Exchange Rate, Expected Profit, and Capital Stock Adjustment:[*] Japanese Experience

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Abstract

This paper empirically investigates the impact of exchange rate shocks on corporate investment. An intertemporal optimization model is developed in which an individual corporation in an open economy adjusts its capital stock according to the Tobin's q, which represents the future stream of the profit rate and changes by the real exchange rate. By explicitly considering the marginal q, the transmission mechanism from real exchange rate shocks to investment dynamics via expected profitability is examined based on the Vector Autoregressive model. Empirical evidence suggests that the depreciation of the Japanese yen increases the expected profitability of the firm and stimulates corporate investment, especially in the machinery sector. This characteristic basically corresponds to the structure of external exposure and offers an important finding from the viewpoint of Japanese macroeconomic fluctuations.

Keywords: Intertemporal Optimization, Marginal q, Pass-Through, Export Exposure

JEL classification number: F40, E22, C32

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1. Introduction

In 1973, the Japanese currency switched from a fixed exchange rate, pegged at 360 yen to the U.S. dollar, to a floating exchange rate. Since then, the yen has appreciated its current high level and has experienced wide fluctuations with the U.S. dollar. Today, the yen–U.S. dollar fluctuations are the most volatile among foreign currency pairs[1]. On September 22, 1985, a Group of 5 developed countries (G5) agreed on the depreciation of the U.S. dollar in the "Plaza Accord." After this agreement, the yen appreciated sharply inducing a decline in Japanese exports. This was cited as the major factor behind the 1986 recession. Until then, Japanese economic growth had been export-oriented. As a result, in 1985, the existing economic mechanism started to buckle under the rapid appreciation of the yen. Some Japanese firms began shifting their production bases overseas where production costs were relatively cheap. This was the beginning of the exodus of production facilities overseas and has been called the "hollowing out of industry." The increase of overseas production has reaccelerated since 2000.

Although there have been large exchange rate fluctuations since the introduction of the floating exchange rate system, there remain theoretical and empirical questions on the implications of these movements for real economic activity, especially equipment investment. Generally speaking, investment plays a central role in both the growth of and fluctuations in the macroeconomy. In an open economy like Japan, however, it seems that external shocks, such as the rapid appreciation of the yen, have notable effects on equipment investment.

In a small number of theoretical literatures, Brock (1988) incorporated traded and non-traded investment into the infinite-horizon optimizing model. By including the non-tradable sector, he emphasized the endogenous determination of the relative prices of non-traded goods, referred to as the real exchange rate. Murphy (1993) analyzed the dynamics of the real exchange rate and equity prices for a small open economy based on the intertemporal optimizing model.

Japanese empirical research focusing on the impact of exchange rate shocks on corporate investment has been seen in increasing numbers since the end of the 1980s, when the yen began to appreciate[2]. Tokui and Suzuki (1990) estimated the reduced form between the real exchange rate and equipment investment in the Japanese machinery sector. Their empirical results showed significant negative effects of exchange rate appreciation on investment. Tokui and Miyagawa (1991) constructed the imperfect competitive static model and induced an analytical relationship between exchange rate and investment. They followed this with several empirical investigations and their study undertook several important steps. Eichengreen and Hatase (2005) applied the

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[1] This finding is also discussed in Bank of Japan(2000)/

[2] Miyagawa (1997) made a comprehensive survey in this area. It is worth noting that if investment is affected by the real exchange rate, the framework of the neoclassical saving-investment balance approach, in which investment and saving are not influenced by the real exchange rate, may be modified. The detailed explanation of this point is summarized in Matsubayashi (2006).

theoretical framework developed in Tokui and Miyagawa (1991) to investigate whether the real effective exchange rate had a negative impact on Japanese investment during the fixed exchange rate system in Japan. Miyagawa and Takeda (1994) extended Brock (1988) and Murphy (1993) to incorporate the discontinuous adjustment cost of investment. Although the model developed in their study determines the real exchange rate and investment endogenously, it does not directly investigate the relationship between the real exchange rate and investment. Its main focus is on capital accumulation in the trade balance, especially discontinuous adjustment costs. Nonetheless, their study was the first research to pay substantial attention to the effect of the real exchange rate on expected profitability.

Outside Japan, only a few attempts have been made. Goldberg (1993) investigated the linkage between exchange rate and investment in the U.S. He found that the depreciation of the U.S. dollar stimulated capital stock adjustment during the 1970s. Campa and Goldberg (1995) introduced a new measure of external exposure, which emphasized the exposure to external markets through both export sales and import inputs into production, and used this measure to explore the linkage between exchange rate and investment in the U.S. Campa and Goldberg (1999) extended these results and estimated their model for the two-digit manufacturing sectors of the U.S., the U.K., Canada, and Japan. They found that exchange rates tended to have insignificant effects on investment rates in high markup sectors. On the other hand, the response of investment to the exchange rate was strong in low markup sectors. Moreover, there was no significant effect for either low or high markup industries in Canada.

Nucci and Pozzolo (2001) investigated investment responsiveness to exchange rate fluctuations using firm-level panel data in the Italian manufacturing industry. Their results support the view that a depreciation of the exchange rate has a positive effect on investment through the revenue channel and a negative effect through the cost channel.

Harchaoui et al. (2005) examined the relationship between exchange rate and investment using industry level data for Canadian industries. They showed that the overall effect of exchange rates on total investment is insignificant. Their investigation also revealed that exchange rate depreciation had a positive effect on total investment when exchange rate volatility is low.

Based on the above studies, this paper re-examines the impact of exchange rate shocks on corporate investment. Here there are three distinct analytical differences from earlier studies. First, an intertemporal optimization model is developed in which an individual corporation in an open economy adjusts its capital stock according to Tobin's q under imperfect competition. In addition, there now exists the development of the New Open Economy Macroeconomics. The emphasis of this new direction is on the pricing to market (PTM) behavior and on the pass-through of the exchange rate into export and import prices under imperfect competitive markets. In pioneering works, Campa and Goldberg (1995, 1999) derived a theoretical derivation of the exchange rate–investment relationship under imperfect competition and investigated it empirically. Although their studies may have provided an attractive direction for future research, it did not explicitly consider Tobin's q, which is a main determinant of investment decisions. Schiantarelli and Geogoutsos (1990) and Ogawa and Kitasaka (1999) are examples of the approach that estimates the Tobin's q type investment function under the assumption that the product market is imperfectly competitive. This paper constructs the theoretical relationship between Tobin's q and investment in an open economy with imperfect competition.

Second, we calculate a series of marginal q in twelve industries with a time series analysis. Abel and Blanchard (1986) and Ogawa and Kitasaka (1999) have already specified the stochastic structure underlying the discount factor and profit rate and constructed a series of marginal q. The approach in this paper follows basically the same track. By explicitly considering the marginal q in an open economy model, this paper examines the transmission mechanism from real exchange rate shocks to investment dynamics via expected profit (not present profit) based on the Vector Autoregressive model (VAR). Accordingly, if the real exchange rate shocks become more persistent, then more careful investment decisions must be made. This means that these features are essentially dynamic. Since little attention has been paid to this point, the empirical methodology adopted in this paper is attractive and actually produces some interesting results.

Third, this model is able to shed light on how investment sensitivity varies across industries. In this paper, we consider two main factors: export exposure and pricing power. In general, export-oriented firms are more likely to be affected by exchange rate fluctuations, because the direct effect on export revenue is greater than the substitution effect in the domestic market. The second feature is related to the degree of monopoly power, which is proxied by the price-over-cost markup ratio. When the exchange rate effects on product demand are identical in high and low markup industries, high-markup firms will dampen the exchange rate effect on profitability by adjusting their output prices and markups. Therefore, the lower the industry markup ratio, the stronger the exchange rate effect on profits, and hence on investment.

The remainder of this paper is organized as follows. In Section 2, the basic framework of this analysis is presented. In Section 3, a data series is calculated. In Section 4, the VAR system is employed and dynamic simulations are performed. In Section 5, the structures of external exposure are carefully examined. Finally, In Section 6, our conclusions are presented.

2. Model

This section extends the open economy model developed by Campa and Goldberg (1995), (1999), and Nucci and Pozzolo (2001), in that both input and output prices are affected by the exchange rate. A representative firm produces one output for the domestic and foreign market with three types of inputs: quasi-fixed capital (K), domestic variable input (L), and foreign variable input (L^*). The firm maximizes the expected present value of the discounted sum of future dividend (D) subject to a capital stock accumulation defined as follows:

$$V_t = E_t\left[\sum_{j=0}^{\infty}\beta_{t+j}D_{t+j}\right] \tag{1}$$

$$K_t = (1-\delta)K_{t-1} + I_t \tag{2}$$

$$D_{t+j} = X_{t+j} - p^I_{t+j}I_{t+j} - p^I_{t+j}G\left(I_{t+j}, K_{t+j}\right) \tag{3}$$

$$X_{t+j} = p\left(q_{t+j}, e_{t+j}\right)q_{t+j} + p^*\left(q^*_{t+j}, e_{t+j}\right)q^*_{t+j} - w_{t+j}L_{t+j} - e_{t+j}w^*_{t+j}L^*_{t+j} \tag{4}$$

$$\beta_{t+j} = \prod_{i=1}^{j}\left(1+r_{t+i}\right)^{-1} \qquad j = 1,2,.... \qquad \beta_t \equiv 1$$

D_{t+j}, net cash flow;

X_{t+j}, total revenue;

I_{t+j}, equipment investment;

$G\left(I_{t+j}, K_{t+j}\right)$, adjustment costs in changing the capital stock;

K_{t+j}, capital stock at the end of t + j;

p^I_{t+j}, price of investment good (deflated by general price index);

r_{t+1}, one period discount rate in period t;

p_{t+j}, price of good in the domestic market (deflated by general price index);

p^*_{t+j}, price of good in the foreign market (deflated by general foreign price index);

q_{t+j}, quantities supplied by the firm to the domestic market;

q^*_{t+j}, quantities supplied by the firm to the foreign market;

L_{t+j}, quantities of domestic variable input;

L^*_{t+j}, quantities of foreign variable input;

w_{t+j}, unit cost of the domestic inputs (deflated by general price index);

w^*_{t+j}, unit cost of the foreign inputs (deflated by general foreign price index);

e_{t+j}, real exchange rate defined in terms of domestic currency per unit of foreign exchange (deflated by general price index in domestic and foreign markets);

δ, physical depreciation rate; and

$E_t[\ ]$, conditional expectation operator upon the information available in period t.

Following the standard formation in the investment model (see Hayashi (1982)), it is assumed that there are convex costs in adjusting the capital stock. The cost of adjustment function is linear homogeneous in investment (I) and capital stock (K). It is specified as follows:

$$G(I_t, K_t) = \frac{\phi}{2}\left(\frac{I_t^2}{K_2}\right) \tag{5}$$

The firm produces output for both domestic and foreign markets by constant returns to scale production ($F(\quad)$)

$$q_t + q_t^* = F(K_t, L_t, L_t^*) \tag{6}$$

In equation (4), $p(\cdot)$ and $p^*(\cdot)$ are the domestic and foreign demand curves facing the firm. These functions depend on both the quantities supplied by the firm to each market and the exchange rate. The exchange rate directly influences prices because fluctuations in the exchange rate alter the demand for the firm's products due to changes in the number of competitors in both domestic and foreign markets.

Maximizing Equation (1) subject to Equation (3) yields the following conditions:

$$\left(1-\eta^{-1}\right)p_t = \left(1-\eta^{*-1}\right)e_t p_t^* \tag{7}$$

$$\left(1-\eta^{-1}\right)p_t = \left(1-\eta^{*-1}\right)e_t p_t^* \tag{8}$$

$$\left\{\left(1-\eta^{*-1}\right)p_t^*\right\}F_{L_t^*} = e_t w_t^* \tag{9}$$

$$\frac{I_t}{K_t} = \frac{1}{\phi}\left(\frac{\lambda_t}{p_t^I} - 1\right) \tag{10}$$

$$\lambda_t = E_t \sum_{j=0}^{\infty} \beta_{t+j} (1-\delta)^j \left\{ X_{K_{t+j}} + \frac{\phi}{2} p_{t+j}^I \left(\frac{I_{t+j}}{K_{t+j}} \right)^2 \right\} \tag{11}$$

Equation (7) shows that marginal revenue from the domestic market equals marginal revenue from the foreign market. Equations (8) and (9) state that the marginal cost of domestic and foreign variable inputs equals the value of their marginal productivities. λ_t is the Lagrange multiplier associated with the above optimization. Equation (10) indicates that the investment is positive when λ exceeds 1. Equation (11) represents that q is the discounted stream of the future marginal profit of capital stock, and the discounted stream of its marginal contributions to the reduction in future adjustment costs.

After some modification, Equation (11) is rewritten as follows:

$$\begin{aligned} \lambda_t = {} & E_t\left[\sum_{j=0}^{\infty} \beta_{t+j} (1-\delta)^j \pi_{t+j}\right] - E_t\left[\sum_{j=0}^{\infty} \beta_{t+j} (1-\delta)^j \left(\eta^{-1} \frac{p_{t+j} q_{t+j}}{K_{t+j}}\right)\right] \\ & - E_t\left[\sum_{j=0}^{\infty} \beta_{t+j} (1-\delta)^j \left(\eta^{*-1} \frac{e^*_{t+j} p^*_{t+j} q^*_{t+j}}{K_{t+j}}\right)\right] + E_t\left[\sum_{j=0}^{\infty} \beta_{t+j} (1-\delta)^j \frac{\phi}{2} p^I_{t+j} \left(\frac{I_{t+j}}{K_{t+j}}\right)^2\right] \end{aligned} \tag{12}$$

$$\pi_{t+j} = \frac{p_{t+j} q_{t+j} + e_{t+j} p^*_{t+j} q^*_{t+j} - w_{t+j} L_{t+j} - e_{t+j} w^*_{t+j} L^*_{t+j}}{K_{t+j}} \tag{13}$$

The economic implication of λ is shown in Equation (12). The first term on the right hand side is the discounted stream of future profit rate. The fourth term is the discounted stream of its marginal contributions to the reduction in future adjustment costs. The second and third terms capture the discounted stream of future monopolistic rent.

Monopolistic rent is regarded as the distortional factor arising from profit under imperfect competition. In the case of perfect competition in the domestic and foreign market, the price elasticities of demand (η and η^*) are infinite, and therefore monopolistic rents disappear. As shown in Equation (12), the economic implication of q in the open macroeconomy with imperfect competition is more complicated than in the standard formation. To avoid complexity in the discussion below, we concentrate on the movements of the first term of Equation (12).

We take the Taylor expansion around the mean level of the real exchange rate ($\overline{e}$) in Equation (8). The first term on the right hand side in Equation (12) is expressed as follows[3].

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[3] * shows that the expansion term is evaluated by the mean level.

$$E_t\left\{\sum_{j=0}^{\infty}\beta_{t+j}(1-\delta)^j\pi_{t+j}\right\} \cong E_t\left\{\sum_{j=0}^{\infty}\beta_{t+j}(1-\delta)^j\pi(\bar{e})\right\}+\sum_{i=0}^{\infty}E_t\left\{\sum_{j=i}^{\infty}\beta_{t+j}(1-\delta)^j\frac{\partial\pi_{t+j}}{\partial e_{t+j}}\right\}\Bigg|_*(e_{t+i}-\bar{e}) \tag{14}$$

In the case of i = 0, Equation (14) is rewritten as

$$E_t\left\{\sum_{j=0}^{\infty}\beta_{t+j}(1-\delta)^{t+j}\frac{\partial\pi_{t+j}}{\partial e_{t+j}}\frac{\partial e_{t+j}}{\partial e_t}\right\}\Bigg|_*(e_t-\bar{e}) \tag{15}$$

In Equation (15), $\partial e_{t+j}/\partial e_t$ indicates the persistency effect and it depends on the time series property of e_t[4]. $\partial\pi_{t+j}/\partial e_{t+j}$ shows the profit effect and its sign can be identified by the partial difference by e_{t+j} in Equation (15). First, the time series property of e_t is specified by the following autoregressive process:

$$e_t = b_0+\sum_{k=1}^{m}b_k e_{t-k}+\varepsilon_t \tag{16}$$

$$E_{t-1}(\varepsilon_t)=0, E_{t-1}\left(\varepsilon_t^{\,2}\right)=\sigma^2$$

Equation (16) is expressed by matrix representation as follows:

$$D_t = MD_{t-1}+\theta+\xi_t \tag{17}$$

$$D_t^{'} = (e_t, e_{t-1}, \ldots\ldots, e_{t-k+1})$$

$$\theta^{'} = (b_0, 0, \ldots\ldots, 0)$$

$$\xi_t^{''} = (\varepsilon_t, 0, \ldots\ldots, 0)$$

$$M = \begin{bmatrix} b_1 & b_2 & \ldots & b_k \\ 1 & 0 & \ldots & 0 \\ . & 1 & .. & 0 \\ 0 & \ldots & 1 & 0 \end{bmatrix}$$

By forward recursive substitution and some modifications, Equation (17) is written as

[4] The case of i = 0 is taken to simplify the analysis.

$$e_{t+j} = c^{'} M^{j} D_{t} + c^{'}(I - M)\theta + c^{'}\left(M^{j-1}\varepsilon_{t+1} + M^{j-2}\varepsilon_{t+2} + ... + \varepsilon_{t+j}\right) \tag{18}$$

$$c^{'} = (1,0,.....,0)$$

Then the persistency effect is calculated with Equation (18).

$$\frac{\partial e_{t+j}}{\partial e_{t}} = c^{'} M^{j} c \tag{19}$$

The above magnitude can be measured numerically if the stochastic process expressed by Equation (16) is estimated and the parameter estimates are correctly obtained.

Substituting Equation (19) into Equation (15) with some additional modifications yields the following formulation:

$$\begin{aligned} E_{t}\left\{\sum_{j=0}^{\infty} \beta_{t+j}(1-\delta)^{j} \pi_{t+j}\right\} &\cong E_{t}\left\{\sum_{j=0}^{\infty} \beta_{t+j}(1-\delta)^{j} \pi(\bar{e})\right\} \\ &+ \sum_{i=0}^{\infty} E_{t}\left\{\sum_{j=i}^{\infty} \beta_{t+j}(1-\delta)^{j} \frac{\partial \pi_{t+j}}{\partial e_{t+j}} c^{'} M^{j} c\right\}\Bigg|_{*} \left(c^{'} M^{i}\left(D_{t} - \bar{D}\right) + c^{'} \sum_{s=0}^{i-1} M^{i} \xi^{'}_{t+i-s}\right) \end{aligned} \tag{20}$$

$$\frac{\partial \pi_{t+j}}{\partial e_{t+j}} = A\left\{(1-\omega)\left[\eta_{p.e}\left(1-\eta_{q.p}\right) - \eta_{MKUP.e}\right] + \omega\left[1 - \eta_{p^{*}.e}\left(1-\eta_{q^{*}.p^{*}}\right) - \eta_{MKUP^{*}.e}\right] - \theta\mu\right\}, \tag{21}$$

where

$\omega = \dfrac{ep^{*}q^{*}}{TR}$: share of total revenues associated with foreign sales;

$\theta = \dfrac{wL + ew^{*}L^{*}}{TR}$: share of total costs associated with total revenues;

$\mu = \dfrac{ewL}{wL + ew^{*}L^{*}}$: share of imported inputs in total production costs;

$\eta_{p.e} = \dfrac{\partial p}{\partial e}\dfrac{e}{p}$: exchange rate elasticity of price in the domestic market;

$\eta_{p^{*}.e} = -\dfrac{\partial p^{*}}{\partial e}\dfrac{e}{p^{*}}$: exchange rate elasticity of price in the foreign market;

$\eta_{q.p} = -\dfrac{\partial q}{\partial p}\dfrac{p}{q}$: price elasticity of demand in the domestic market;

$\eta_{q^{*}.p^{*}} = -\dfrac{\partial q^{*}}{\partial p^{*}}\dfrac{p^{*}}{q^{*}}$: price elasticity of demand in the foreign market;

$\eta_{MKUP.e} = -\dfrac{\partial\left(MKUP^{-1}\right)}{\partial e}\dfrac{e}{MKUP^{-1}}$: exchange rate elasticity of markup in the domestic market;

$\eta_{MKUP^*.e} = -\frac{\partial\left(MKUP^{*-1}\right)}{\partial e}\frac{e}{MKUP^{*-1}}$: exchange rate elasticity of markup in the foreign market.

$$MKUP^{-1} = 1 - \eta^{-1} \qquad MKUP^{*^{-1}} = 1 - \eta^{*^{-1}} \qquad A = \frac{TR}{eK}$$

Based on Equations (20) and (21), there seem to be three main channels by which the fluctuations of the real exchange rate affect capital stock adjustment. First, if exchange rate fluctuations persist over the long run, an increase of e_t in period t may affect the real exchange rate in t + j (e_{t+j}). We call this effect the "persistency effect." The size of the persistency effect is captured by $c^{'}M^{j}c$ in Equation (20).

Second, the export and import structure will affect the profitability of firms, and therefore affect investment. We call this the "trade structure effect." In general, export-oriented firms are more likely to be affected by exchange rate movements, because the direct valuation effect on export revenue is greater than the substitution effect in the domestic market. The size of this effect is given by ω, which is the share of total revenues associated with foreign sales. On the other hand, the higher the share of imported inputs in total production costs (μ), the larger the increase in the negative effect when the exchange rate depreciates. Moreover, this effect is amplified by the share of total costs associated with total revenues (θ). Therefore, the trade effect consists of μ and θ.

Third, the degree of the firm's monopoly power contributes to determining the effect of exchange rate change on profitability and investment. We call this the "monopoly power effect." When focusing on Equation (21), the monopoly power effect is determined by the exchange rate elasticity of price in the domestic market ($\eta_{p.e}$), the exchange rate elasticity of price in the foreign market ($\eta_{p^*.e}$), the exchange rate elasticity of markup in the domestic market ($\eta_{MKUP.e}$), and the exchange rate elasticity of markup in the foreign market ($\eta_{MKUP^*.e}$). Here we consider the case in which the exchange rate appreciates (the value of e decreases). The appreciation of the exchange rate increases the price at the same rate in the foreign market (this means that $\eta_{p^*.e} > 0$). At first, the price increase revenue (p^*q^*) in the foreign market rises. Therefore, the profit rate will not decrease at the same rate as the exchange rate appreciation. However, the rise of price in the foreign market gradually decreases the foreign demand (the absolute value of reduction is measured by $\eta_{p^*.e}\ \eta_{p^*.e} \times \eta_{q^*.p^*}$) and the appreciation of the exchange rate reduces the profit rate. Therefore, if the value of $\eta_{q^*.p^*}$ is provided, then the greater is the $\eta_{p^*.e}$, the smaller is $\partial\pi/\partial e$. When firms have monopolistic power in the foreign market, they do not perfectly pass through the change in the exchange rate into the price in the foreign market, and $\eta_{p^*.e}$ is relatively low. In that case, $\partial\pi/\partial e$ is smaller than in the case of perfect pass-through. Next we focus on the parameter $\eta_{MKUP^*.e}$. Monopolistic power is commonly proxied by the price-over-cost markup ratio. In an oligopolic market structure with a high markup ratio, firms will dampen the exchange rate effect on profitability by adjusting markups. In contrast, in highly competitive industries, firms have very limited pricing power and prices are set near the marginal cost (hence $\eta_{MKUP^*.e}$ is small). Therefore, adjustments to exchange rates are largely reflected in changes in the firm's profit. To sum up, the lower the industry markup ratio in the foreign market, the stronger the exchange rate effect on profitability, and hence on investment[5)].

Taking into account the above analytical considerations, an appreciation of the real exchange rate may decrease investments, but this cannot be recognized precisely. Therefore, detailed empirical examinations are indispensable in the following sections.

3.Data

The main variables in this study are the investment-capital ratio, the real exchange rate, and the marginal q. This section introduces how these variables are calculated[6)].

The above theoretical model assumes that corporate investments consist of only non-residential buildings and structures. In fact, this data is chosen from the Quarterly Report of Financial Statements of Incorporated Business (compiled by the Ministry of Finance). Twelve industries are selected over the period from 1975 (Q1) to 2005 (Q4). They comprise chemicals, steel, nonferrous metals, fabricated metals, industrial machinery, transportation machinery, electrical machinery, precision machinery, wholesale, construction, and electricity. The sample period basically corresponds to the period of the floating exchange rate regime in which there have been remarkable exchange rate fluctuations for about thirty years.

Table 1 summarizes the basic statistics on the investment-capital ratio in each industry. The average value of the machinery sector is larger than that of the materials sectors and

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5) In this situation, firms reduce the markup ratio and do not change the price. Krugman (1987) calls this phenomenon "pricing to market" (PTM).

6) The details of the calculations are provided in the Appendix.

non-manufacturing industries. This finding shows that the investments in the value-added industries represented by precision machinery and electrical machinery are relatively high[7]. The volatility measured by the coefficient of the variation differs from industry to industry. The steel industry and construction industry, in which investments are large, each adjust their capital stock frequently.

The exchange rate is the real effective exchange rate as computed by the Bank of Japan. The marginal q is unobservable since it includes unobservable factors such as the future stream of the profits rate and a subjective discount factor. Since the discounted value of the marginal adjustment costs (the fourth term of Equation (12)) seems to be relatively small, this term is ignored. The discounted value of monopolistic rent (the second and third terms of Equation (12)) is also ignored. Then equation (12) is rewritten as follows:

$$Mq_t = \frac{1}{p_t^I} E_t \left[\sum_{j=0}^{\infty} \beta_{t+j} (1-\delta)^j \pi_{t+j} \right] \tag{22}$$

To make Equation (22) operational, one has to know the stochastic structure underlying the profit rate and discount factor. Ogawa and Kitasaka (1999) constructed a series of marginal q based on the univariate autoregressive specification of the underlying factors[8]. The approach in this paper is basically on the same track except for the specification of the stochastic process underlying the two variables. Unlike Ogawa and Kitasaka (1999), we conduct a multivariate autoregressive specification because the profit rate and discount factor, which are calculated by the required interest, may simultaneously determine that they are affected by each other[9]. Before specification, the unit root and cointegration test are conducted on both variables. In almost industries, profit rate and discount factor are nonstationary, and a cointegration relationship between them is not observed. Then the stochastic process for profit rates and discount factor is specified as in the following VAR model:

$$\Delta d_t = b_{10} + \sum_{i=1}^{k} b_{1i} \Delta d_{t-i} + \sum_{i=1}^{k} b_{2i} \Delta \pi_{t-i} + \varepsilon_{1t} \tag{23}$$

$$\Delta \pi_t = b_{20} + \sum_{i=1}^{k} b_{3i} \Delta d_{t-i} + \sum_{i=1}^{k} b_{4i} \Delta \pi_{t-i} + \varepsilon_{2t} \tag{24}$$

7) In the 1960s, however, construction investments in materials industries were high, and the Japanese business cycles in the period were induced by the demand for construction. See Yoshikawa (1995) for the details.
8) Ogawa and Kitasaka (1999) estimated the investment function in the Japanese manufacturing industry over the period from 1970 Q1 to 1990 Q4.
9) Ogawa (2000) and Otaki and Suzuki (1986) specify the stochastic process as bivariate-VAR.

$$d_t = \frac{1-\delta}{1+r_t}$$

$$E_t[\varepsilon_{1t+i}] = 0, i \geq 0 \quad E_t[\varepsilon_{2t+i}] = 0, i \geq 0$$

When the stochastic process is characterized by Equations (23) and (24), the marginal q can be written as follows[10]:

$$q_t = \left\{ \frac{\pi_{t-1}}{1-d_{t-1}} + \frac{\pi_{t-1}}{(1-d_{t-1})^2} c'(1-d_{t-1}M)^{-1} MB_{t-1} + \frac{\pi_{t-1}}{(1-d_{t-1})^3} c'(1-d_{t-1}M)^{-1}\theta \right. \qquad (25)$$
$$\left. \frac{1}{1-d_{t-1}} d'(1-d_{t-1}M)^{-1} MB_{t-1} + \frac{1}{(1-d_{t-1})^2} d'(1-d_{t-1}M)^{-1}\theta \right\} \frac{1}{p_t^N}$$

$$B_t = \theta + MB_{t-1} + \xi_t \qquad (26)$$

$$\theta' = [b_{10}, \ldots., 0, b_{20}, \ldots., 0]$$

$$B_t' = [\Delta d_t, \Delta d_{t-1}, \ldots.., \Delta d_{t-k+1}, \Delta\pi_t, \Delta\pi_{t-1}, \ldots.., \Delta\pi_{t-k+1}]$$

$$\xi_t' = [\varepsilon_{1t}, \ldots., 0, \varepsilon_{2t}, \ldots., 0]$$

$$c' = [1, 0, \ldots\ldots\ldots\ldots\ldots, 0]$$
$$d' = [0, \ldots\ldots\ldots, 0, 1, \ldots\ldots\ldots, 0]$$

$$M = \begin{pmatrix} b_{11} & b_{12} \ldots & b_{1k-1} & b_{1k} & b_{21} & b_{22} \ldots & b_{2k-1} & b_{2k} \\ 1 & 0 \ldots & 0 & 0 & 0 & 0 \ldots & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \ldots & 0 & 0 \\ . & . & . & . & . & . & . & . \\ 0 & 0 & 1 & 0 & 0 & 0 \ldots & 0 & 0 \\ b_{31} & b_{32} \ldots & b_{3k-1} & b_{3k} & b_{41} & b_{42} \ldots & b_{4k-1} & b_{4k} \\ 0 & 0 \ldots & 0 & 0 & 1 & 0 \ldots & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \ldots & 0 & 0 \\ . & . & . & . & . & . & . & . \\ 0 & 0 & 0 & 0 & 0 & 0 \ldots & 1 & 0 \end{pmatrix}$$

Figures 1-1 and 1-2 show the movements of marginal q calculated by the above method. Some common features can be seen among the industries. First, the marginal q shows a declining tendency over the period from 1977 to 1998. In particular, it declines to one tenth in precision machinery because of a rapid increase in the accumulation of capital compared with the profit

[10] The main steps for the derivation in Equation (25) are as follows. First, Equation (22) is linearized around the steady-state level of the profit rate and discount factor. Then Equations (23) and (24) are substituted into linearized Equation (22) and some transformations are made.

rate. Second, at the end of the 1980s, the so-called bubble period, the marginal q shows a remarkable increase. However, during the period of the long stagnation in the 1990s, it decreases except in 1996 and 1997. These two periods correspond to the temporal recovery of cooperative achievements and lower required interest rates. Some descriptive statistics are summarized in Table 2. It should be noted that in the machinery sector, both the level and the volatility are higher than in the material sector.

4. Empirical Results (1)

4-1 Specification of VAR

In this section, the VAR system is constructed based on the above variables, i.e., the investment ratio, the marginal q, and the real exchange rate. Then some empirical investigations are conducted to examine the relationship between investment and exchange rate.

To construct the VAR system, a preliminary test is employed to check whether each variable has a unit root. Table 3 shows the results of this unit root test. As the table elucidates, the investment ratio and the marginal q are stationary. The real exchange rate, which is not reported in Table 3, is nonstationary (ADF statistics with lag one shows −1.887). The above preliminary test indicates that the level of investment ratio, the level of marginal q, and the first difference of the real exchange rate need to be adopted in the specification for VAR. It is not necessary to include error correction terms in VAR because the investment ratio is the I (0) series for all industries, as shown in Table 3.

This paper employs the structural VAR developed by Sims (1986) and Blanchard and Watson (1986). This type of specification imposes identification restrictions on contemporaneous relationships without making assumptions about long-term relationships, such as in Blanchard and Quah (1989), Shapiro and Watson (1988), and Gali (1992). The short-term structure can be written as follows:

$$Ae_t = u_t \tag{27}$$

$$e_t = \begin{pmatrix} e_{e_t} \\ e_{Mq_t} \\ e_{INV_t} \end{pmatrix}, u_t = \begin{pmatrix} u_{e_t} \\ u_{Mq_t} \\ u_{INV_t} \end{pmatrix}, A = \begin{pmatrix} 1 & 0 & 0 \\ a_1 & 1 & 0 \\ 0 & a_2 & 1 \end{pmatrix}$$

e_t is the observed residual from the first stage reduced from estimation, while u_t is the unobserved structural innovations. A is a 3 × 3 matrix to be estimated[11].

[11] In practice, the structural innovations are assumed to be orthonormal, and their covariance matrix is the identity matrix. Therefore, Equation (27) is written precisely as $Ae_t = Bu_t$, where B is a 3 × 3 diagonal matrix. The assumption of orthonomal innovations imposes the following identifying restrictions on A and

4-2 Impulse response in VAR

Based on the above types of specification, the VAR systems in the individual industries are estimated and some simulations are employed. It is well known that these simulation results depend largely on the lag length. To deal with the lag problem, two different types of lag lengths, two and four, are selected to check the robustness of the simulation results[12].

In the two specifications of lag length, the simulation results do not differ greatly. Then the impulse response functions with lag two are reported in Figures 2-1–2-12 to assess the quantitative impact of a real exchange rate shock. In each case, one standard deviation of residuals in the real exchange rate equation is generated as a yen depreciation shock, and impulse responses for periods 0 through 40 (for 10 years) are simulated. Response standard errors are also computed by Monte Carlo simulation with one thousand repetitions. The first column in each figure shows the accumulated response of marginal q to an exchange rate shock. The second column is the accumulated response of marginal q to investment. A real exchange rate shock influences the investment dynamics via the marginal q. Then, comprehensive considerations are necessary based on the above two types of accumulated impulses.

Accumulated responses in manufacturing are shown in Figures 2-1–2-9. The effect of a real exchange rate shock induces a contemporaneous increase in the marginal q; however, this increase is not necessarily sustained. Investment is stimulated by the exchange rate as shown in the second column. The accumulated response of investment is significantly positive in almost manufacturing industries. These simulation results indicate that real exchange rate depreciation shocks may possibly stimulate investment via the marginal q in manufacturing industries. On the other hand, in the non-manufacturing sector, the effect of a real exchange rate shock on investment is almost insignificant.

Figure 3 summarizes the accumulated responses of marginal q and investment to the real exchange rate calculated in Figure 2. The impact of the yen's depreciation on the machinery sectors, especially transportation machinery and industrial machinery, is relatively large. Interestingly, the accumulated response of marginal q to the real exchange rate for electrical machinery and precision machinery is relatively weak. The implications of this finding are investigated carefully in the subsequent section.

B: $A\sum A' = BB', \sum = E[e_t e_t']$.

[12] To select the lag order of VAR, various criteria, such as the Akaike Information Criterion (AIC), the Shwarz Information Criterion (SBIC), the Hanann-Quinn Criterion (HAC), and other statistical tests, such as Likelihood test have been considered. However, these criteria do not necessarily sign the same lag length. Considering these problems, two types of ad hoc lag lengths are assumed in this paper.

5. Empirical Results (2)

5-1 Structure of external exposure

In the previous section, the accumulated responses of marginal q and investment to the real exchange rate vary in each industry. In general, the magnitude is high in the manufacturing sector. However, careful observation reveals that the magnitude in the manufacturing industry differs across sectors. Some examinations are conducted to investigate this point.

The firm's structure of external exposure is theoretically derived in Equations (20) and (21). First, the export and import structure will affect the profitability of the firms, and therefore affect investment. In general, export-oriented firms are more likely to be affected by exchange rate movements, because the direct valuation effect on export revenue is greater than the substitution effect in the domestic market. The size of this effect is given by ω, which is the share of total revenues associated with foreign sales. Second, the higher the share of imported inputs in total production costs (μ), the larger the increase in the negative effect when the exchange rate depreciates. Moreover, this effect is amplified by the share of total costs associated with total revenues (θ). Therefore, the trade effect consists of μ and θ.

The values of the above parameters in each industry are summarized in Table 4. It is clear that the export share is relatively high in the machinery sectors and its average share is about thirty percent. On the other hand, in the non-manufacturing industries, the export share is nearly zero percent. The import input share in the material sectors is larger than that of the machinery sectors. The impact of the yen's depreciation on the machinery sectors, especially transportation machinery and industrial machinery, is relatively large. This tendency seems to be consistent with the high level of the share of exports in total revenues. However, it is unclear why the accumulated response of marginal q to the real exchange rate for electrical machinery and precision machinery is relatively weak despite its high export share.

5-2 Structure of oligopolic power

The degree of a firm's monopoly power contributes to determining the effect of exchange rate change on profitability and investment. We call this effect the "monopoly power effect." When focusing on Equation (21), the monopoly power effect is determined by the exchange rate elasticity of price in the domestic market ($\eta_{p.e}$), the exchange rate elasticity of price in the foreign market ($\eta_{p^*.e}$), the exchange rate elasticity of markup in the domestic market ($\eta_{MKUP.e}$), and the exchange rate elasticity of markup in foreign market ($\eta_{MKUP^*.e}$). Here we focus on the values of $\eta_{p^*.e}$ and $\eta_{MKUP^*.e}$. The time-varying estimation of $\eta_{p^*.e}$ in each industry is shown in Figure 4[13]. Interestingly, $\eta_{p^*.e}$ in the machinery sectors is lower than in the material sectors. This implies that the oligopolic power of the machinery sectors is relatively high and that its pass-through is weak.

Chida (1995) examines the markup ratio for industrial machinery, electric machinery, and transportation machinery. His contribution is worth mentioning because the calculation is made in both the domestic and foreign market. Chida (1995) finds that the value of the markup ratio is higher in the electric machinery than in any other industry. Using the markup value calculated by Chida (1995), $\eta_{MKUP^*.e}$ is estimated and the result is summarized in Table 6. It is clear that the markup elasticity is relatively high in the electric machinery, and that such high elasticity will dampen the exchange rate effect on profit and investment by adjusting markups. The last column in Table 5 summarizes the total effect on export share (ω), export price elasticity ($\eta_{p^*.e}$), and markup elasticity ($\eta_{MKUP^*.e}$). The calculation result indicates that the impact of the exchange rate on profit differs across the machinery sectors and is relatively small in the electric machinery. This finding is consistent with the results in Figure 3-1.

5-3 Persistency of exchange rate movement

In the previous section, a series of real exchange rates turned out to be a random walk process, and this implied that exchange rate shocks are persistent. To examine the persistency effect, the measure of persistency effect specified in Equation (19) is calculated[14]. Figure 5 shows that the persistency effect declines after the beginning of the 1990s. This is consistent with the appreciation of the yen from the end of the 1980s to the beginning of the 1990s. These exchange rate movements have a persistent effect on both profitability and investment. To examine this point, estimation periods for the VAR system are divided into two sub periods: the former period is from 1975Q1 to 1994Q4 and the latter is from 1995Q1 to 2005Q4. Impulse responses are calculated for each period and the simulation results are summarized in Figures 7 and 8. As both figures show, the impulse responses of marginal q and investment to exchange rate are relatively high in the former periods.

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[13] Rolling regressions are conducted to estimate $\eta_{p^*.e}$ over the period from 1984Q1 to 2003Q1.

[14] The stochastic process of the real exchange rate follows the AR(4) process. Rolling regression is conducted over the period from 1980Q1 to 2005Q4 (estimation windows are 8 years).

6. Conclusions

There is a lack of both theoretical and empirical literature on the significant impact of recent exchange rate fluctuations on the real economic activity, especially equipment investment. This paper has succeeded in theoretically deriving the linkages among the investment, marginal q, and exchange rate by developing an intertemporal optimization model in which domestic firms interact with external markets under imperfect competition.

By explicitly considering the marginal q, this paper examines the transmission mechanism from real exchange rate shocks to investment dynamics via expected profitability is empirically investigated based on the Vector Autoregression (VAR) model and obtains some interesting results. In previous literature, little attention was given to dynamic characteristics. In addition, the empirical methodology adopted in this paper seems attractive. The evidence suggests that the Japanese yen depreciation has some effect in increasing the expected profitability, and that the stimulation of investment in the manufacturing industry is larger than that in the non-manufacturing industry. More careful investigation indicates the following two points. First, the impact of the yen's depreciation on the machinery sectors, especially transportation machinery and general machinery, is relatively large. This tendency seems to be consistent with the high-level share of export in total revenues. In the case of electric machinery, however, the impact of the exchange rate on investment is small. This characteristic reflects that the stronger an industry's oligopolic power, the lower the exchange effect on profits, and hence on investment. Second, the magnitude of the implied investment response to exchange rates varies over time with changes in the permanent component of exchange rates. As this paper shows, since the end of the 1990s, permanent changes in the Japanese yen have become relatively weak, and thus the impact of the exchange rate on investment has declined.

Japan's economy has been expanding moderately since early 2002. The remarkable feature of today's economy is that a rise in exports has played the central role in this expansion. Moreover, Japanese firms have been successful in capturing global demand, as evidenced in this increase in exports, and this rapid export growth induces corporate investment. Looking at the real effective rate, it started to fall in 2002. This movement has also affected export growth. However, the recent export expansion is not merely driven as a consequence of the yen's depreciation. Rapid growth in the global economy and the production of higher value-added export goods also play an important role in recent export expansion. Considering these factors, it seems that, since 2000, the Yen depreciation has had a strong effect of increasing expected profitability and also of stimulating investment.

There seem to be some important tasks for future research. The first task is to investigate the dynamic properties in non-manufacturing sectors more carefully, and to test empirically the spectral substitution mechanism of economic resources by exchange rate fluctuations. All talks of industrial restructuring, especially prevalent in non-manufacturing sectors, ceased at the end of the 1980s because Japan entered a short-term economic boom known as the bubble economy.

The second task is to examine the impact of exchange rate uncertainty on the level of investment. Frequent changes in the exchange rate increase the volatility, and hence uncertainty. Given the uncertainty, firms often find it convenient to delay investing. Under the floating rate system, these problems become serious and careful investigations are indispensable.

The last task is to develop a model in which both domestic investment and foreign direct investment are jointly determined. The increase in overseas production has reaccelerated since 2000, and this tendency now requires research on the capital stock mechanism from an international perspective.

Data Appendix

The data in this study is taken mainly from the Quarterly Report of Financial Statements of Incorporated Business compiled by the Ministry of Finance. Seven industries are selected over the period from 1975 (Q1) to 2005 (Q4): chemicals, steel, nonferrous metals, fabricated metals, industrial machinery, transportation machinery, electrical machinery, precision machinery, wholesale, construction, and electricity.

It should be noted that there are discontinuities in the data series in the Quarterly Report of Financial Statements. A complete renewal of all corporations is conducted every April (Quarterly one) and the number of corporations is fixed for one year. The Institute for Social Engineering (1976) and Ogawa (2000) provide detailed procedures for correcting such data discontinuities. The procedures suggested by them are adopted in this study.

Corporate Investment (I_t) and Capital Stock (K_t)

Data in investment is given in the Quarterly Report of Financial Statements. Real investment series are deflated by the price of the construction good reported in the Annual Report of Prices (Bank of Japan). Given the initial value of the capital stock, real investment series, and physical depreciation rate, the value of the real capital stock for each industry is computed by the perpetual inventory method. The physical depreciation rate is given by Ogawa and Kitasaka (1999), Table A-2. A division of the real investment by the capital stock yields the investment-capital stock, which is used in this empirical research. Some descriptive statistics for this series are reported in Table 1.

Profit Rates (π_t) and Discount Factor (d_t)

The marginal q is unobservable since it includes unobservable factors such as the future stream of the profits rate and the subjective discount factor. Therefore, one has to know the stochastic structure underlying the profit rate and discount factor.

The profit rate is calculated as the ratio of operating profit to real capital stock computed by the above procedure. The subjective discount factor consists of the nominal discount rate (r_t) and the physical depreciation rate. The nominal discount rate (r_t) is calculated by the following method:

$r_r =$ (interest and discount paid + bond interest expenses)/(short-term and long-term loans payable + bonds payable + notes receivable discounted).

Export Price (p_t^*)

Export price is given in export price index (Bank of Japan).

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Table.1 Summary statistics of Investment-Capital Ratio

1975Q1-2005Q4

Industry	Mean	Standard Deviation	Coefficient of Variation	Maximum	Minimum
Total Manufacturing sector	0.037	0.021	0.573	0.140	0.019
Chemicals	0.036	0.024	0.678	0.163	0.018
Steel	0.032	0.025	0.790	0.159	0.013
Nonferrous metals	0.037	0.021	0.585	0.154	0.019
Fabricated metals	0.037	0.021	0.532	0.114	0.019
Industrial Machinery	0.037	0.020	0.533	0.128	0.019
Transportation Machinery	0.047	0.028	0.594	0.162	0.021
Electrical Machinery	0.039	0.023	0.603	0.161	0.019
Precision Machinery	0.045	0.029	0.642	0.189	0.020
Total Non-Manufacturing Sector	0.044	0.032	0.735	0.228	0.018
Wholesale	0.034	0.022	0.662	0.135	0.012
Construction	0.038	0.033	0.860	0.212	0.009
Real estate	0.034	0.020	0.596	0.165	0.011
Electricity	0.036	0.025	0.696	0.135	0.011

Table.2 Summary Statistics of of Marginal q
1976Q2-2005Q4

Industry	Mean	Standard Deviation	Coefficient of Variation
Total Manufacturing sector	0.842	0.271	0.322
Chemicals	0.946	0.265	0.280
Steel	0.355	0.265	0.746
Nonferrous metals	0.660	0.363	0.549
Fabricated metals	1.022	0.411	0.402
Industrial Machinery	1.269	0.572	0.450
Transportation Machinery	0.555	0.352	0.634
Electrical Machinery	0.892	0.452	0.506
Precision Machinery	1.079	0.647	0.599
Total Non-Manufacturing Sector	0.572	0.186	0.325
Wholesale	2.188	0.667	0.304
Construction	1.717	0.468	0.272
Real estate	2.035	0.528	0.259
Electricity	0.548	0.158	0.288

Table.3 Unit Root Test
1976Q2-2005Q4

Industry	Investment Ratio		Marginal q	
	Drift +Trend	Drift	Drift +Trend	Drift
Total Manufacturing sector	-5.717*** (0)	-7.043*** (0)	-1.440 (4)	-2.317 (4)
Chemistry	-7.132*** (0)	-7.929*** (0)	-1.868 (4)	-1.809 (4)
Steel	-7.820*** (0)	-8.873*** (0)	-2.163 (2)	-2.623* (2)
Nonferrous metals	-5.402*** (0)	-5.226*** (0)	-3.295* (1)	-2.827* (1)
Fabricated metals	-5.163*** (0)	-6.137*** (0)	-2.866 (4)	-2.324 (4)
Industrial Machinery	-3.382*** (0)	-2.662* (0)	-2.692 (0)	-2.598* (0)
Transportation Machinery	-5.652*** (0)	-6.164*** (0)	-2.640 (1)	-3.745*** (1)
Electrical Machinery	-2.606 (0)	-4.790*** (0)	-4.346*** (0)	-3.965*** (0)
Precision Machinery	-4.193*** (0)	-5.118*** (0)	-2.159 (0)	-2.795* (0)
Total Non-Manufacturing Sector	-4.496*** (1)	-4.646*** (0)	-1.489 (3)	-2.268 (3)
Wholesale	-1.835 (0)	-3.258** (0)	-3.412* (0)	-3.907** (0)
Construction	-4.214*** (0)	-5.135*** (0)	-2.309 (2)	-2.332 (2)
Real estate	-1.469 (1)	-2.410 (1)	-1.645 (1)	-1.265 (1)
Electricity	-3.279* (2)	-3.746*** (2)	-6.032*** (0)	-4.596*** (0)

ADF test shows augmented Dickey-Fuller test. Optimal lag length determined by Schwarz Information Criterion is shown in parentheses. * denotes the significance level at the 10% level, ** at the 5% level, and *** at the 1%

Table.4 . Structure of External Exposure （1）

Industry	Export share ω	Total cost share θ	Import input share μ	Total cost share× Import input share $\theta \times \mu$
Chemicals	0.175	0.682	0.117	0.079
Steel	0.179	0.790	0.070	0.055
Nonferrous metals	0.126	0.870	0.052	0.045
Fabricated metals	0.026	0.798	0.098	0.078
Industrial Machinery	0.265	0.768	0.093	0.071
Transportation Machinery	0.345	0.845	0.032	0.027
Electrical Machinery	0.327	0.834	0.076	0.063
Precision Machinery	0.367	0.763	0.076	0.052
Wholesale	0120	0.864	NA	NA
Construction	0.023	0.837	0.033	0.027
Real estate	0	0.555	NA	NA
Electricity	0	0.739	0.184	0.139

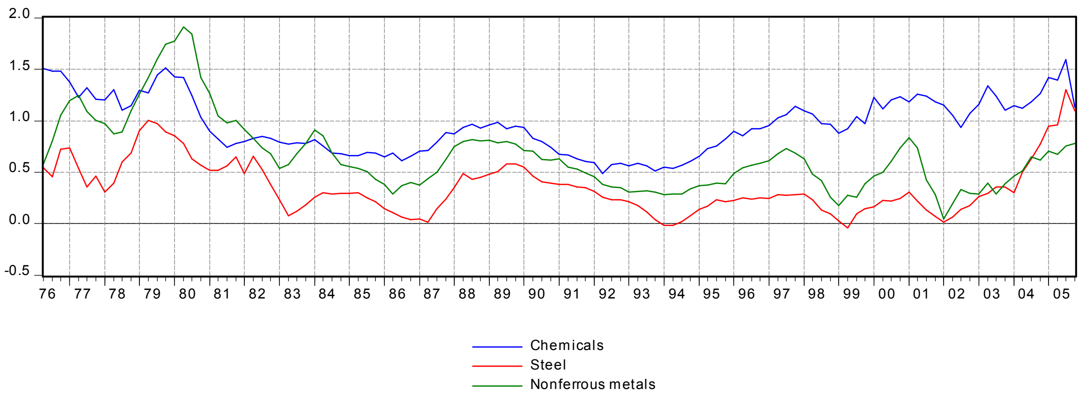
Export share in 2005 is from *Short-term Economic Survey of Enterprises in Japan* (BOJ). Total input share in 2005 is from *Quarterly Report of Financial Statements of Incorporated Business* (compiled by the Ministry of Finance). Import input share in 2000 is from Asian international Input-output Table (Asian International input-output Project Institute of Developing Economies Japan External Trade Organization)

Table.5. Structure of External Exposure （2）

Industry	Export share ω	Export price elasticity $\eta_{p^*.e}$	Markup elasticity $\eta_{MKUP^*.e}$	Export volume elasticity $\eta_{q^*.p^*} \times \eta_{p^*.e}$	Total effect $\omega\left(1-\eta_{p^*.e}+\eta_{p^*.e}\times\eta_{q^*.p^*}-\eta_{MKUP^*.e}\right)$
Industrial Machinery	0.265	0.120	0.593	0.484	0.204
Transportation Machinery	0.345	0.155	0.602	0.489	0.252
Electrical Machinery	0.327	0.126	0.759	0.475	0.192

Fig. 1-1 Marginal q

1976Q2-2005Q4



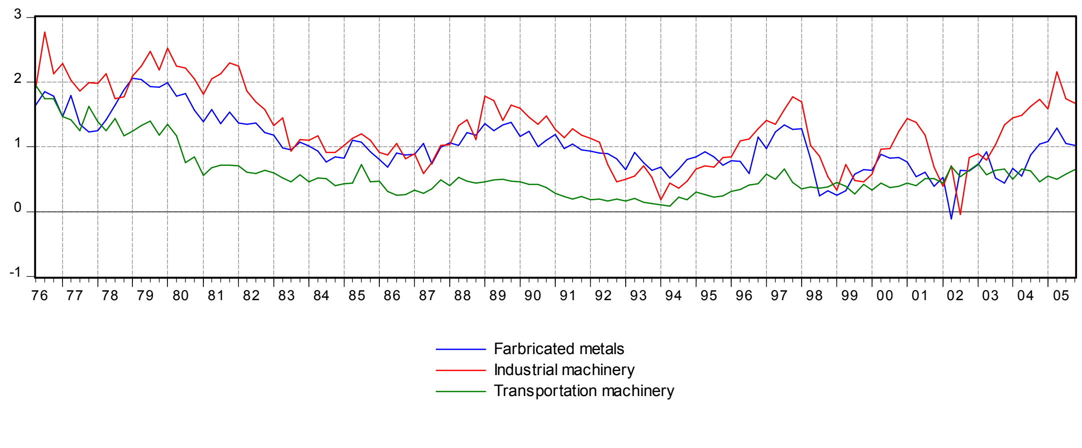
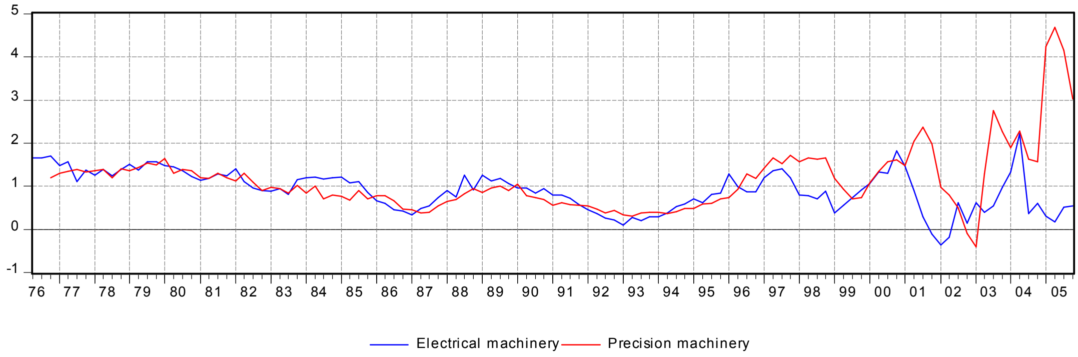


Fig. 1-2　Marginal q

1976Q2-2005Q4



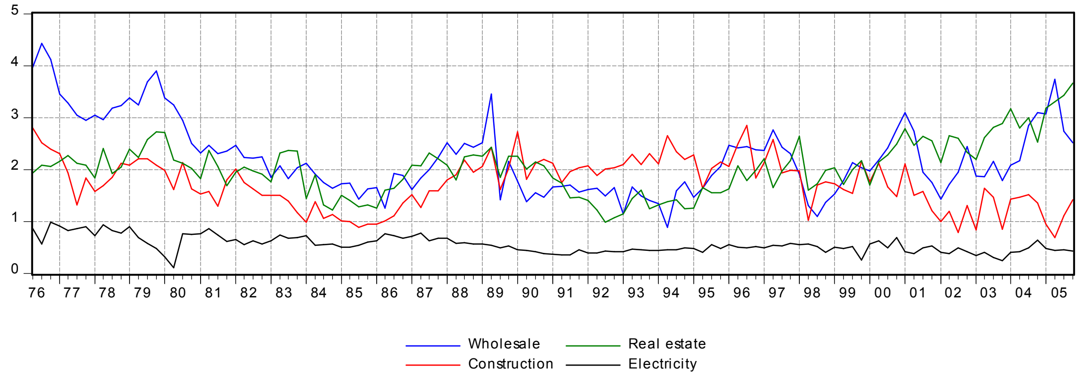
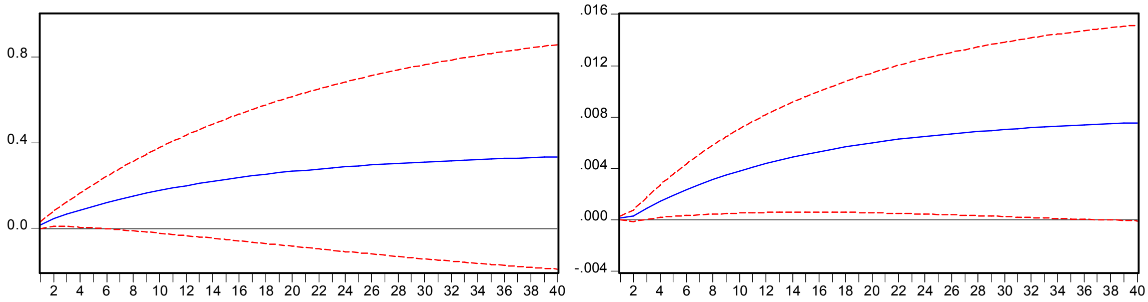


Fig.2 Accumulated Responses (Lag=2)

1975Q1-2005Q4

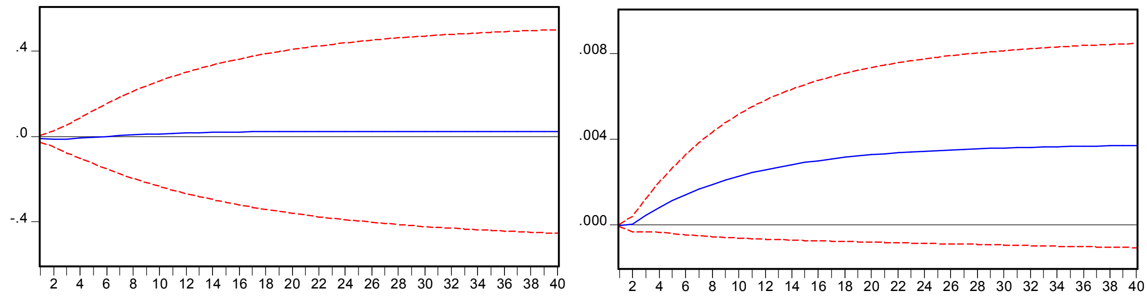
2-1 Chemicals

EXR→MQ EXR→INV



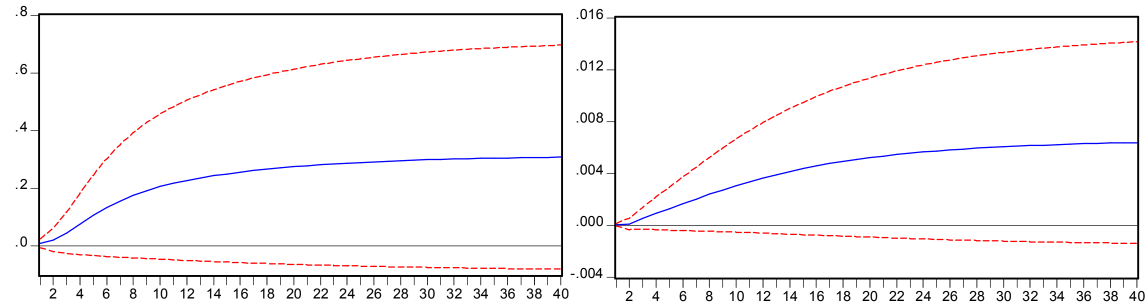
2-2 Steel

EXR→MQ EXR→INV



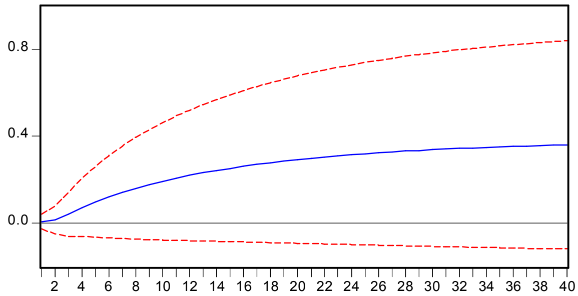
2-3 Nonferrous metals

EXR→MQ EXR→INV

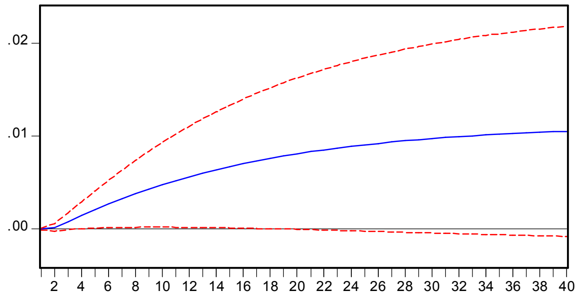


2-4　Fabricated metals

EXR→MQ

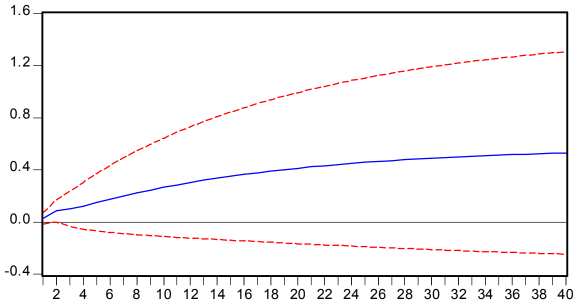


EXR→INV

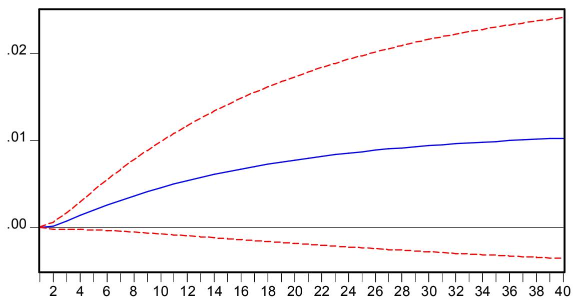


2-5　Industrial machinery

EXR→MQ

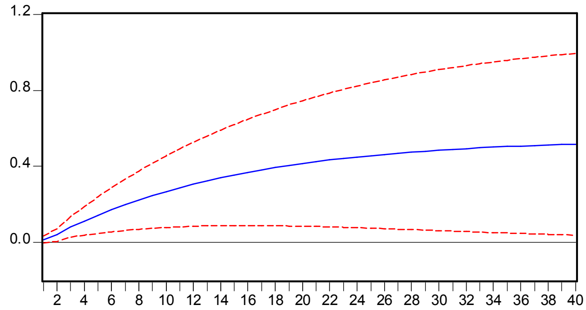


EXR→INV

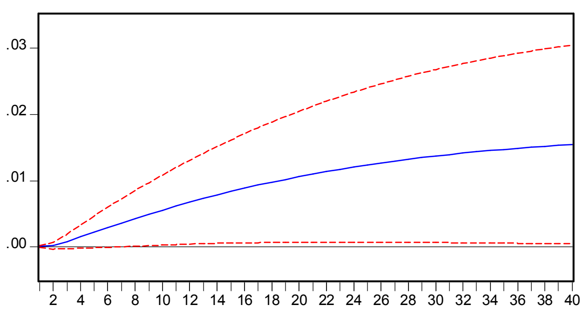


2-6　Transportation machinery

EXR→MQ

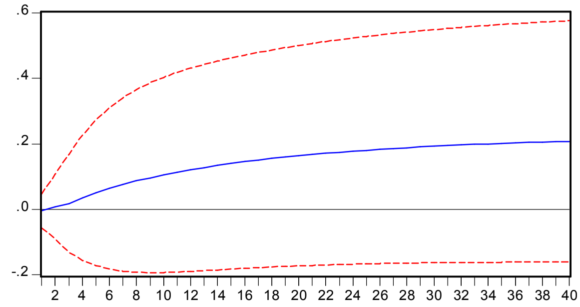


EXR→INV

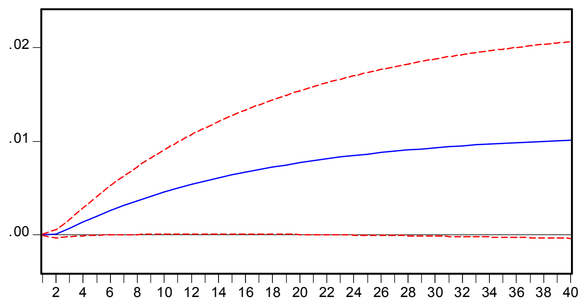


2-7 Electrical machinery

EXR→MQ

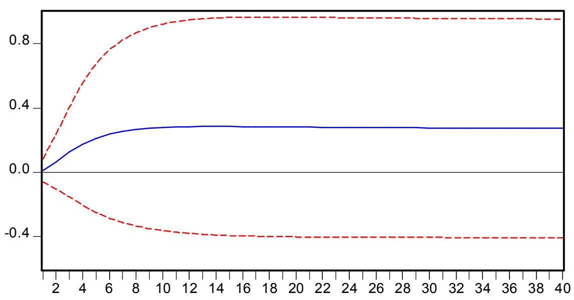


EXR→INV

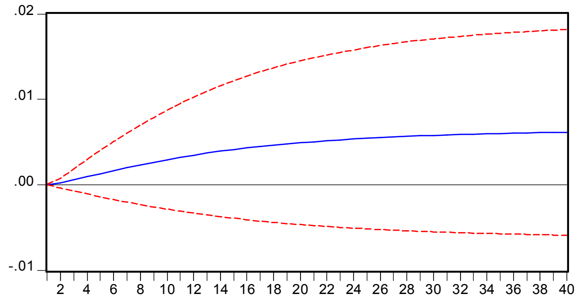


2-8 Precision machinery

EXR→MQ

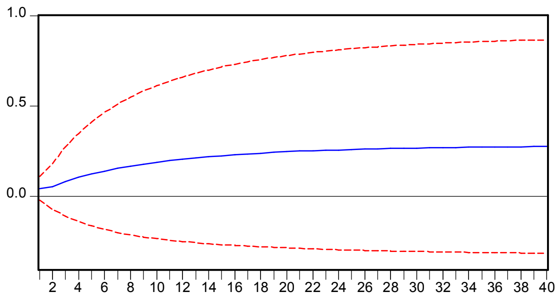


EXR→INV

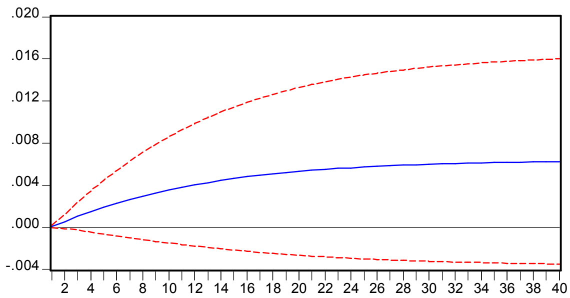


2-9 Wholesale

EXR→MQ

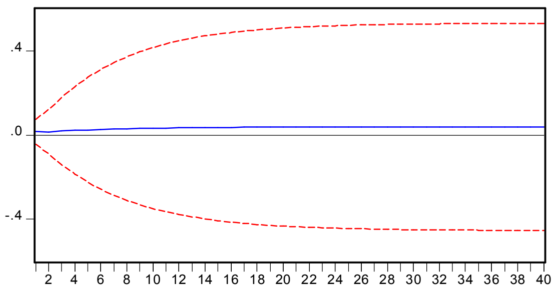


EXR→INV

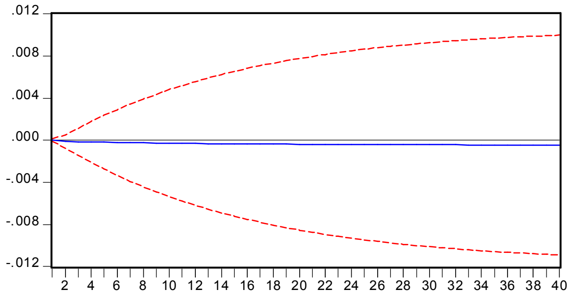


2-10　Construction

EXR→MQ

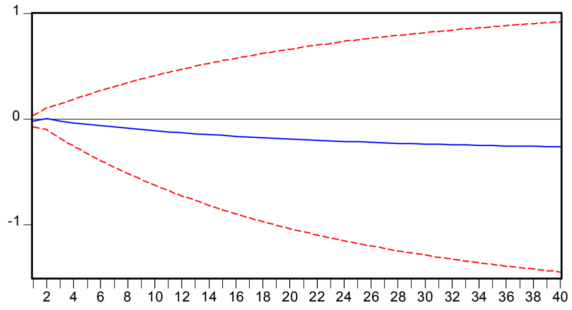


EXR→INV

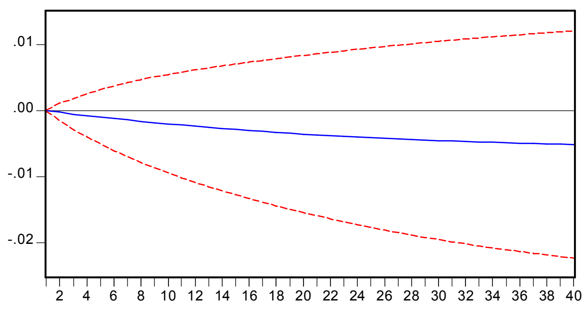


2-11　Real estate

EXR→MQ

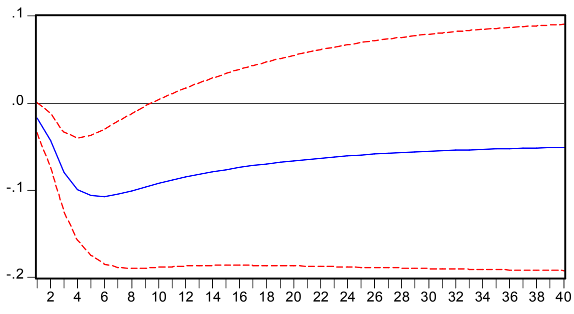


EXR→INV



2-12　Electricity

EXR→MQ



EXR→INV

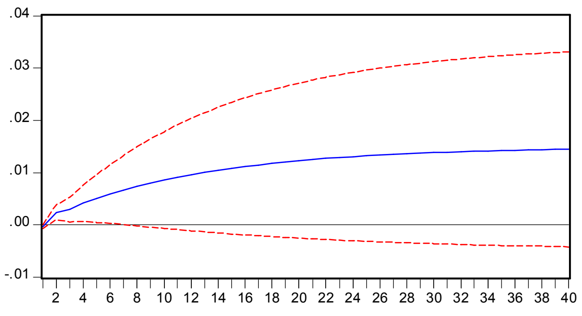


Fig.3-1 Accumulated Response of Marginal q to Exchange Rate Innovation

Manufacturing Sectors

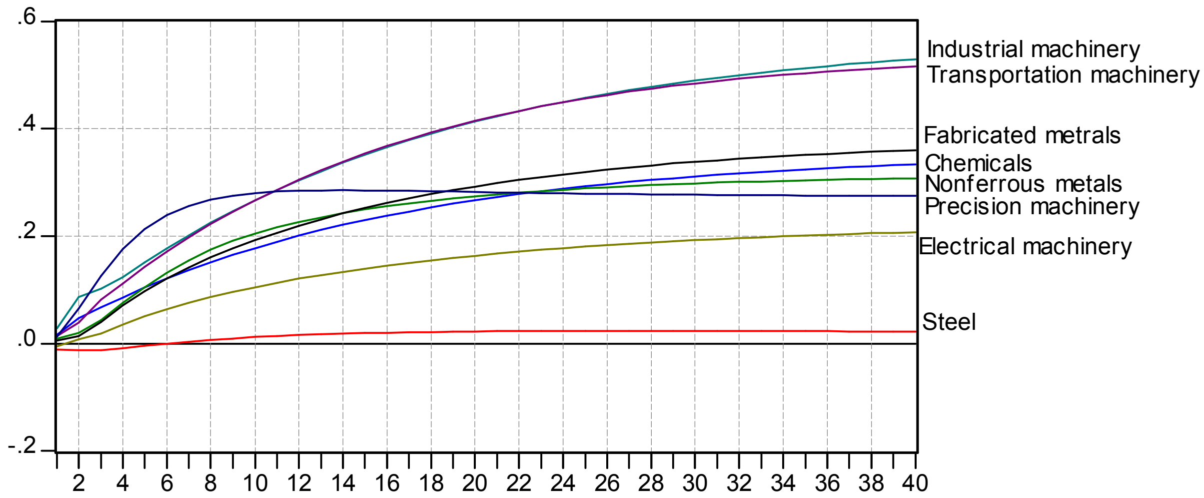


Fig. 3-2 Accumulated Response of Investment to Exchange Rate Innovation

Manufacturing Sectors

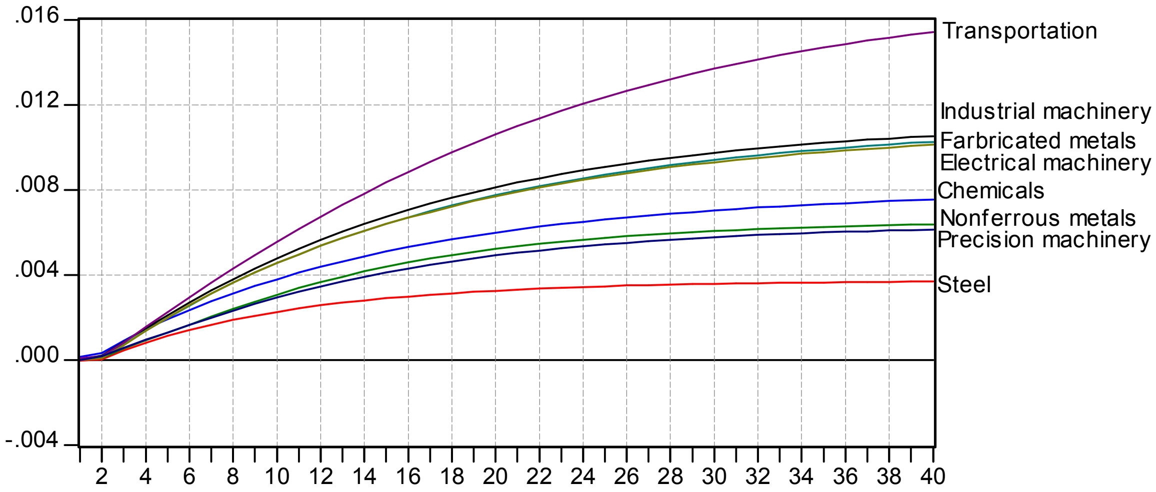


Fig. 3-3　Accumulated Response of Marginal q to Exchange Rate Innovation

Non-Manufacturing Sectors

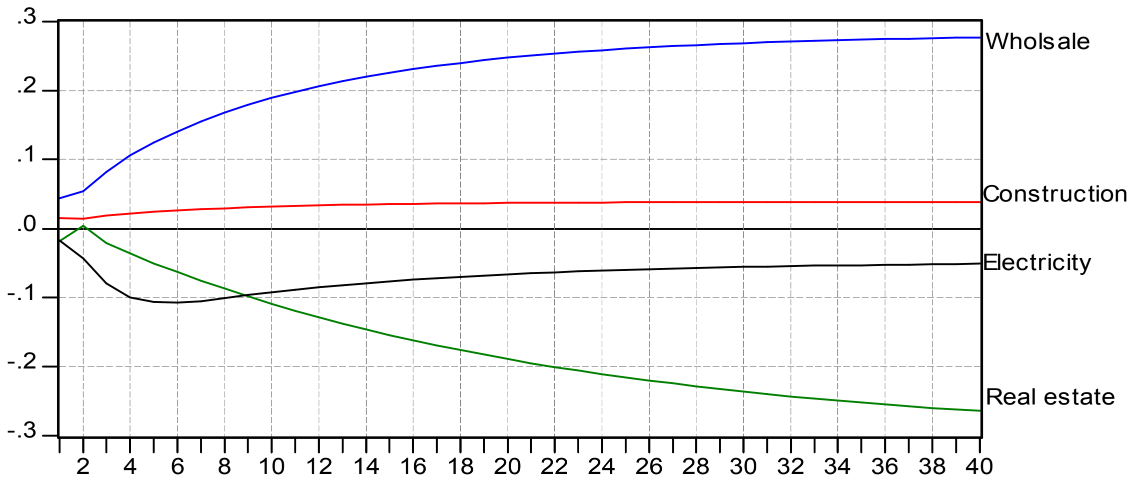


Fig. 3-4 Accumulated Response of Investment to Exchange Rate Innovation

Non-Manufacturing Sectors

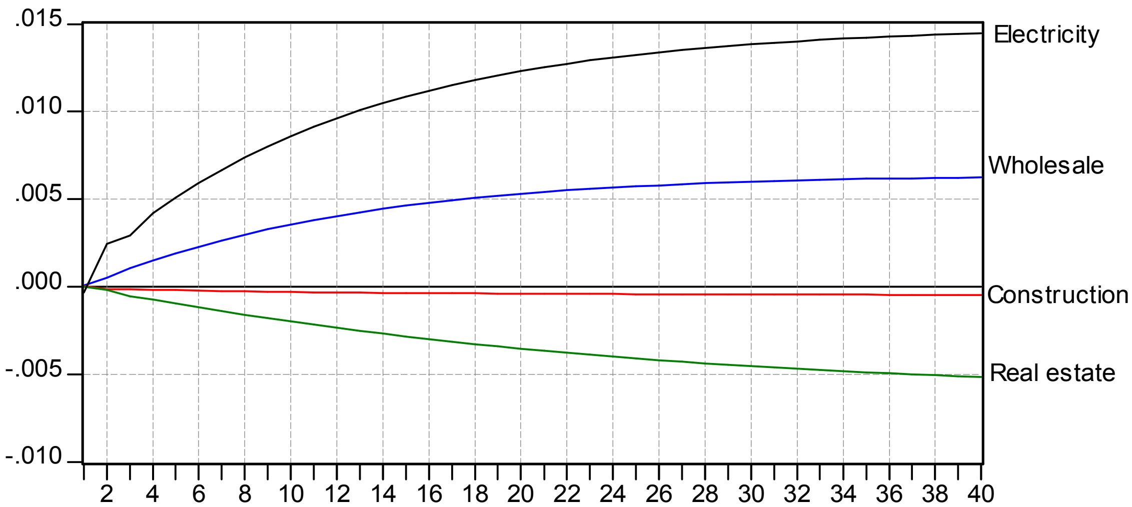


Fig. 4 Export Price Elasticity

1984Q1-2003Q1

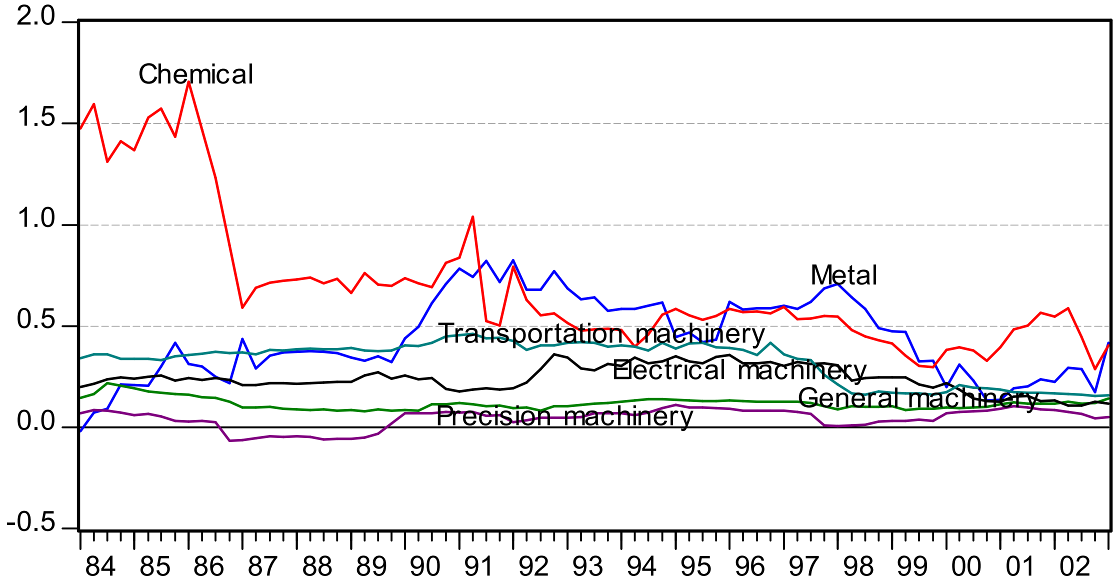


Fig. 5-1 Exchange Rate Persistency (j=2)

1983Q1-2001Q1

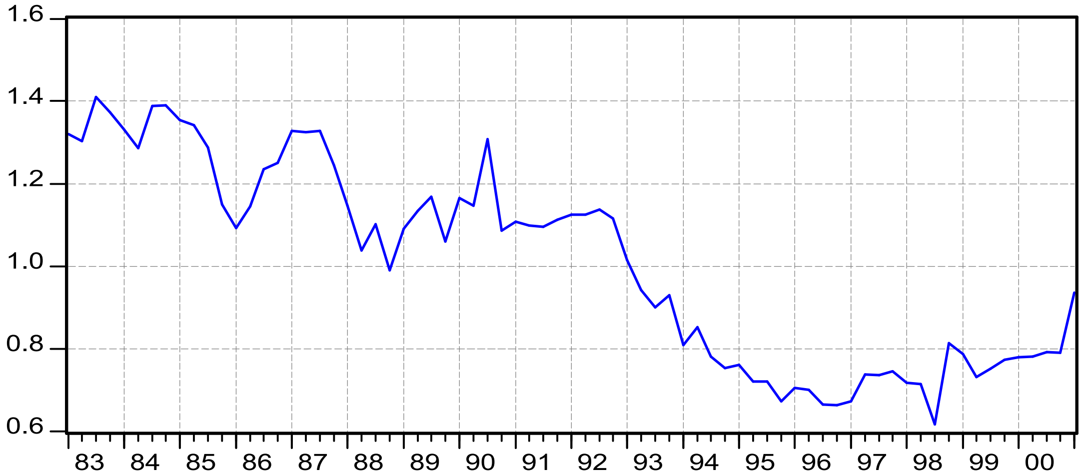


Fig. 5-2 Exchange Rate Persistency (j=4)

1983Q1-2001Q1

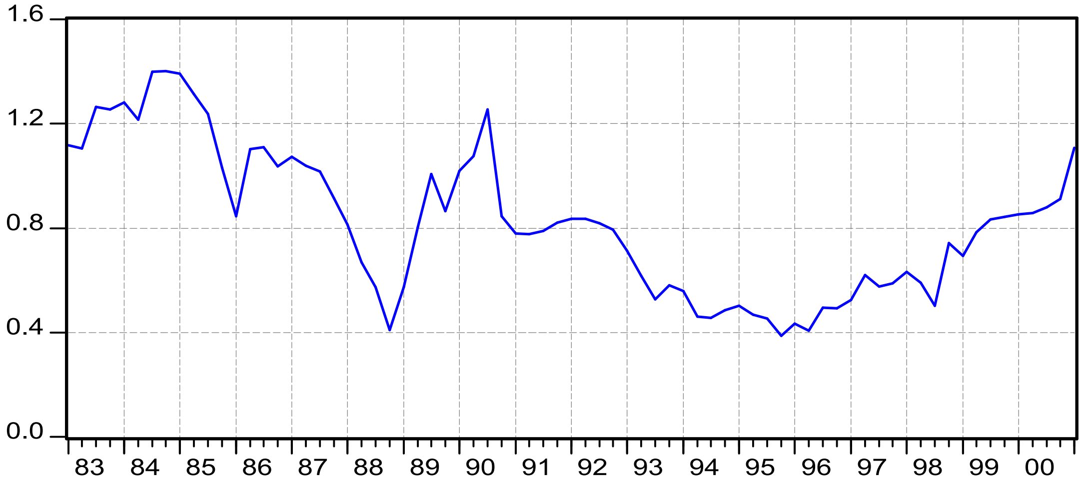


Fig. 6-1　Cochrane statistics

1980Q1-1994Q4

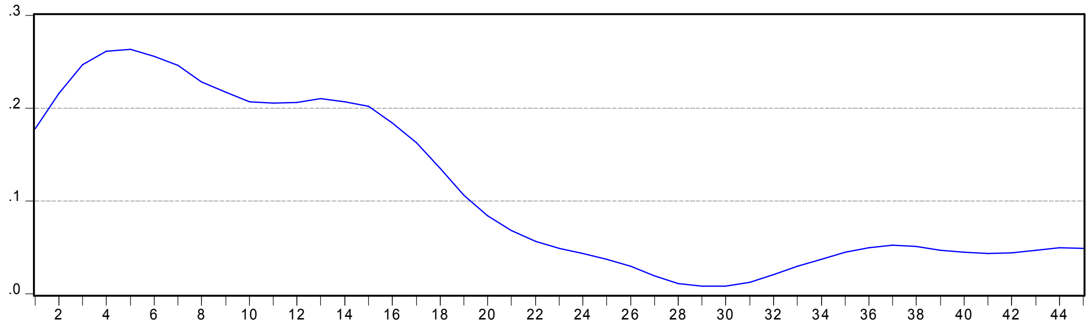


Fig. 6-2　Cochrane statistics

1995Q1-2005Q4

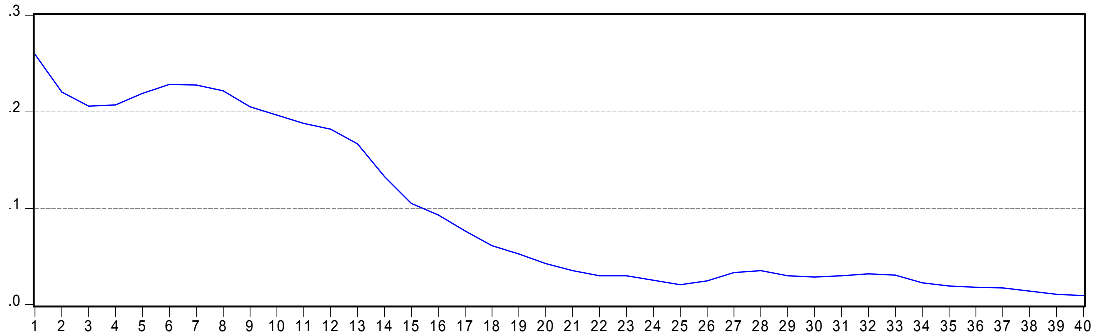
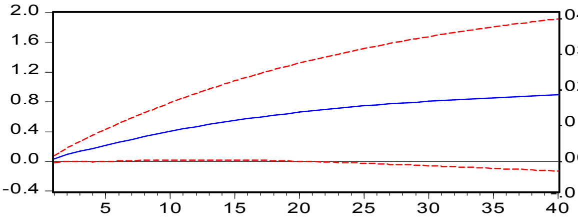


Fig.7Accumulated Responses (Lag=2)

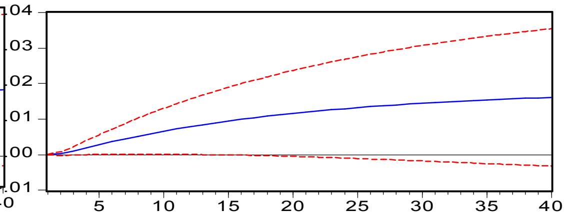
1975Q1-1994Q4

7-1　Industrial machinery

EXR→MQ

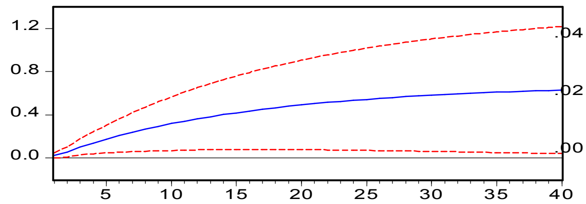


EXR→INV

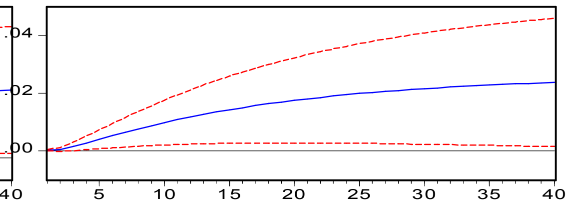


7-2　Transportation machinery

EXR→MQ

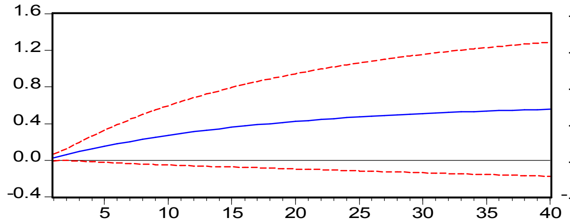


EXR→INV

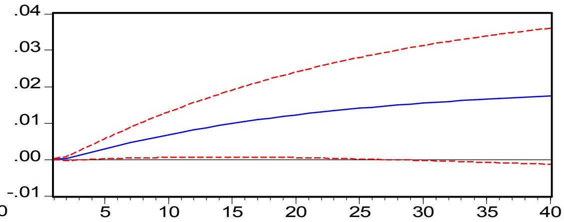


7-3　Electrical machinery

EXR→MQ

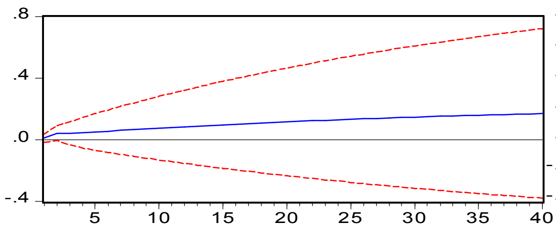


EXR→INV



7-4　Precision machinery

EXR→MQ



EXR→INV

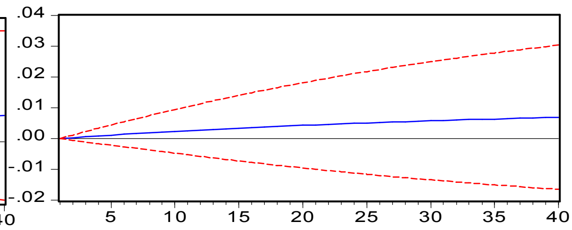
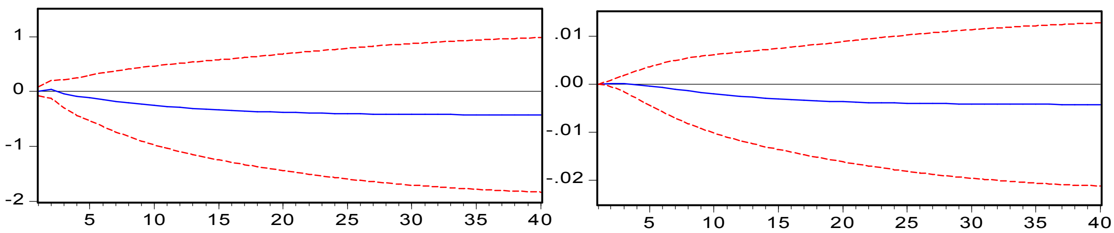


Fig. 8　Accumulated Responses (Lag=2)

1995Q1-2005Q4

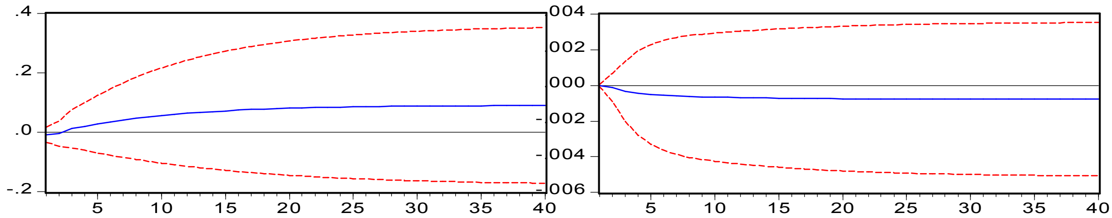
8-1　Industrial machinery

EXR→MQ　　　　　　　　　　EXR→INV



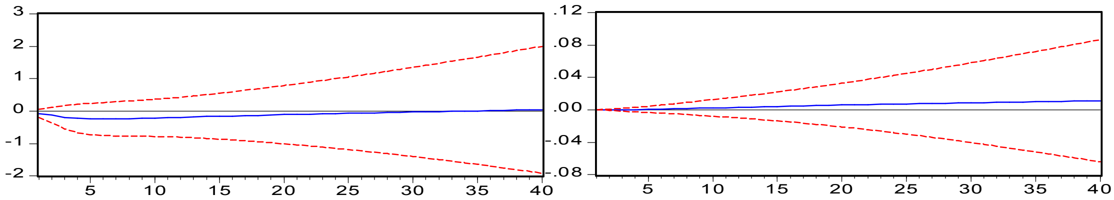
8-2　Transportation machinery

EXR→MQ　　　　　　　　　　EXR→INV



8-3　Electrical machinery

EXR→MQ　　　　　　　　　　EXR→INV



8-4　Precision machinery

EXR→MQ　　　　　　　　　　EXR→INV