Asymmetric Exchange Rate Pass-Through in Japanese Exports: Application of the threshold vector autoregressive model

Thi-Ngoc Anh NGUYEN
Yokohama National University

SATO Kiyotaka
Yokohama National University

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Thi-Ngoc Anh NGUYEN[†] and SATO Kiyotaka[‡]

Abstract

This paper employs a threshold vector autoregressive (TVAR) model to analyze a possible asymmetric behavior of exchange rate pass-through (ERPT) or pricing-to-market (PTM) in Japanese exports between the yen appreciation and depreciation regimes. We developed a new approach to estimating the exporting firm's reference (predicted) exchange rate by applying the threshold autoregressive (TAR) model with a rolling window. We also use an industry-specific nominal effective exchange rate on a contract currency basis to better capture a role of the U.S. dollar as the third currency for trade invoicing. It is found that the degree of PTM (ERPT) was larger (smaller) in the yen depreciation regime up to the end of the 1990s but became smaller (larger) in the 2000s and after. A decline (increase) in PTM (ERPT) in the yen depreciation regime suggests that Japanese exporters tend to lower the yen-based export price and fail to fully exploit foreign exchange gain in response to the yen depreciation, likely due to an increase in export competition in the world market.

Keywords: Exchange rate pass-through, Pricing-to-market, Threshold vector autoregressive model, Japanese exports, Yen appreciation and depreciation regimes, Time-varying threshold

JEL classification: C22, D22, E31, F31

1. Introduction

Japanese exporters have been facing a large fluctuation of the yen for more than 40 years. The yen appreciated in nominal terms vis-à-vis the U.S. dollar from 360 yen in 1971 to 79.75 yen, a historical record high for that period, in April 1995. After the collapse of Lehman Brothers in September 2008, the yen started to appreciate from around 110 yen vis-à-vis the U.S. dollar to 75.32 yen in October 2011, marking a new post-war record high. However, the "Abenomics", an economic stimulus package of the Prime Minister Abe starting in the end of 2012, drove the yen to depreciate dramatically to around 120 yen vis-à-vis the U.S. dollar in the end of 2014.

It is well known that Japanese exporters tend to conduct the pricing-to-market (PTM) strategy by stabilizing export prices in the local currency, even though squeezing their profit margin during the yen appreciation period.[1] Importer's currency is typically chosen in Japanese exporter's PTM behavior.[2] In contrast, during the yen depreciation period, Japanese exporters can enjoy large exchange gain by pursuing the PTM strategy, given that importer's currencies are chosen in invoicing of Japanese exports. Alternatively, during the yen depreciation period, exporters can raise the extent of exchange rate pass-through (ERPT) and lower export prices in the local currency to improve export price competitiveness, while keeping a certain level of profit margins. Thus, the exporter's pricing strategy can be different between the home currency appreciation and depreciation periods.

In addition, the exporter's pricing strategy can differ across industries. Previous studies, such as Giovannini (1988), Friberg (1998), and Bacchetta and van Wincoop (2005), demonstrated that the degree of product differentiation in export goods could affect the choice of invoice currency and ERPT/PTM. A possible difference in pricing behavior between the yen appreciation and depreciation periods could also be affected by industry-level differences in product differentiation of export goods.

There have so far been only a few studies on a possible difference in ERPT between the home currency appreciation and depreciation periods. Mahdavi (2002) and

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[1] See for example, Marston (1990), Parsons and Sato (2008), Yoshida (2010).
[2] See Sato (2003) and Ito, Koibuchi, Sato and Shimizu (2012).

Pollard and Coughlin (2004), for instance, analyzed a difference in ERPT between the appreciation and depreciation periods by observing a short-run change in the exchange rate. Specifically, a positive change in the home currency exchange rate (S_t), $\Delta \ln S_t > 0$, was considered to be the depreciation period, while a negative change ($\Delta \ln S_t < 0$) was included in the appreciation period. Such a conventional identification approach, however, cannot correctly distinguish between the appreciation and depreciation periods.

Figure 1 shows the index of the nominal exchange rate of the yen vis-à-vis the U.S. dollar from January 1990 to December 2014, where the exchange rate is standardized to 100 as of 2005. In Figure 1, for instance, the yen appreciated substantially from 143.8 in April 1990 to 75.9 in April 1995.[3] During the yen appreciation period, however, we observe a number of small and short-run depreciations, which are considered to be the yen depreciation period by the conventional approach. However, it is obvious that such a small depreciation should not be regarded as a part of the yen depreciation period when considering the effect of exchange rate changes on the exporter's pricing behavior. Thus, the conventional way of distinction between the yen appreciation and depreciation periods needs to be reconsidered for a rigorous empirical examination.

To overcome the drawback of previous studies, this paper employs a threshold vector autoregressive (TVAR) model to analyze a possible asymmetric behavior of ERPT/PTM in Japanese exports between the yen appreciation and depreciation regimes. Exporters typically set an export price and quantity assuming their own reference (predicted) exchange rate that is periodically revised based on the information on the past and expected future movements of exchange rates. This study develops a new approach to the exporter's predicted exchange rate by estimating a time-varying threshold based on the exchange rate *level*.[4] Employing the estimated time-varying thresholds as a predicted exchange rate, we first distinguish between yen appreciation

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[3] The monthly average nominal exchange rate of the yen vis-à-vis the U.S. dollar changed in practice from 158.47 in April 1990 to 83.67 in April 1995 (IMF, *International Financial Statistics*).
[4] Murase (2013) conducts the nonlinear estimation of ERPT by defining the exchange rate volatility as a threshold variable. Although it is a useful approach, we assume the exchange rate in *level* to be a threshold variable in the present research.

and depreciation regimes for each industry. Given such an industry-specific difference in exchange rate regimes, we investigate whether the Japanese exporter's pricing strategy is regime-dependent. More specifically, we attempt to reveal whether the pricing strategy differs between yen appreciation and depreciation regimes and whether it changes over time.

By conducting the TVAR estimation and impulse response function analysis, we have found that the degree of PTM is smaller in the yen appreciation regime than in the yen depreciation regime. The degree of PTM is larger in the yen depreciation regime up to the end of the 1990s, but it becomes smaller in the 2000s and after. A decline in PTM in the yen depreciation regime suggests that Japanese exporters tend to lower the yen-based export price and fail to fully exploit foreign exchange gain in response to the yen depreciation, likely due to an increase in export competition in the world market as well as growing intra-firm trade.

The remainder of this paper is organized as follows. Section 2 elaborates the empirical model. Section 3 describes the data. Section 4 presents the results of estimation and discussion. Finally, Section 5 concludes this study.

2. Empirical Model

2.1. Estimation of the threshold level

To estimate thresholds, we employ the following conventional ERPT model that Goldberg and Knetter (1997) propose:

$$p_t = \alpha + \delta X_t + \gamma E_t + \psi Z_t + \varepsilon_t, \qquad (1)$$

where all variables are in natural logarithm, p denotes the price for the sample product, X represents the primary "control" variable, E stands for the exchange rate, and Z

includes other control variables in the model. The first-difference specification of the above empirical model is often used in previous studies, such as Campa and Goldberg (2005) and Ceglowski (2010).

The above model can be extended to the following threshold model to estimate a threshold, θ, using an indicator function, I_t:

$$
\begin{aligned}
\Delta p_t^{x,i} = I_t\left(c_1 + \sum_{k=1}^{n} \alpha_{1k} \Delta p_{t-k}^{x,i} + \sum_{k=0}^{m} \beta_{1k} \Delta e_{t-k} + \sum_{k=0}^{l} \gamma_{1k} \Delta p_{t-k}^{ip,i} + \sum_{k=0}^{r} \delta_{1k} \Delta ipi_{t-k} \right) \\
+ \left(1 - I_t\right)\left(c_2 + \sum_{k=1}^{n} \alpha_{2k} \Delta p_{t-k}^{x,i} + \sum_{k=0}^{m} \beta_{2k} \Delta e_{t-k} + \sum_{k=0}^{l} \gamma_{2k} \Delta p_{t-k}^{ip,i} + \sum_{k=0}^{r} \delta_{2k} \Delta ipi_{t-k} \right) + \varepsilon_t
\end{aligned}
\tag{2}
$$

where I_t is defined as $I_t = 1$ if $E_t > \theta$ and $I_t = 0$ if $E_t \leq \theta$. p^x denotes the yen-based export price index; e represents the nominal effective exchange rate (NEER), an increase (decrease) of which is defined as depreciation (appreciation) of the yen;[5] p^{ip} stands for the domestic input price index as a proxy for production cost; and ipi indicates the world industrial production index as a proxy for the world demand. Δ denotes the first difference operator. The lower case letters such as p and e represent the natural log transformed variables, while the upper case letter (E) indicates a variable in level. Superscript i indicates a specific industry, and subscripts $t - k$ with k running from 1 or 0 to n,m,l,r denote a lag of the export price, the exchange rate, the input price, and the world industrial production, respectively. The lag length is determined by regressing the export price on the lag of the export price, the exchange rate, the input price, and the world industrial production with maximum lag length 12 for all variables, based on the Akaike Information Criterion (AIC). ε_t is an error term. θ is a threshold selected from E_t, the NEER series in level, which minimizes the error term. If E_t exceeds a threshold level (θ), it is regarded as the yen depreciation regime; otherwise, it is

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[5] This definition differs from the conventional definition of effective exchange rates. As will be shown below, we employ a new approach to constructing nominal effective exchange rates.

considered as the yen appreciation regime.

A rolling estimation of equation (2) is conducted with a 4 year-window to obtain time-varying thresholds. Specifically, an estimated threshold obtained in each window is treated as the threshold of seventh month to the end month of each 4-year window in order to allow for not only backward-looking but also forward-looking aspects.[6] The estimated time-varying thresholds for all industries will be presented in Section 4.

2.2. Structural near-VAR model

After obtaining the time-varying thresholds, we analyze the Japanese exporter's ERPT/PTM behavior, that is, the response of Japanese export price on a yen basis to exchange rate changes. We employ a near-VAR model including the first-difference series of the natural log of industrial production index (Δipi), NEER (Δe), input price index (Δp^{ip}), and the yen-based export price (Δp^{x}).

We set up a following near-VAR model with block exogeneity:[7]

$$\sum_{s=0}^{p} \begin{bmatrix} A_{11}(s) & A_{12}(s) \\ A_{21}(s) & A_{22}(s) \end{bmatrix} \begin{bmatrix} y_{1,t-s} \\ y_{2,t-s} \end{bmatrix} = \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix} \tag{3}$$

where $A_{12}(s) = 0$ for each $s = 0, 1, \ldots, p$, $y_{1,t}$ is a vector of exogenous variables external to the domestic country, and $y_{2,t}$ is a vector of variables in the domestic country. A vector of structural shocks, $\varepsilon_{t} = \begin{bmatrix} \varepsilon_{1,t} & \varepsilon_{2,t} \end{bmatrix}'$, is uncorrelated with past y_{t-s} for $s > 0$, and satisfies $E[\varepsilon_{t}\varepsilon_{t}' \mid y_{t-s}, s > 0] = I$ and $E[\varepsilon_{t} \mid y_{t-s}, s > 0] = 0$, where $\varepsilon_{1,t}$ is

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[6] For example, in the four year window from January 2000 to December 2003, the estimated threshold is treated as the threshold value (exporter's predicted rate) for June 2003.
[7] See Cushman and Zha (1997), Zha (1999), and Maćkowiak (2007) for an analysis using a near-VAR model with block exogeneity.

a vector of structural shocks of external origin and $\varepsilon_{2,t}$ is a vector of structural shocks of domestic origin. We impose the block exogeneity restriction, $A_{12}(s) = 0$ for each $s =$ 0, 1…p, which indicates that domestic shocks, $\varepsilon_{2,t}$, have neither contemporaneous nor lagged effects on the external variables, $y_{1,t}$.

A foreign block, $y_{1,t}$, includes the world IPI, i.e., the first-difference of the natural log of industrial production index (Δipi). A domestic block, $y_{2,t}$, includes three variables, namely the first-difference of the natural log of NEER (Δe), input price index (Δp^{ip}) and the yen-based export price (Δp^{x}). We impose the Cholesky decomposition in the domestic block. Since the domestic input price includes procurements of intermediate inputs from both domestic and foreign sectors, the domestic input price index is contemporaneously affected by the change in NEER, but not *vice versa*. The yen-based export price is also contemporaneously affected by the change in NEER, because more than 50 percent of Japanese exports are denominated or invoiced in U.S. dollars. Thus, NEER is the most exogenous in the domestic block, and the order of variables is: NEER (Δe), input price index (Δp^{ip}), and the yen-based export price (Δp^{x}).[8] The RATS 9.0 econometric software program is used for estimation, and four lag is chosen for the near-VAR system to avoid a small sample size problem.

3. Data and Contract Currency Based Nominal Effective Exchange Rate

All data of this study are monthly series with the sample period from January 1980 to December 2014. Domestic input prices and yen-based export prices are obtained from the website of the Bank of Japan (BOJ) with the base year 2005 and 2010,

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[8] As will be discussed below, we tried estimation with a different order of variables in the domestic block, and the result is very similar to the benchmark result.

respectively. We use the industry breakdown data for domestic input price and the yen-based export price: (i) All Manufacturing, (ii) Textile, (iii) Chemical and related products (henceforth, Chemical), (iv) Metal & related products (Metal), (v) General purpose, production and business oriented machinery (General Machinery), (vi) Electric and electronic products (Electric Machinery), (vii) Transportation Equipment, and (viii) Other Manufacturing.

In contrast to the previous studies, we use the "contract currency based NEER" (henceforth, contract-NEER) that Ceglowski (2010) first used to measure the degree of exporter's price responses to changes in the yen vis-à-vis the invoice currencies. As shown in Ito, Koibuchi, Sato and Shimizu (2012), Japan's exports are invoiced mainly in U.S. dollars and the yen. In the second-half of 2014, 53.5 percent of Japanese exports to the world are invoiced in U.S. dollars and 35.7 percent are invoiced in the yen.[9] Conventional NEERs, for instance provided by the Bank for International Settlements (BIS), are based on a trade weight, which cannot reflect a large role of the third currency (U.S. dollar) in trade invoicing of Japanese exports.

The contract-NEER can be constructed by using export price indices published by BOJ. Specifically, BOJ publishes two types of export price indices by industry/commodity: one is on a *yen* basis and the other on a *contract (invoice) currency* basis.[10] For simplicity, suppose only three currencies are used in Japanese exports: the yen, the U.S. dollar, and the Euro. Export price indices on a contract currency basis (P_{con}^{EX}) and on a yen basis (P_{yen}^{EX}) can be expressed as follows:[11]

$$P_{con}^{EX} = \left(P_{yen}\right)^{\alpha}\left(P_{usd}\right)^{\beta}\left(P_{eur}\right)^{\gamma} \qquad (4)$$

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[9] The data on Japan's trade invoice currency is published by the Ministry of Finance.
[10] BOJ collects the export price data when cargo is loaded in Japan at the customs clearance stage, and the free on board (FOB) prices at the Japanese port of exports are surveyed. As long as traded in foreign currencies, the sample prices are recorded on the original contract currency basis, and finally compiled as the "export price index on the contract currency basis". To compile the "export price index on the yen basis", the sample prices in the contract currency are converted into the yen equivalents by using the monthly average exchange rate of the yen vis-à-vis the contract currency. See the BOJ website (https://www.boj.or.jp/en/statistics/pi/cgpi_2010/index.htm/) for further details.
[11] By definition, the sum of the weights in respective equations (4) and (5) is assumed to be unity.

$$P_{yen}^{EX} = \left(P_{yen}\right)^{\alpha}\left(E_{yen/usd}P_{usd}\right)^{\beta}\left(E_{yen/eur}P_{eur}\right)^{\gamma} \qquad (5)$$

BOJ collects the information on the choice of contract (invoice) currency when making survey with Japanese exporters at a port level. BOJ first constructs export price indices on a contract currency basis, and then converts the indices into the export price indices on a yen basis using the nominal exchange rate of the yen vis-à-vis the contract currency. Dividing equation (5) by equation (4), we obtain the following formula of the contract-NEER:

$$NEER_{yen}^{Contract} = \frac{P_{yen}^{EX}}{P_{con}^{EX}} = \left(E_{yen/usd}\right)^{\beta}\left(E_{yen/eur}\right)^{\gamma}. \qquad (6)$$

The above discussion based on the three contract (invoice) currencies can be generalized to the case of four or more contract currencies.

The contract-NEER has two notable advantages. First, we can calculate the *industry-specific* NEER on a contract currency basis. Since BOJ publishes the industry-/commodity-breakdown data on export price indices for both yen basis and contract currency basis, we can calculate the industry-specific contract-NEERs. Second and more importantly, the contract-NEER reflects the degree of exchange rate risk that exporters face in each industry. In equation (6), the larger the weight of α is, the smaller is the extent of exchange rate risk. The contract-NEER will be compared across industries in the next section.

The world industrial production index is calculated by taking average of the industrial production index (base year 2010 data) of 20 major trading partner countries and areas for Japan.[12] The 20 partner countries and areas are selected by the criteria that the share of the destination country or area is equal to 1 percent or larger in Japan's total exports. All series are finally standardized to 100 as of the 2010 base year.

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[12] The 20 countries and areas are France, Germany, Netherland, Australia, Canada, Hong Kong, Korea, Singapore, the United States, the United Kingdom, China (mainland), India, Indonesia, Malaysia, the Philippines, Thailand, Vietnam, Russia, Mexico, and Taiwan

Since employing a 4-year window for rolling estimation, time-varying thresholds are available from July 1983 to June 2014. In this paper, near-VAR estimation is conducted for the whole sample from January 1985 to June 2014. To analyze whether the degree of ERPT/PTM has changed over the sample period, we also divide the whole sample period into two sub-periods: one is from January 1985 to December 1999 and the other is from January 2000 to June 2014.

Before proceeding to the near-VAR estimation, we checked time-series properties of variables by the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test with the lag length determined by the Schwarz Information Criterion (SIC). Although not reported in this paper, the results of both ADF and PP unit-root tests show that all variables are non-stationary in level but stationary in first-differences. Thus, we use a near-VAR model including the first-difference series. The lag order of the near-VAR model is set to four to avoid a small number of observations in conducting threshold near-VAR estimation for sub-samples.

4. Empirical Result

4.1 Difference in Exchange Risk and Predicted Exchange Rate across Industries

Figure 2 presents both contract-NEERs and time-varying thresholds. The level and changes in contract-NEERs differ to a large extent across industries. For instance, as shown in Table 1, an average of contract-NEERs is the lowest and the corresponding standard deviation is the smallest in General Machinery. Figure 2 also indicates that the contract-NEER of General Machinery fluctuates within a far narrower range over the sample period than that of other industries. During a large appreciation from January 1985 to January 1995, the contract-NEER of All Manufacturing changed from 190.3 to 98.2, while that of General Machinery declined (appreciated) only from 148 to 99.4. Such small fluctuations of the contract-NEER suggest that Japanese exporters of General Machinery tend to face smaller foreign exchange risk, reflecting the choice of invoice currency. As shown in Table 2, 61.9 percent of General Machinery exports are

invoiced in the yen as of December 2014, which is consistent with the smallest fluctuations of the contract-NEER of General Machinery. Thus, the higher the share of yen invoicing exports, the less exchange rate risk the exporters tend to face. This aspect is fully taken into account when investigating the predicted exchange rate based on the contract-NEER.

Figure 2 also shows the predicted NEERs obtained by the time-varying threshold estimation, which differ across industries. Given a strong trend of the yen appreciation from 1985 to 1995, Table 1 shows that just 15-20 percent of the months from 1985 to 1999 are regarded as the yen depreciation regime. Even in the second half of the sample period from 2000 to 2014, about 20-40 percent of the months are considered as the yen depreciation regime. Among the industries, General Machinery has more observations in the yen depreciation regime than others, reflecting the highest share of yen invoicing exports. Since both contract-NEERs and time-varying thresholds are quite different across industries, the length and timing of the yen appreciation and depreciation regimes also differ across industries, which has not been considered in the previous studies.

4.2 Result of TVAR Estimation with the Time-varying Threshold

The main purpose of this research is to demonstrate possible differences in the degree of ERPT/PTM in Japanese exports by industry between the exchange rate appreciation and depreciation regimes. We estimate impulse responses of the yen-based export price to a one standard deviation shock to the contract-NEER.

The results of impulse responses in All Manufacturing and seven industries for the whole sample period are presented in Figure 3. Impulse responses of yen-based export prices to the contract-NEER shock are generally larger in the yen depreciation regime than in the yen appreciation regime, except for General Machinery. While it is said that PTM is a typical pricing strategy of Japanese exporters, the degree of PTM in practice differs between the yen appreciation and depreciation regimes. Japanese exporters tend to pursue a higher degree of PTM in the yen depreciation regime, which results in a large foreign exchange gain in response to the yen depreciation. Only in the

case of General Machinery exports, the degree of impulse responses is not very different between two regimes, likely due to a large share of yen invoicing exports.

We also divide the whole sample period into two sub-sample periods, and conduct TVAR estimation. Results of the impulse response function analysis are presented in Figure 4. First, during the first sub-sample period from 1985 to 1999, the degree of export price responses to the contract-NEER shock is much higher in the yen depreciation regime than in the yen appreciation regime in all industries. This result is almost consistent with the findings of Figure 3 obtained by the TVAR estimation for the whole sample period. Second, however, during the second sub-sample period from 2000 to 2014, impulse responses in the yen depreciation regime become much smaller, and the degree of differences in impulse responses becomes quite small between the two regimes. Impulse responses of export prices to the contract-NEER shock in the yen appreciation regime do not change or become somewhat smaller in the second sub-sample period. Thus, Japanese exporter's pricing behavior has not changed over time in the yen appreciation regime, but did change in the yen depreciation regime.

The above results are consistent with our observation in Figure 1. During the rapid yen appreciation period from 1990 to 1995, Japanese export prices on a contract currency basis increased to a large extent, especially from 1992-93. The similar increase in export prices on a contract currency basis can also be observed in the recent yen appreciation period from 2008 to 2012. As shown in Figure 1, even during the unprecedented yen appreciation period, Japanese exporters raised the export price on a contract currency basis to a certain extent. Thus, Japanese exporters tend to raise the export price itself in response to a rapid and large appreciation of the yen.[13]

Given an increasingly competitive global market, Japanese exporters cannot fully exploit foreign exchange gains as before, even in the yen depreciation period, and are forced to lower the export price itself to improve their export price competitiveness. Moreover, Japanese exporters have increased their overseas production especially since the collapse of Lehman Brothers, and a share of intra-firm trade in Japan's total exports

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[13] By estimating the time-varying parameter model, Shimizu and Sato (2015) found that the coefficient of the contract-NEER (i.e., the PTM elasticity) declined sharply but temporarily during the yen appreciation period from 2011 to 2012, which indicates an increase in ERPT.

becomes far larger than before.[14] As long as trading with group-companies, Japanese exporters are more likely to share exchange rate risk with overseas subsidiaries and adjust their profit margins strategically. The above results of impulse responses based on the TVAR model reflect such a change in pricing strategy of Japanese exporting firms.

5. Concluding Remarks

In contrast to the previous ERPT research on Japanese exports, this study has evaluated the degree of ERPT/PTM by employing the NEER based on a contract currency weight. The contract-NEER itself provides the useful information on the degree of exchange rate risk across industries. By taking into consideration such a difference in exchange rate risk, we estimate time-varying thresholds as a proxy for exporter's predicted exchange rates, which is a novel technique for distinguishing the yen appreciation and depreciation regimes. Allowing for an industry-specific difference in exchange rate regimes, we employ a TVAR model to demonstrate whether the degree of ERPT/PTM is regime-dependent.

It is found that the degree of PTM (ERPT) is lower (higher) in the yen appreciation regime than in the depreciation regime. During the yen depreciation regime, the degree of PTM becomes lower in the latter sub-sample period from 2000 to 2014 than in the former sub-sample from 1985 to 1999. Likely due not only to increasing competition in global markets but also to growing production network and intra-firm trade, Japanese exporters tend to lower yen-based export prices and fail to fully exploit foreign exchange gain in response to the yen depreciation. Although asymmetric pricing behavior was typically observed before 2000, Japanese exporters pricing behavior becomes more symmetric after 2000 between the yen appreciation and depreciation regimes.

Finally, this study can be extended by investigating time-varying responses of export price indices to the exchange rate shock. Shimizu and Sato (2015) apply the

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[14] See Ito, Koibuchi, Sato and Shimizu (2012, 2013) for the Japanese firm's pricing strategy in intra-firm trade.

Kalman filter technique to the single-equation model of ERPT in Japanese exports. Shioji (2014a, 2014b) employs a time-varying parameter VAR approach to analyze the ERPT in Japanese imports. Such time-varying technique will be useful for further understanding of possible changes in ERPT and PTM.

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Figure 1. Japanese Export Price Indices and the Nominal Exchange Rate (2005=100)
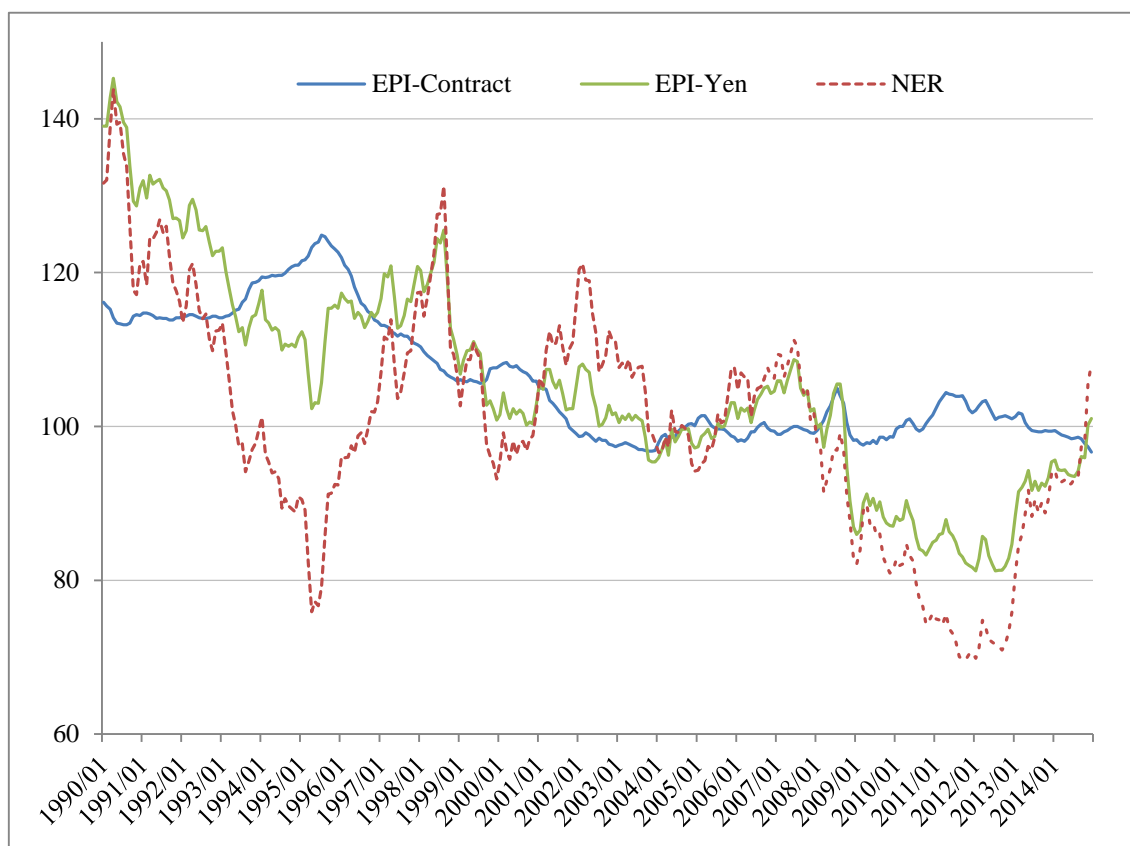
Note: "EPI-Contract" denotes the Japanese manufacturing export price on a contract currency basis; "EPI-Yen" denotes the corresponding export price on a yen basis; "NER" denotes the index (2005=100) of the nominal exchange rate of the yen vis-à-vis the U.S. dollar. An increase (decrease) in NER denotes depreciation (appreciation) of the yen.
Source: Bank of Japan and CEIC Database.

Figure 2. Contract Currency Based NEER and Time-varying Threshold
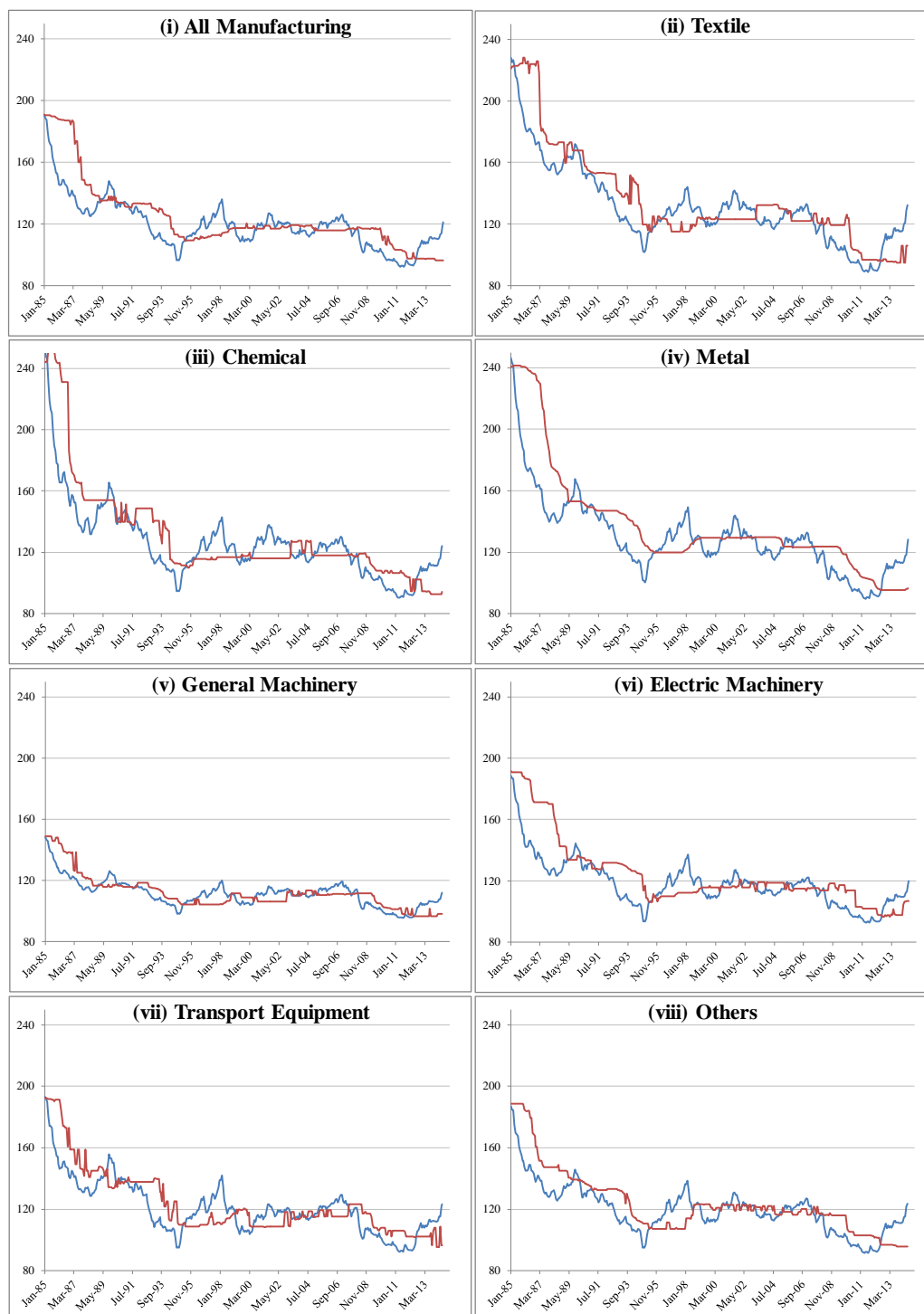
Note: A blue line shows the contract currency based NEER (January 2010 = 100). A red line indicates the time-varying threshold that is considered as the predicted exchange rate at an industry level.

Figure 3. Result of Impulse Response Function Analysis: Whole Sample Period
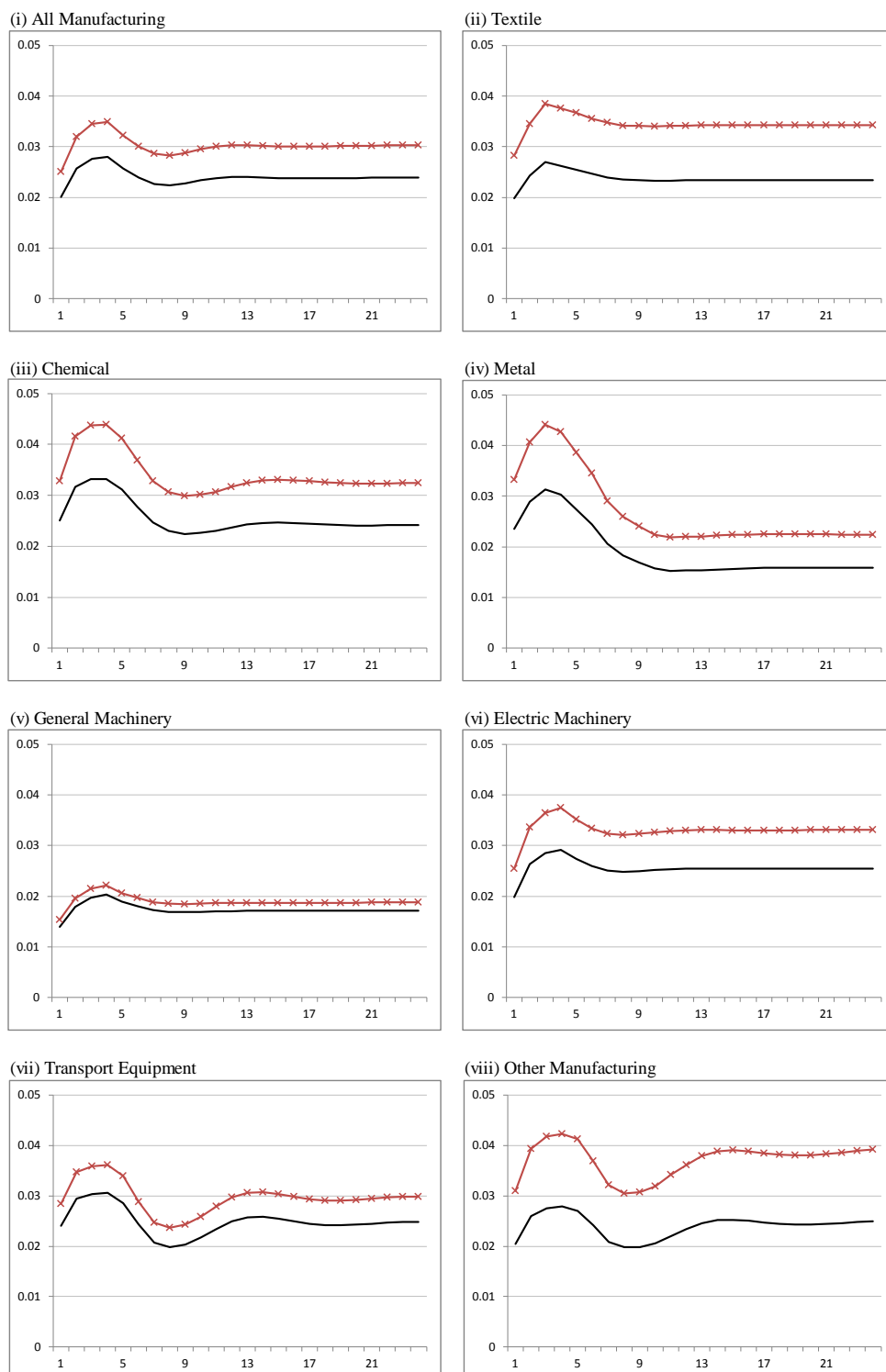
Note: A red and black line show the impulse responses of the export price index to the one standard deviation shock to the contract-NEER in the yen depreciation and appreciation regimes, respectively.

Figure 4. Impulse Response Function: Comparison between Two Periods

(i) All Manufactureing (1985-1999)

(i) All Manufactureing (2000-2014)

(ii) Textile (1985-1999)

(ii) Textile (2000-2014)

(iii) Chemical (1985-1999)

(iii) Chemical (2000-2014)

(iv) Metal (1985-1999)

(iv) Metal (2000-2014)
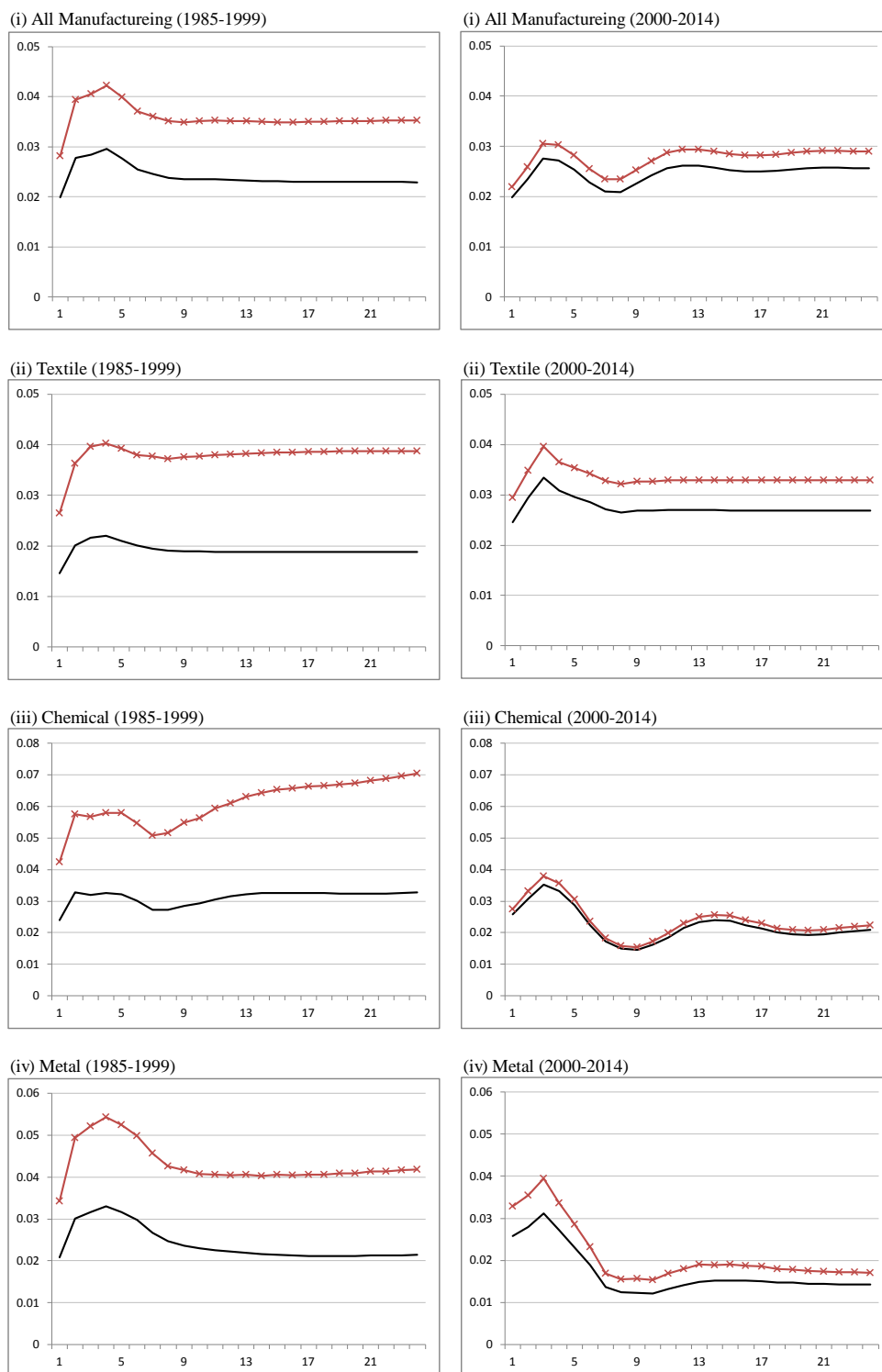
Figure 4 (cont.) Impulse Response Function: Comparison between Two Periods
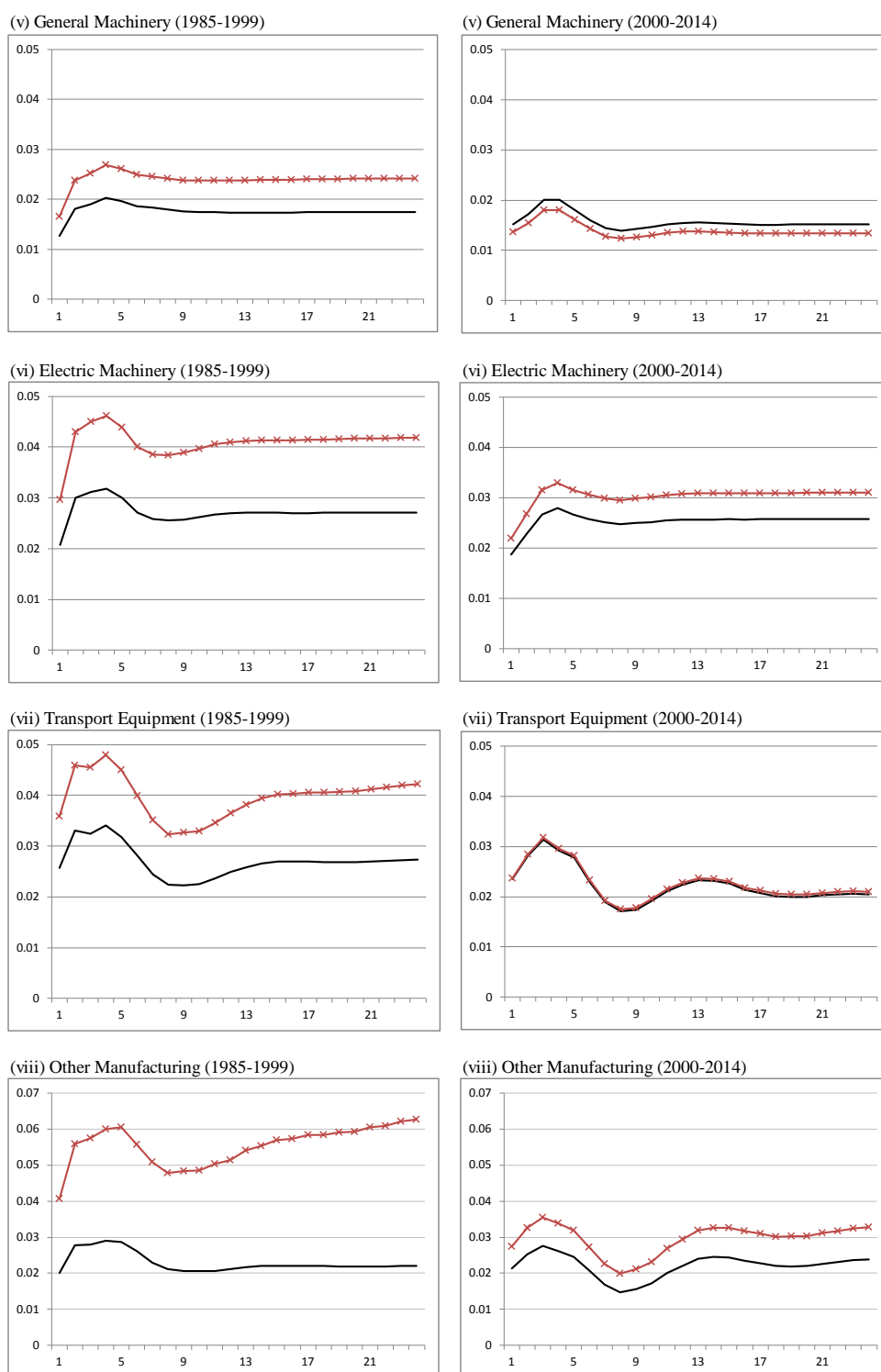
(v) General Machinery (1985-1999)

(v) General Machinery (2000-2014)

(vi) Electric Machinery (1985-1999)

(vi) Electric Machinery (2000-2014)

(vii) Transport Equipment (1985-1999)

(vii) Transport Equipment (2000-2014)

(viii) Other Manufacturing (1985-1999)

(viii) Other Manufacturing (2000-2014)

Note: A red and black line show the impulse responses of the export price index to the one standard deviation shock to the contract-NEER in the yen depreciation and appreciation regimes, respectively.

Table 1. Key Statistics of Contract-NEER and Time-varying Threshold

Contract Currency NEER:		All	Textile	Chemical	Metal	General	Electric	Transport	Others
1985-1999	Average	127.0	144.8	136.8	142.1	114.7	125.2	129.5	126.9
	Stdev	17.1	26.6	27.4	26.2	9.0	17.1	18.4	16.4
2000-2014	Average	111.5	116.7	114.2	116.2	107.8	110.4	111.6	112.4
	Stdev	9.6	14.0	12.4	13.9	6.5	8.9	9.8	10.5
Time-Varying Threshold:		All	Textile	Chemical	Metal	General	Electric	Transport	Others
1985-1999	Depreciation	61	46	60	58	73	59	62	45
	Appreciation	293	308	294	296	281	295	292	309
	Average	135.7	154.3	147.4	156.6	116.8	135.6	135.6	134.0
	Stdev	25.7	34.9	39.1	39.6	12.6	25.7	23.7	23.5
2000-2014	Depreciation	82	79	89	74	100	79	95	76
	Appreciation	272	275	265	280	254	275	259	278
	Average	112.0	116.9	112.6	118.2	106.3	111.9	110.9	113.2
	Stdev	8.2	12.7	9.4	12.8	5.6	7.4	6.8	9.3

Table 2. Share of Invoice Currency in Japanese Export and Import Indices as of December 2014 (%)

Industry:	Export Price Index				*Industry*:	Import Price Index			
	JPY	USD	EUR	Others		JPY	USD	EUR	Others
					Foodstuffs (75.8)	30.3	62.6	3.8	3.3
Textiles (12.5)	9.5	79.8	10.7	0.0	Textiles (53.5)	57.5	40.9	0.7	0.9
Chemicals (95.4)	28.9	69.4	1.7	0.0	Chemicals (83.3)	51.5	36.2	9.8	2.5
Metals (118.2)	21.5	77.8	0.6	0.0	Metals (117.1)	11.0	87.0	0.0	2.0
					Wood & Lumber (16.5)	4.1	70.3	16.1	9.4
					Petroleum (305.4)	8.7	91.3	0.0	0.0
General Machinery (192.0)	61.9	26.0	9.0	2.9	General Machinery (53.9)	40.1	54.4	2.7	2.7
Electric Machinery (232.9)	37.3	53.5	8.3	1.1	Electric Machinery (184.3)	44.9	54.0	0.2	0.9
Transport Equipment (240.6)	29.8	50.3	10.3	9.7	Transport Equipment (34.1)	42.1	42.8	15.1	0.0
Other Products (108.4)	33.0	62.3	3.1	1.5	Other Products (76.1)	21.9	71.9	3.2	3.0
All Industries (1,000.0)	36.7	53.1	6.9	3.2	All Industries (1,000.0)	27.2	69.0	2.4	1.5

Note: A round number is presented as a share of invoice currency. Figures in parentheses under the name of each industry (commodity group) denote a weight of the corresponding industry. The weight of all industries is 1,000.0.

Source: Bank of Japan, Export and Import Price Indices (2010 base).

Appendix Figure 1. Result of Impulse Response Function with Error Confidence Band

(i) All Manufacturing

(ii) Textile
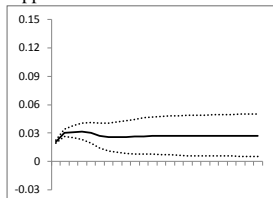

(iii) Chemical

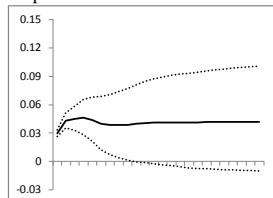

(iv) Metal

(v) General Machinery

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Appendix Figure 1 (cont.) Result of Impulse Response Function with Error Confidence Band
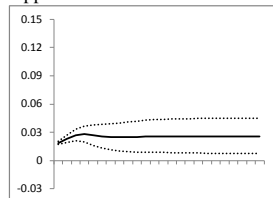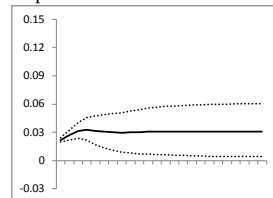
(vi) Electric Machinery

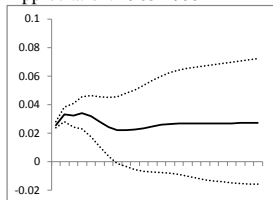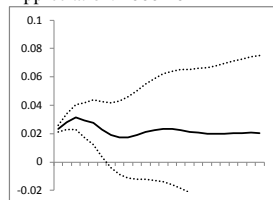| Appreciation: 1985-1999	Depreciation: 1985-1999	Appreciation: 2000-2014	Depreciation: 2000-2014

(vii) Transport Equipment
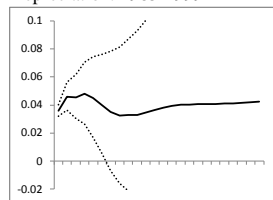
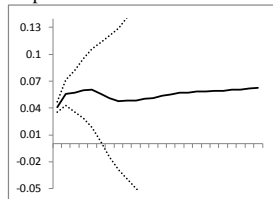| Appreciation: 1985-1999	Depreciation: 1985-1999	Appreciation: 2000-2014	Depreciation: 2000-2014
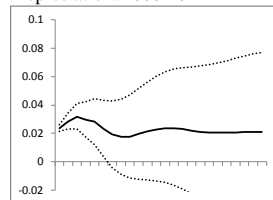
(viii) Other Manufacturing
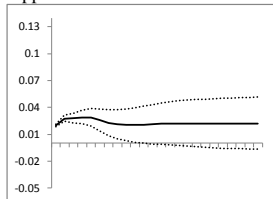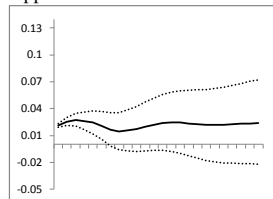
Appreciation: 1985-1999	Depreciation: 1985-1999	Appreciation: 2000-2014	Depreciation: 2000-2014
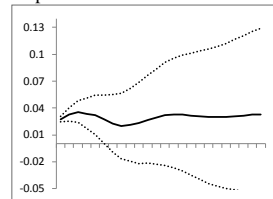
Note: A solid line shows the impulse responses of the export price index to the one standard deviation shock to the contract-NEER. The dotted lines show error confidence bands.