[30] Many theoretical studies exist on the choice of invoice currency for trading (for example, Bacchetta and Wincoop [2002]). They assume that there exists uncertainty about change in exchange rates. Then, they show the condition regarding the choice of invoice currency by comparing the expected utility from profit when a firm chooses a local currency as invoice currency (local currency pricing) with that when it chooses the domestic currency (producer currency pricing).

1999 and 2000. This observation implies the possibility that recent decline in exchange rate pass-through on import prices is closely related with the "internationalization of yen" in the choice of invoice currency.

The above evidence becomes clearer when we compute the implied pass-through from the invoice currency ratio, by simply assuming that import prices are sticky in the short term.[31] Figure A-3 plots the invoice currency-based pass-through, together with the estimated long-term pass-through. We can see from the figure that these two estimates of pass-through move parallel, in spite of small discrepancy in their levels due to a difference in their coverage. Note that the invoice currency-based pass-through covers all the categories, while the estimated long-term pass-through excludes fuels and materials.

In this connection, it should be noted that the invoice currency-based pass-through is comparable with the estimates of long-term estimated pass-through, but not short-term estimated pass-through. On the one hand, considering the time lags in trade transactions from contract to implementation and settlement, import prices are considered to be pre-set at least several months ahead of the termination of the import transaction.[32] On the other hand, as for the estimated pass-through, the time frame of the short-term corresponds to the frequency of data, i.e., one month, and that of the long term is the duration until the impact of current changes in the exchange rate on import prices is exhausted. A simple calculation based on our estimates indicates that the long-term period is three to seven months.[33]

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[31] The procedure to compute exchange rate pass-through from invoice currency is as follows. Suppose the invoice currency ratio of yen is 20 percent and that of other currencies is 80 percent. In the short term when prices are sticky, since the pass-through in the case of yen is zero and that of other currencies is one, the implied exchange rate pass-though from the invoice currency is 0*0.2 + 1*0.8 = 0.8.

[32] In fact, the time of settlement after importers receive goods is mentioned in the contract and it includes "at sight" and "90 days after sight".

[33] This result can be obtained as follows. Suppose the long-term is the period in which the total effect of the current exchange rate on current and future import prices is 99.99 percent. Letting n be this period, $\alpha + \alpha\gamma + \alpha\gamma^2 + \cdots + \alpha\gamma^{n-1} > 0.9999(\alpha + \alpha\gamma + \alpha\gamma^2 + \cdots + \alpha\gamma^{\infty})$ holds. Substituting the estimation result of α and γ leads to the result that n is three to seven months.

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Table 1 Exchange Rate Pass-Through:
Benchmark Estimation Results

	Jan. 78-Mar. 02	Jan. 78-Dec. 89 (a)	Jan. 90- Oct. 02 (b)	(b)-(a)
[A] Short-term pass-through				
(OLS estimation)				
Overall	0.63 (0.03)	0.79 (0.05)	0.53 (0.04)	-0.26 [0.00]
Overall excl. fuels	0.65 (0.02)	0.74 (0.04)	0.60 (0.02)	-0.14 [0.00]
Overall excl. fuels & materials	0.61 (0.02)	0.65 (0.04)	0.58 (0.02)	-0.07 [0.05]
(SUR estimation)				
Foods	0.62 (0.04)	0.72 (0.06)	0.57 (0.04)	-0.15 [0.00]
Materials	0.78 (0.04)	0.95 (0.06)	0.66 (0.04)	-0.29 [0.00]
Fuels	0.64 (0.08)	0.94 (0.10)	0.44 (0.12)	-0.50 [0.26]
Chemicals	0.49 (0.04)	0.64 (0.06)	0.40 (0.05)	-0.24 [0.02]
Textiles	0.41 (0.02)	0.31 (0.04)	0.49 (0.03)	0.18 [0.00]
Metals	0.63 (0.06)	0.64 (0.11)	0.66 (0.06)	0.02 [0.50]
Machinery	0.61 (0.02)	0.64 (0.03)	0.60 (0.02)	-0.04 [0.00]
Others	0.62 (0.03)	0.64 (0.05)	0.62 (0.02)	-0.02 [0.00]
[B] Long-term pass-through				
(OLS estimation)				
Overall	1.02 (0.06)	1.42 (0.12)	0.65 (0.05)	-0.76 [0.00]
Overall excl. fuels	0.81 (0.03)	0.97 (0.06)	0.66 (0.03)	-0.31 [0.00]
Overall excl. fuels & materials	0.74 (0.03)	0.86 (0.06)	0.64 (0.03)	-0.22 [0.05]
(SUR estimation)				
Foods	0.79 (0.05)	1.00 (0.09)	0.61 (0.05)	-0.40 [0.00]
Materials	1.11 (0.06)	1.30 (0.09)	0.93 (0.08)	-0.37 [0.00]
Fuels	1.46 (0.21)	2.06 (0.26)	0.94 (0.28)	-1.13 [0.26]
Chemicals	0.78 (0.07)	0.97 (0.10)	0.64 (0.10)	-0.33 [0.02]
Textiles	0.55 (0.04)	0.49 (0.07)	0.59 (0.04)	0.10 [0.00]
Metals	0.92 (0.09)	0.91 (0.15)	0.94 (0.10)	0.03 [0.50]
Machinery	0.76 (0.03)	0.87 (0.05)	0.65 (0.03)	-0.21 [0.00]
Others	0.81 (0.04)	0.91 (0.08)	0.71 (0.03)	-0.20 [0.00]

Notes: Figures in parentheses are standard errors. Figures in brackets are *p*-values for the *F*-test on the null hypothesis that estimates in column (a) and (b) are identical.

Table 2 Decomposition of Changes in Pass-Through between the 1980s and the 1990s

	Changes in pass-through to overall import prices	Contributions of	
		Changes in Import share	Changes in pass-through to category import prices
(Long-term pass through)			
Overall	-0.76	-0.17	-0.51
(contribution of each categories)			
Foods		-0.01	-0.05
Materials		0.02	-0.05
Fuels		-0.02	-0.33
Chemicals		-0.01	-0.02
Textiles		-0.03	0.01
Metals		0.00	0.00
Machinery		-0.11	-0.04
Others		-0.02	-0.02
(Short-term pass-through)			
Overall	-0.26	-0.05	-0.21
(contribution of each categories)			
Foods		0.00	-0.03
Materials		0.00	-0.03
Fuels		0.01	-0.13
Chemicals		0.00	-0.02
Textiles		-0.01	0.01
Metals		0.00	0.00
Machinery		-0.03	-0.01
Others		-0.01	0.00

Note: Sum of the contributions is not necessarily equal to changes in estimated pass-through to overall import prices because of approximation error.

Table 3 Robustness Check (1): Alternative Specification

	Jan. 78-Mar. 02	Jan. 78-Dec. 89 (a)	Jan. 90-Oct. 02 (b)	(b)-(a)
[A] Short-term pass-through				
(OLS estimation)				
Overall	0.70 (0.04)	0.87 (0.07)	0.58 (0.04)	-0.29 [0.00]
Overall excl. fuels	0.67 (0.02)	0.79 (0.04)	0.60 (0.02)	-0.19 [0.00]
Overall excl. fuels & materials	0.63 (0.02)	0.69 (0.04)	0.59 (0.02)	-0.10 [0.00]
(SUR estimation)				
Foods	0.66 (0.04)	0.75 (0.07)	0.59 (0.04)	-0.16 [0.35]
Materials	0.83 (0.04)	1.04 (0.07)	0.69 (0.05)	-0.35 [0.00]
Fuels	0.74 (0.10)	1.01 (0.13)	0.53 (0.15)	-0.48 [0.00]
Chemicals	0.54 (0.05)	0.75 (0.07)	0.40 (0.06)	-0.35 [0.00]
Textiles	0.41 (0.03)	0.32 (0.05)	0.49 (0.03)	0.17 [0.00]
Metals	0.72 (0.07)	0.79 (0.13)	0.71 (0.07)	-0.08 [0.24]
Machinery	0.62 (0.02)	0.65 (0.03)	0.60 (0.02)	-0.06 [0.00]
Others	0.63 (0.03)	0.64 (0.06)	0.62 (0.02)	-0.02 [0.00]
[B] Long-term pass-through				
(OLS estimation)				
Overall	1.00 (0.25)	1.50 (0.43)	0.57 (0.25)	-0.93 [0.00]
Overall excl. fuels	0.74 (0.15)	0.91 (0.29)	0.59 (0.15)	-0.33 [0.00]
Overall excl. fuels & materials	0.69 (0.15)	0.83 (0.29)	0.58 (0.14)	-0.25 [0.00]
(SUR estimation)				
Foods	0.67 (0.24)	0.79 (0.41)	0.54 (0.27)	-0.25 [0.35]
Materials	0.85 (0.27)	1.13 (0.42)	0.63 (0.32)	-0.50 [0.00]
Fuels	1.36 (0.65)	2.30 (0.81)	0.56 (0.91)	-1.74 [0.00]
Chemicals	0.59 (0.29)	0.87 (0.45)	0.31 (0.36)	-0.56 [0.00]
Textiles	0.52 (0.16)	0.45 (0.29)	0.59 (0.17)	0.14 [0.00]
Metals	0.77 (0.42)	0.99 (0.79)	0.64 (0.42)	-0.35 [0.24]
Machinery	0.75 (0.12)	0.90 (0.20)	0.62 (0.13)	-0.28 [0.00]
Others	0.77 (0.18)	0.93 (0.35)	0.63 (0.15)	-0.30 [0.00]

Notes: Figures in parentheses are standard errors. Figures in brackets are *p*-values for the *F*-test on the null hypothesis that estimates in column (a) and (b) are identical.

Table 4　Robustness Check (2): Alternative Series of Effective Exchange Rate

	Short-term pass-through		Long-term pass-through	
(OLS estimation)				
Overall	0.54	(0.04)	0.68	(0.06)
Overall excl. fuels	0.60	(0.02)	0.68	(0.03)
Overall excl. fuels & materials	0.58	(0.02)	0.66	(0.03)
(SUR estimation)				
Foods	0.52	(0.04)	0.57	(0.05)
Materials	0.66	(0.04)	0.91	(0.07)
Fuels	0.37	(0.11)	0.86	(0.29)
Chemicals	0.38	(0.06)	0.68	(0.12)
Textiles	0.46	(0.02)	0.55	(0.04)
Metals	0.93	(0.09)	1.32	(0.14)
Machinery	0.62	(0.02)	0.67	(0.03)
Others	0.62	(0.03)	0.71	(0.04)

Notes: 1. Figures in parentheses are standard errors.
2. Sample Period is Jan. 90-Dec. 01

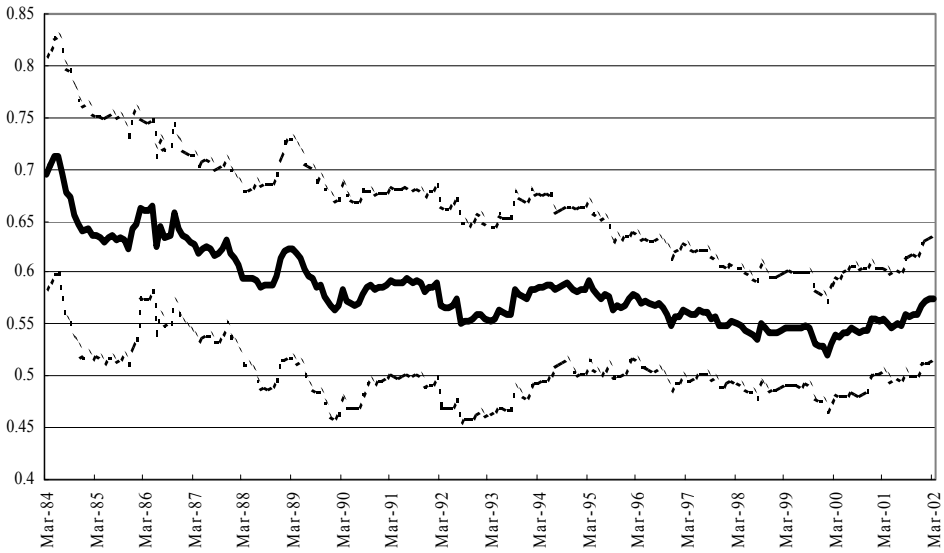
Table 5 Robustness Check (3): Alternative Series of Import Prices

	78/1Q-02/4Q	78/1Q-89/4Q (a)	90/1Q- 02/4Q (b)	(b)-(a)
[A] Short-term pass-through				
(OLS estimation)				
Overall	0.84 (0.07)	1.13 (0.10)	0.69 (0.07)	-0.44 [0.00]
(SUR estimation)				
Foods	0.79 (0.06)	0.90 (0.11)	0.69 (0.05)	-0.21 [0.21]
Materials	0.93 (0.07)	1.22 (0.12)	0.72 (0.08)	-0.50 [0.02]
Fuels	0.95 (0.21)	1.79 (0.27)	0.46 (0.26)	-1.33 [0.00]
Manufactures	0.85 (0.06)	0.97 (0.08)	0.75 (0.08)	-0.22 [0.00]
[B] Long-term pass-through				
(OLS estimation)				
Overall	1.12 (0.11)	1.56 (0.12)	0.77 (0.11)	-0.79 [0.00]
(SUR estimation)				
Foods	0.85 (0.07)	0.89 (0.12)	0.76 (0.07)	-0.13 [0.21]
Materials	1.08 (0.10)	1.39 (0.15)	0.79 (0.12)	-0.60 [0.02]
Fuels	1.34 (0.32)	2.83 (0.51)	0.48 (0.12)	-2.35 [0.00]
Manufactures	0.86 (0.07)	1.13 (0.11)	0.66 (0.08)	-0.47 [0.00]

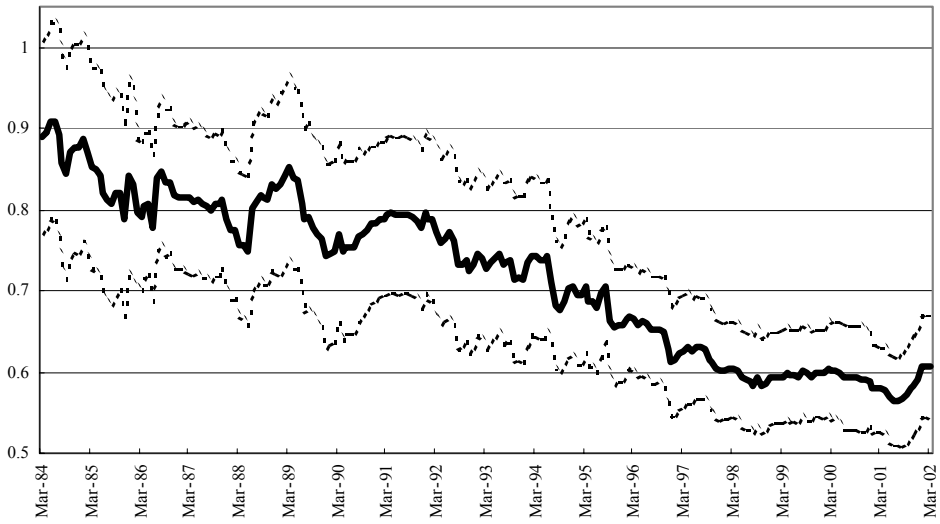
Notes: Figures in parentheses are standard errors. Figures in brackets are *p*-values for the *F*-test on the null hypothesis that estimates in column (a) and (b) are identical.

Figure 1 Exchange Rate Pass-through over Time
(Overall excluding Fuels and Materials/IMF Nominal Effective Exchange Rate)

[A] Short-term pass-through coefficient

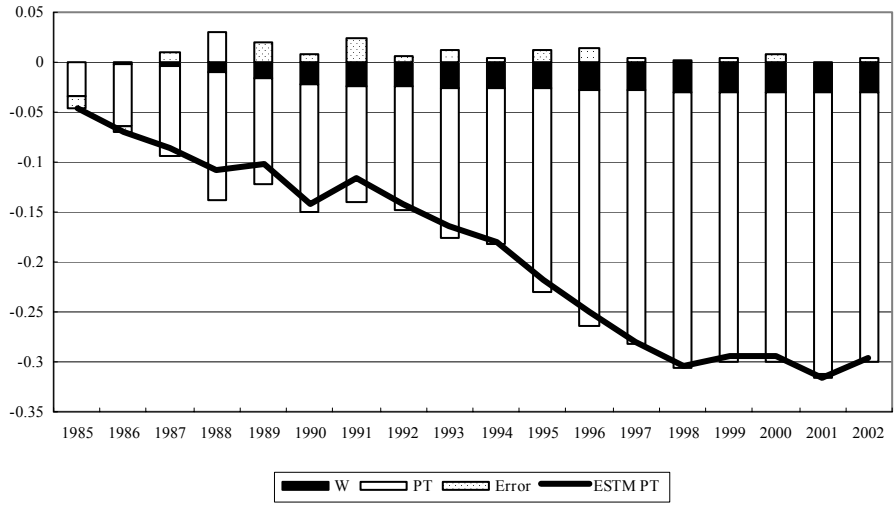


[B] Long-term pass-through coefficient



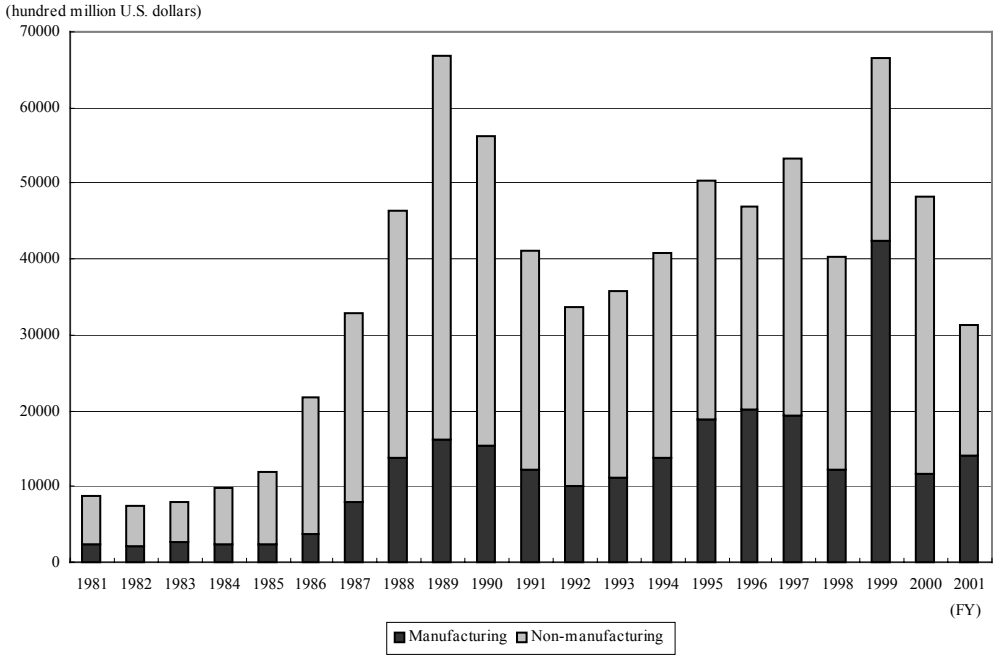
Notes: 1. Rolling regressions on Lag 1 are conducted with sub-samples of 72 months ending at each month on the horizontal axis.
2. Dotted lines respectively indicate upper and lower bounds of the 95 percent confidence interval.

Figure 2　Factor Decomposition:
Cumulative Change in Long-term Exchange Rate Pass-Through
(Overall excluding Fuels and Materials)



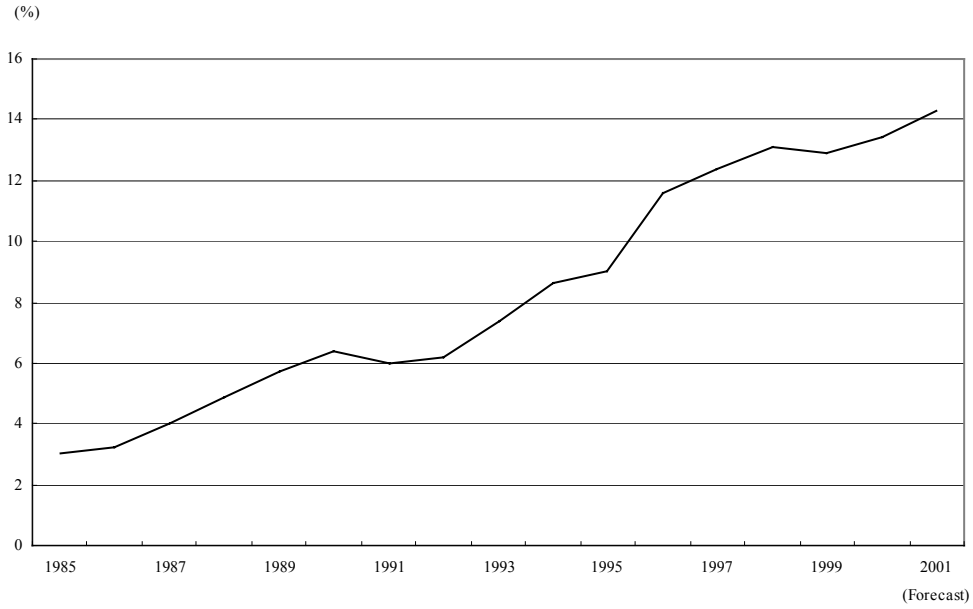
Notes: W: contribution of import composition changes to the cumulative changes in pass-through, PT: cumulative change in pass through for each goods; Error: estimated pass-through – W - PT, ESTM PT: estimated pass through.

Figure 3　The Value of Japan's Foreign Direct Investment



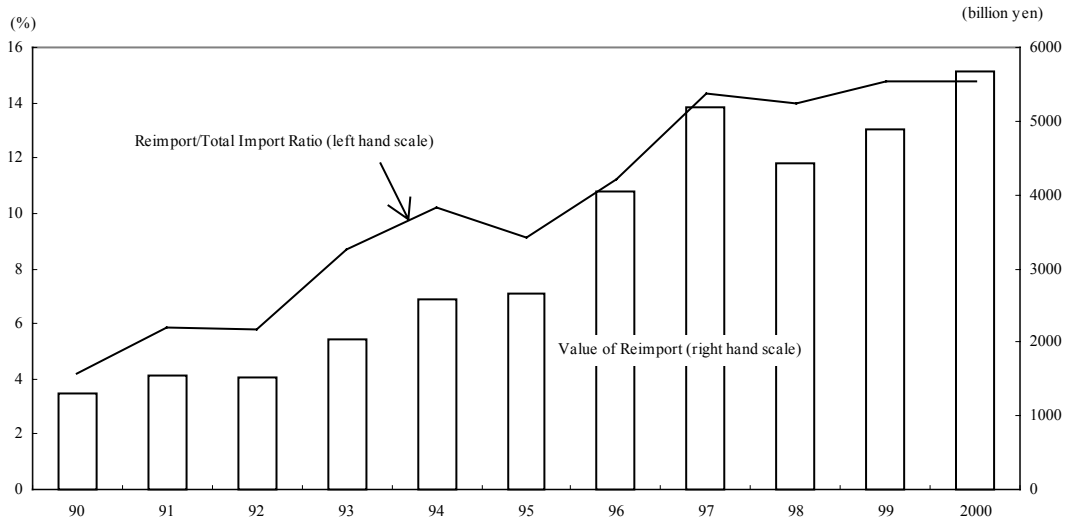
Source: Ministry of Economy, Trade, and Industry, *Basic Survey of Overseas Business Activities*.

Figure 4　Overseas Production Ratio of Japanese Manufacturers



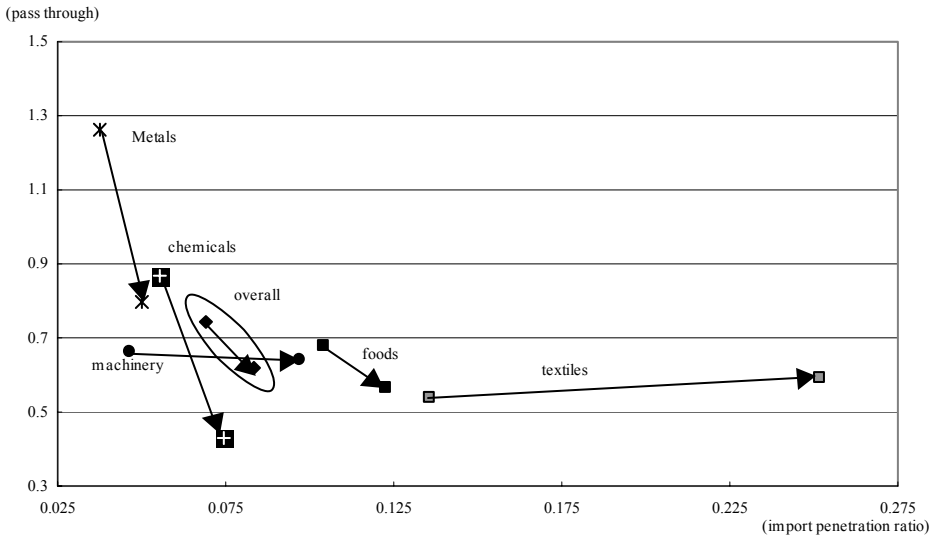
Source: Ministry of Economy, Trade, and Industry, *Basic Survey of Overseas Business Activities*.

Figure 5　Japan's Re-imports



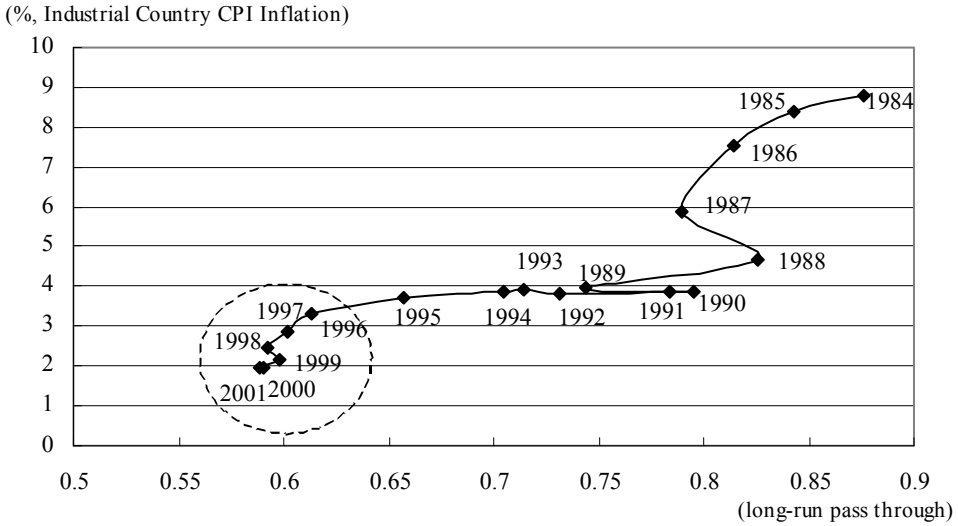
Source: Ministry of Economic, Trade, and Industry, *Basic Survey of Overseas Business Activities*.

Figure 6 Import Penetration Ratio and Exchange Rate Pass-Through



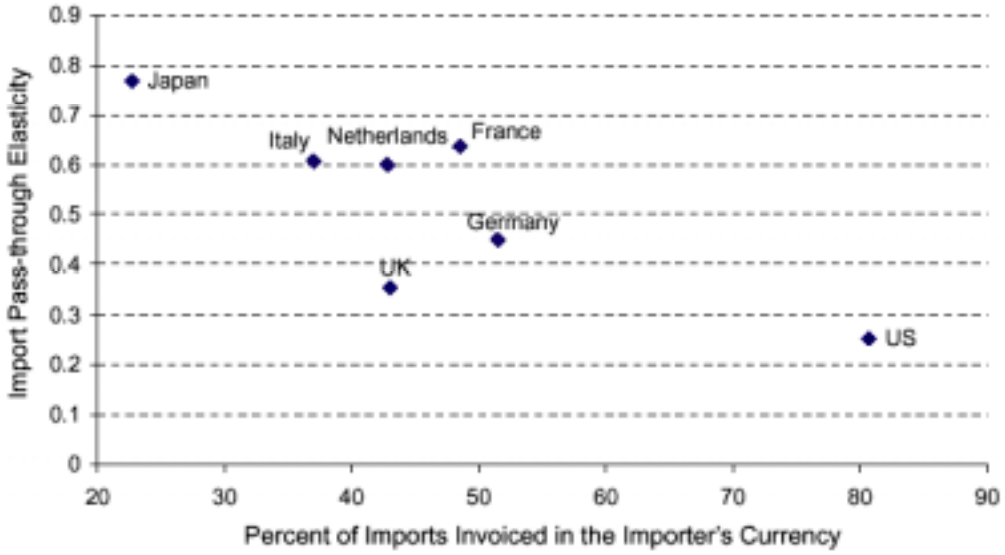
Notes: 1. Import penetration ratio is calculated in 6 groupings (Overall, Foods, Chemicals, Textiles, Metals, and Machinery) that match CGPI groupings.
2. Arrows indicate direction of changes from the 1980s to 1990s.
Source: Ministry of Economy, Trade, and Industry, "Industrial Statistics."

Figure 7 World Producer Price Index and Long-run Pass-Through



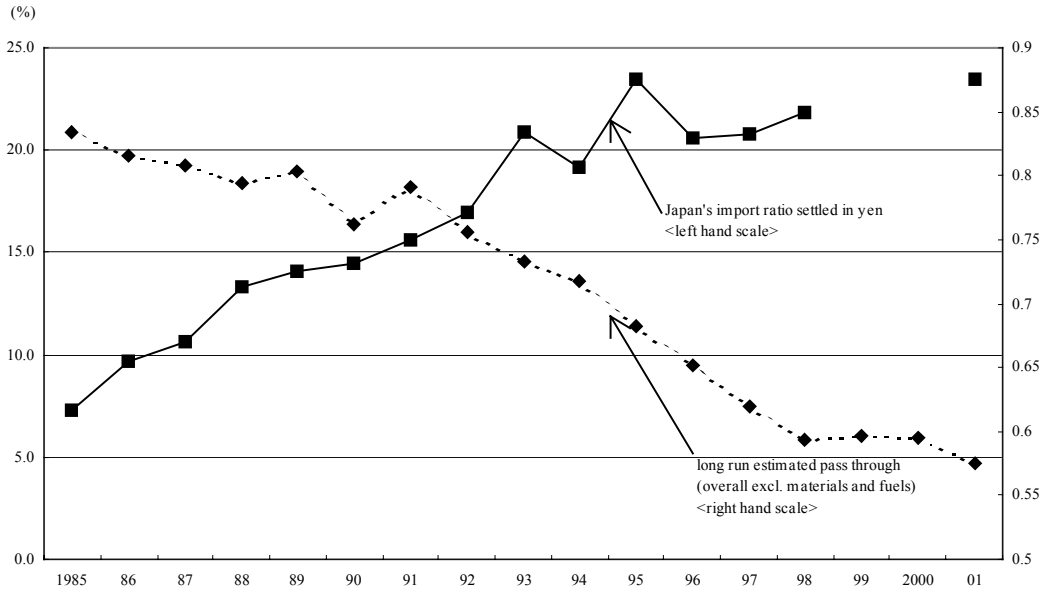
Notes: 1. Long-run pass-through (overall excl. fuels and materials) is the estimated coefficient of rolling regression in the section3. Numbers in the figure exhibit the sample end of estimation. For example, long-run pass-through in 2001 means the coefficient estimated using data from Jan. 1996 to Dec. 2001.
2. Inflation is an average over the sample period of corresponding estimated pass-through.
Source: International Monetary Fund, *International Financial Statistics*.

Figure A-1 Invoice Currency and Exchange Rate Pass-Through



Source: Bacchetta and van Wincoop (2002).

Figure A-2 Japan's Import Ratio Settled in Yen and Estimated Long-term Pass-through



Note: Figures from 1995 to 1997 are averages of numbers in the March and September survey.
Sources: Ministry of Economy, Trade, and Industry, *Survey of Import-Export Settlement Currency*; Sources: Ministry of Economic, Trade, and Industry, *Survey of import export settlement currency*, Ministry of Finance, *Trade Ratio by Settlement Currency*; Fukuda and Ji (1994).

Figure A-3 Estimated Long-term Pass-through and Implied Pass-through from Invoice Currency