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Exchange Rate Exposure and Exchange Rate Risk Management: The case of Japanese exporting firms

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Exchange Rate Exposure and Exchange Rate Risk Management:[†] The case of Japanese exporting firms

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Abstract

In this paper, we estimate Japanese firms' exchange rate exposure and investigate the impact of exchange rate risk management on them. By using the results of the questionnaire survey sent to all Tokyo Stock Exchange listed firms in 2009, we conduct empirical analysis to investigate whether each risk management tool—financial and operational hedging, the choice of invoice currency, and the price revision strategy (pass-through)—specifically affects their foreign exchange exposure. As a result, we confirm the following characteristics: first, firms with larger dependency on foreign markets have larger foreign exchange exposure. Second, the higher is the U.S. dollar invoicing share, the larger is the foreign exchange exposure, but it is reduced by using both financial and operational hedging. Third, yen invoicing itself reduces the foreign exchange exposure. These findings indicate that Japanese firms utilize operational and financial hedging strategies and price revision policy depending on their choice of invoicing currency.

Keywords: Exchange Rate exposure, Exchange rate risk management, Invoice currency, Operational hedge, Financial hedge, Exchange rate pass-through

JEL classification: F31, G15, G32

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1. Introduction

A strong yen is said to hurt Japanese exporters because it makes their goods less competitive and diminishes funds sent back to Japan. Over the past five years, the dollar's value has fallen more than 30 percent against the yen. Strong concerns persist about the effects of the yen's rapid appreciation on the export-dependent Japanese economy. Such a long-lasting yen appreciation trend, however, is not the first time for Japan; it has occurred several times since Japan moved into the free-floating exchange rate regime in the 1970s.

Japanese exporting firms' foreign exchange risk management has been cultivated and matured under the long and volatile yen–dollar exchange rate movement. Japanese firms usually use both financial and operational hedging to manage their currency exposure. Although financial hedges are conducted to hedge their currency exposure using foreign exchange derivatives in a foreign exchange market, operational hedges are often used for a firm's international transactions between the head office and foreign subsidiaries to reduce their foreign exchange exposure. With the development of sophisticated financial hedge techniques in foreign exchange markets, such as forward transactions, currency swaps, and currency options, firms can hedge their currency exposure against foreign exchange risks. Nevertheless, these transactions can only ensure a certain amount of earnings in terms of the yen during a certain period. They cannot fully protect a party against the effect of the yen's appreciation itself. In response to drastic yen appreciation in 1995, Japanese exporting firms have promoted the transfer of production bases overseas, or have increased the capacity of existing overseas bases, and have increased the proportion of imported components from overseas or have taken other measures to ensure the benefits of the strong yen.

Japan is well known for its unique pattern of US dollar-oriented trade invoicing. According to "stylized facts" of the choice of invoice currency, which are based on 1970s empirical research such as that by Grassman (1973), trade between two economically advanced countries tends to be invoiced in the exporter's currency, and trade between economically advanced and economically developing countries is generally invoiced in the economically advanced country's currency. However, Japan's currency invoicing pattern differs puzzlingly from these stylized facts[1]. According to the Ministry of Finance data, Japanese exporters have a strong tendency to choose the importer's currency for their exports to economically advanced countries such as the US and EU. Dollar invoicing is prevalent in Japan's exports to Asia. This is the other reason why the strong yen turns quickly into an economic and political issue in Japan. If their exports are invoiced in yen, their business performance would not be affected by a stronger yen, at least for a short time horizon. Consequently, the choice of invoicing a currency is strongly

[1] Ito et al. (2010, 2012) investigate this puzzle by conducting interview analysis.

related to Japanese firms' exchange rate risk management.

Furthermore, whether firms can make their price revisions in response to foreign exchange fluctuations (exchange rate pass-through) and how frequently they can do so are also related to their exchange rate risk management. If firms are sufficiently competitive to revise their price to maintain their constant earnings, then exchange rate fluctuations would not cause any severe impact on their performance, at least while the trading volume does not change. Accordingly, the effectiveness of exchange risk management, the choice of invoicing currency, and the decision of exchange rate pass-through are strongly and mutually related.

Then, how can the effectiveness of Japanese firms' exchange rate risk management be measured? One possible way is to measure each firm's exchange rate exposure at first, and to investigate the relation between the exchange rate exposure and the exchange rate risk management. Following previous studies that have estimated exchange rate exposure, it is a sensitivity of firms' cash flows to the fluctuations in exchange rate. Because the value of a firm is the present value of its future cash flows streams, the exchange rate variation is regarded as affecting it. To date, many empirical studies have used stock returns as a proxy for firm value, and have obtained exchange rate exposure from a regression of stock returns on an exchange rate change. Although the issue of exchange rate exposure and its measurement for firms has demanded the attention of many researchers in the corporate finance area for a long time, few existing studies have specifically undertaken firm level analysis of exchange rate exposure and exchange rate risk management including the choice of invoice currency and pass-through policy.

As described in this paper, we investigate the relation between exchange rate exposure and exchange rate risk management of Japanese firms based on a questionnaire survey. Questionnaires were sent to all Japanese manufacturing firms listed on the Tokyo Stock Exchange in September 2009 with the cooperation of the Research Institute of Economy, Trade, and Industry (RIETI). This survey (2009 RIETI survey) presents rich information not only on the firms' foreign exchange rate risk management but also on the firms' choice of invoicing currency and price revision (pass-through) strategy. The survey results are classified by industry and by the firm size, using annual financial reports of sample firms, through which new evidence of Japanese firm's exchange rate risk management, such as the usage of financial and operational hedging and price revision are presented[2]. Our analysis shows how Japanese firms combine three different tools of exchange rate risk management policies, operational and financial hedging, and exchange rate pass-through under their own choice of invoicing currency, to reduce their exchange rate exposure. Given a growing regional production network of Japanese firms, our findings based on the questionnaire study will present important

[2] Please see Ito et al. (2010a) for details.

implications for future exchange rate policies to support more effective exchange rate risk management.

The remainder of this paper is organized as follows. Section 2 reviews earlier studies of firms' foreign exchange risk management and presents a discussion of the relation between the variety of exchange rate risk management and invoicing currency choice conducted by Japanese firms. Section 3 reviews earlier studies' methodology of firm exchange rate exposure and presents our estimated results. Section 4 conducts empirical analyses to find the relation between exchange rate risk management and the exchange rate exposure. Finally section 5 concludes this paper.

2. Exchange Rate Risk Management of Japanese Firms

2-1. Variety of Exchange Rate Risk Management

Numerous empirical studies have examined the question of how firms accommodate or mitigate foreign exchange risk. Usually, firms use two means to hedge exchange rate risk. One is a financial hedge through financial market instruments such as exchange rate derivatives or foreign currency debt. The other is an operational hedge through operational organization of the exporting firm. To manage long-term exchange rate risks effectively, firms should build operational hedging strategies in addition to widely used financial hedging strategies. Most studies specifically examine currency hedging[3]. These studies analyze the relation between operational hedging and financial hedging and underscore the effectiveness of both strategies by conducting empirical analysis based on firms' stock return. For example, Pantzalis, Simkins, and Laux (2001), using a sample of 220 US multinational firms, and find that operational and financial hedges are complementary risk management strategies. Hommel (2003) shows that operational hedging creates flexibility, a strategic complement to financial hedging. Allayannis, Ihrig and Weston (2003) also investigate both financial and operational exchange-rate risk management strategies of multinational firms and confirm that operational hedging strategies benefit shareholders only when used in combination with financial hedging strategies. Kim, Mathur and Nam (2006) investigate how operational hedging is related to financial hedging. They confirm that although operational and financial hedging strategies are complementary, firms using operational hedging are less dependent on the use of financial derivatives[4].

[3] For example, Carter, Pantzalis, and Simkins (2001) investigate the impact of firmwide risk management practices for US multinational corporations and find that currency risk can be reduced effectively through transactions in the forward exchange market.

[4] They use a sample of 424 firm observations from the COMPUSTAT Geographic Segment files for 1998.

The relation between invoicing currency and hedging is rarely investigated. The exception appears to be a study by Döhring (2008), which was the first reported survey study of both the choice of invoicing currency and financial/operational hedging. Results show that invoicing choice is a substitute for derivative hedging such as exchange rate forward in eliminating transaction risk and also that firms are expected to opt for either of them depending on the relative cost of the strategy. Conducting a survey of actual hedging strategies and techniques of large corporations from a euro-area perspective, Döhring (2008) concludes that whether a domestic currency invoicing and hedging are substitutes or complements depends crucially on the size and geographical orientation of the exporting firm and on the structure of the destination market.[5]

As for recent country-specific studies, Chiand and Lin (2007) examine financial and operational hedge strategies of foreign exchange exposures using multiple-horizon data of Taiwan non-financial firms during 1998–2005. They report that the use of operational hedging strategies does not help reduce foreign exchange exposure for Taiwan firms. Pramborg (2005) compares the hedging practices between Swedish and Korean nonfinancial firms and shows that Korean firms used much smaller financial derivatives than Swedish firms with more dependence on foreign debt than derivatives. Both studies describe the difficulties of exchange rate risk management in underdeveloped foreign exchange markets such as those of Taiwan and Korea. Regarding research using data for Japan, Jayasinghe and Tsui (2008) examine the exchange rate exposure of sectoral indexes in Japanese industries and report evidence of exposed returns and its asymmetric conditional volatility of exchange rate exposure using a bivariate GJR-GARCH model. Although Japanese exporting firms tend to face large volatility of the yen/US dollar exchange rate, surprisingly few studies conduct firm level analysis of hedging and exchange rate risk management with the choice of invoicing currency.

2-2. Japanese Firms' Feature of Currency Invoicing and Pass Through

Japan is well-known for its unique pattern of the choice of trade invoice currency, which is an overdependence of the US dollar invoicing in spite of an economically advanced country. According to the "stylized facts" related to the choice of invoice currency based on the empirical research in the 1970s such as Grassman (1973), trade between two economically advanced countries tends to be invoiced in the exporter's currency. Trade between economically advanced and economically developing countries is generally invoiced in the economically

[5] Regarding the relation between pass-through and hedging, Bartram, Brown and Minton (2010) shows empirically that firms pass-through some porting of currency changes to customers and use both operational and financial hedges for the rest of the foreign exchange exposure.

advanced country's currency. However, Japan's currency invoicing pattern evidently contradicts the stylized facts. First, Japanese exporters have a strong tendency to choose the importer's currency for their exports to economically advanced countries such as the United States and EU. Second, US dollar invoicing is prevalent in Japan's exports to Asia.

Increasingly, studies have examined the determinants of currency invoicing. They typically use data of the share of currency invoicing at a country level, but few Japanese firm level empirical studies have been done[6]. One recent exception is that of Ito et al. (2010b) who conducted an interview survey of leading Japanese exporters to overcome a data constraint[7]. Because of the interview survey related to firm-level information related to exchange rate risk management, the destination breakdown data for the choice of invoice currency, and the underlying reason for their invoicing choice, Ito et al. (2010, 2012) confirmed the new determinants of Japanese firms' invoice currency as follows: (1) export channels of for instance, intra-firm trade, inter-firm trade, or trade via a trading company; (2) each currency's transaction cost; (3) the intensity of competition in the export destination markets and the degree of product differentiation; and (4) the structure of production and distribution network in which goods are produced in Asia and shipped to the United States as the final destination.

Regarding intra-firm trade, invoicing in the importer's currency is prevalent for Japanese exports to economically advanced countries. Because the exports are destined for local subsidiaries that face severe competition in the local markets, Japanese parent firms have a strong tendency to take an exchange rate risk by invoicing in the importer's currency. It also makes economic sense to concentrate currency risk at the headquarters because it is better equipped with risk management expertise and with scale economies. Especially if the local subsidiaries are production based and if their final destination is US, then their choice of US dollar invoicing is rational as a part of their strategy of exchange rate risk management.

Some Japanese firms that export highly differentiated products or which have a dominant share in global markets choose yen invoicing. In addition, small firms, which have no treasury department because of budget constraints, usually ask a trading company to manage their foreign exchange business. In this case, they also tend to use yen invoicing in their transactions with a trading company. Accordingly, Japanese firms' choice of invoice currency is rather complicated, but should be considered along with other risk management tools.

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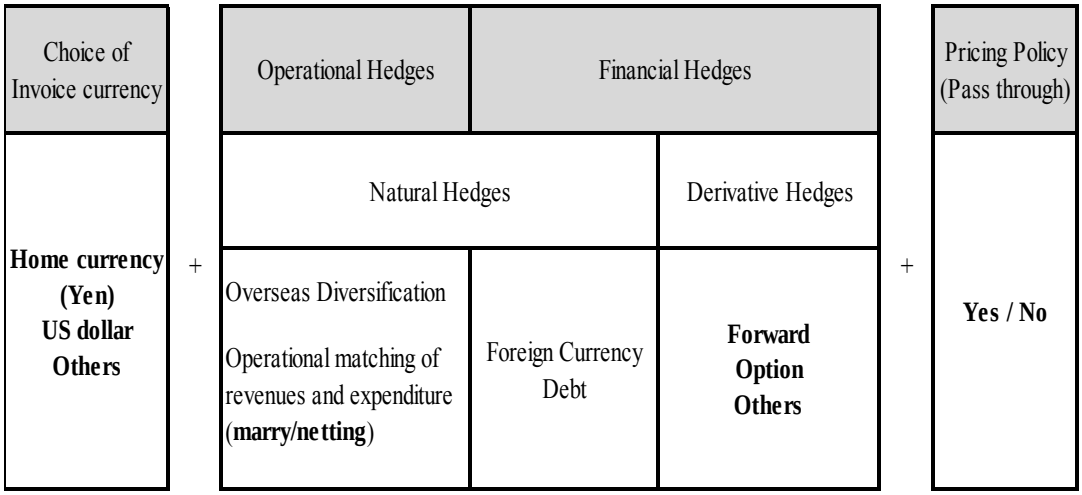
[6] Goldberg and Tille (2009) used highly detailed Canadian import data at a customs level with rich information on the source country, invoice currency, value of transactions, etc. The other is a study by Friberg and Wilander (2008), who conduct a questionnaire survey analysis with Swedish exporting firms for empirical tests on determinants of currency invoicing, which is a useful approach to obtain detailed data at a firm level.

[7] Ito et al. (2010b) interviewed treasurers of 23 Japanese companies from four major export industries (automobile, electrical machinery, general machinery, and electronic components) over the one-year period of autumn 2007 – autumn 2008.

As do Bartram, Brown and Minton (2010), we assume that Japanese firms have four options of exchange rate risk management to mitigate the impact of currency fluctuations: (1) choice of invoice currency, (2) pricing (pass-through) policy, (3) operational hedging, and (4) financial hedging. Figure 1 shows our conceptual diagram of exchange rate risk management, based on which we analyze the results of 2009 RIET survey to clarify the notable characteristics of Japanese firms' exchange rate risk management. Compared with the related studies above, the novelty of this paper is that it describes detailed empirical analysis of the exchange rate risk management of Japanese firms using three different tools: invoicing currency choice, pricing (pass through) strategy and financial/operational hedging policy.

Figure 1. Concept of Exchange Rate Risk Management



Note: The part of "Operational hedges" and "Financial Hedges" is from Döhring (2008).

2-3. Effectiveness of the Japanese Firms' Exchange Rate Risk Management

Because we have summarized the features of Japanese firms' exchange risk management in the previous section, invoicing currency pattern, exchange rate risk management of two types, such as financial hedge and operational hedge, and exchange rate pass-through are viewed as four key components to express Japanese firms' robustness to avoid the exchange rate risk. Because they are closely related each other, it is very difficult to set the order of priority which choice is done at first. As described herein, we put these four components in the following order: (1) the choice of invoicing currency (the share of yen or US dollar invoicing), (2) with or without an operational hedge ("marry and netting"), (3) the degree of financial hedge (the hedge ratio of the forward contract), and (4) with or without an exchange rate pass through (price revision). From the four perspectives above, we consider the effectiveness of Japanese firms' exchange rate risk management to reduce their exchange rate exposure.

Choice of invoicing currency (share of yen or US dollar invoicing)

As shown by Ito et al. (2010), Japanese firms that export highly differentiated products or which have a dominant share in global markets tend to choose yen invoicing. If their exports are invoiced in the yen instead of the US dollar, their business performance would not be affected by a stronger yen at least for a short-time horizon. However, most firms usually are not sufficiently competitive to decide their invoicing currency in their own sake, but negotiate it with their customers or just follow their customers' decision. For each firm, the choice of invoicing currency is a matter of its own reason and depends not only on the competitiveness, but also on other various factors such as firm size, products, trading partners, trading countries, and financial characteristics. Although firms with 100% share of yen invoicing are robust against a yen's sudden appreciation because they have no foreign currency exposure, firms with a high share of US dollar invoicing are vulnerable because of their foreign currency exposure. In this case, they must use operational or financial hedging to manage them. From the standpoint of the choice of invoicing currency only, the higher the US dollar invoicing share, the larger the exchange rate exposure is. The higher the yen invoicing share is, the smaller the exchange rate exposure is.

With or without an operational hedge ("marry and netting")

In response to severe yen appreciation in 1995, Japanese exporting firms have promoted the transfer of production bases overseas, or increased capacity of existing overseas bases, and increase the proportion of imported components from overseas and other measures to ensure the benefits of a strong yen. In such cases, firms often use "marry and netting" in their intra-trade transactions[8]. However, not all firms can use this technique. For example, firms that produce goods made using Japanese materials only and export them abroad cannot do marry or netting because they have no payable foreign currency.

From the standpoint of operational hedge, applying "marry and netting" can reduce the amount of firms' foreign currency exposure. For firms with higher US dollar invoicing share, "marry and netting" presumably works more effectively to reduce currency exposure.

Degree of financial hedge (hedging ratio of forward contract)

The RIETI survey 2009 showed that more than 70% of firms use some kind of hedging instrument through the foreign exchange market. Among them, more than 90% of firms use

[8] There is another technique of operational hedging, such as using a foreign currency denominated debt to cancel out the foreign currency exposure. In this paper, we regard "marry and netting" as a major technique of operational hedging for Japanese firms.

"Forward contracts". However, no specific choice of hedging ratio of "Forward contract" exists by industry or firm size, which suggests that deciding the hedging ratio depends on each firm's foreign exchange risk management strategy. From the standpoint of financial hedging, the higher the US invoicing share is, the greater is the financial hedge usage to reduce the exchange rate exposure. Firms with almost 100% yen invoicing have no need to use financial hedging because they have no foreign currency exposure.

With or without an exchange rate pass through

Whether firms can make their price revisions in response to foreign exchange fluctuations (foreign exchange pass through) and how frequently they do so are also related to the firm's robustness against the yen's sudden appreciation. If firms are sufficiently competitive to revise their prices to maintain their constant earnings in terms of the Japanese yen, then foreign exchange fluctuations can cause no severe impact on their performance, at least while the amount of sales does not change. From the standpoint of exchange rate pass through, two different patterns depend on the invoicing currency share: for a larger share of yen invoicing firms, no existence of price revision in 2008 is more robust against the yen's appreciation, and for a larger of US dollar invoicing firms, existence of price revision in 2008 is more robust against the yen's appreciation.

3. Estimating Japanese Firms' Exchange Rate Exposure

Many researchers empirically investigate the exchange rate exposure of firms. Most of them measure the exposure as the elasticity between changes in firm value and exchange rates. The exchange rate exposure is a sensitivity of firms' cash flows to the fluctuations in exchange rate. Because the value of a firm is the present value of its future cash flows streams, the exchange rate variation is regarded as affecting it. To date, many empirical studies have used stock returns as a proxy for the value of the firm, and have obtained the exposure elasticity from a regression of stock returns on the exchange rate change.

As described above, Japanese firms are highly involved with sophisticated exchange rate risk management because of their high share of US dollar invoicing. Several previous studies have specifically examined Japanese firms. For example, Dominguez (1998) examined the exchange rate exposure of Japanese main industries during 1984–1995 and found that many Japanese companies are exposed to yen–dollar movements. Their results imply that they do not fully hedge against exchange rate risk. He and Ng (1998) investigated a sample of 171 Japanese multinational firms' stock price returns for January 1979 – December 1993 and found that the exchange rate exposure increases with the firm's export ratio and decreases with the level of

hedging activity.[9] Doukas et al. (2003) examined the exchange rate exposure for 1,079 firms traded on the Tokyo stock exchange during 1975–1995 and confirmed that the exchange rate exposure is found to be positively associated with the degree of the firm's foreign economic involvement and that it is inversely related to its size and debt-to-asset ratio.

Among the models of previous studies, the simplest is that of Adler and Dumas (1984), who define the exchange rate exposure as the change in the market value of the firm resulting from a unit change in the exchange rate. According to them, the exchange rate exposure of the firm is obtainable from the coefficient on the exchange rate variable only as follows.

$$R_{i,t} = \beta_{0,i} + \beta_{1,i} \cdot \Delta s_t + \varepsilon_{i,t}$$
$$R_{i,t} : \textit{the return on firm i's stock} \qquad (1)$$
$$\Delta s_t : \textit{the change in the relevant exchange rate}$$

Therein, $R_{i,t}$ is the stock return for firm i, Δs_t is the percentage change in an exchange rate variable, defined as the home currency price of foreign currency, and $\beta_{1,i}$ is the elasticity of firm value to the exchange rate change. This elasticity indicates the firm's average exchange rate exposure over the estimation period, in home currency units, as a percentage of the firm's market value.

To control for other macroeconomic factors on realized returns, most empirical studies include a return to a market portfolio in the regression model. For example, Dominguez and Tesar (2006) and many other related studies estimate the control of macroeconomic factors using market portfolio as follows.

$$R_{i,t} = \gamma_{0,i} + \gamma_{1,i} \cdot \Delta s_t + \gamma_{2,i} \cdot R_{m,t} + \varepsilon_{i,t}$$
$$R_{m,t} : \textit{the return on the market portfolio} \qquad (2)$$

Therein, $R_{m,t}$ is the return on the market portfolio and $\gamma_{1,i}$ is the elasticity of firm value to the exchange rate change adjusted by the firm's market portfolio.

Although most previous studies choose a regression model (2) to estimate Japanese firms' exchange rate exposure with adoption of TOPIX as a market portfolio, two problems exist in model (2). First, because TOPIX is correlated strongly with the dollar/yen rate, the two-factor regression model has a multicollinearity problem. Second, Bodnar and Wang (2003) warned that the market portfolio variable strongly influences the results, and that it sometimes underestimates the coefficient and suffers from much lower levels of statistical significance[10].

[9] In addition, they confirmed that keiretsu multinational corporations are more exposed to exchange-rate risk than non-keiretsu firms are.

[10] Bodnar and Wang (2003) demonstrate that different constructions of a market portfolio have different exposures to exchange rates because of a significant size effects in exchange rate exposures. They propose the use of cap-based portfolios as controls for market factors.

As described in this paper, we estimate the sampled firms' exchange rate exposure using two different models above on a monthly basis. Following Bodnar and Wang (2003), we refer to $\beta_{I,i}$ as *the total exchange rate exposure* and $\gamma_{I,i}$ as *the residual exchange rate exposure*. For the exchange rate measure, we use the nominal exchange rate (Japanese yen per US$) and nominal effective exchange rate (NEER) published by BIS. For a market portfolio, we use TOPIX and MSCI Japan Index[11,12]. We use the latter index is because TOPIX is correlated strongly with the nominal exchange rate of the Japanese yen per US$. So the estimated coefficients of exchange rate return might have a downward bias.

As described in the previous section, our sample firms are those which answer the RIETI Survey 2009. The number of samples is 277. There are 15 industries, including Food, Textile, Chemicals, Medicinal Chemicals, Coal and Oil Products, Rubber Products, Glass and Stone Products, Iron and Steel, Non-Metal Products, Metal Products, General Machinery, Electrical Machinery, Transport Equipment, and Other products. The sample period is from January 2005 to December 2009 in response to the RIETI Survey 2009. Because some estimated exchange rate exposures are negative as a result of their industrial characteristics and because most of the exchange rate exposure estimated by NEER usually is negative, we use their absolute value[13].

Figure 2 shows the estimated total exchange rate exposure using the yen/dollar exchange rate and NEER by BIS. On average, their size is larger than 100% except for "Food" and "Medicinal Chemicals". Among 15 industries, the total exchange rate exposure of "Transport Equipment" is the highest and above 200%. This result indicates that the exchange rate risk of "Transport Equipment" industries is larger than other industries and their stock return is affected more than twice of exchange rate change. Except for "Coal and Oil Products", the exchange rate exposures estimated by NEER are higher than those of the yen/dollar exchange rate. This result suggests that most Japanese industries face not only the fluctuation risk of the yen/dollar exchange rate, but also other trade countries' exchange rates.

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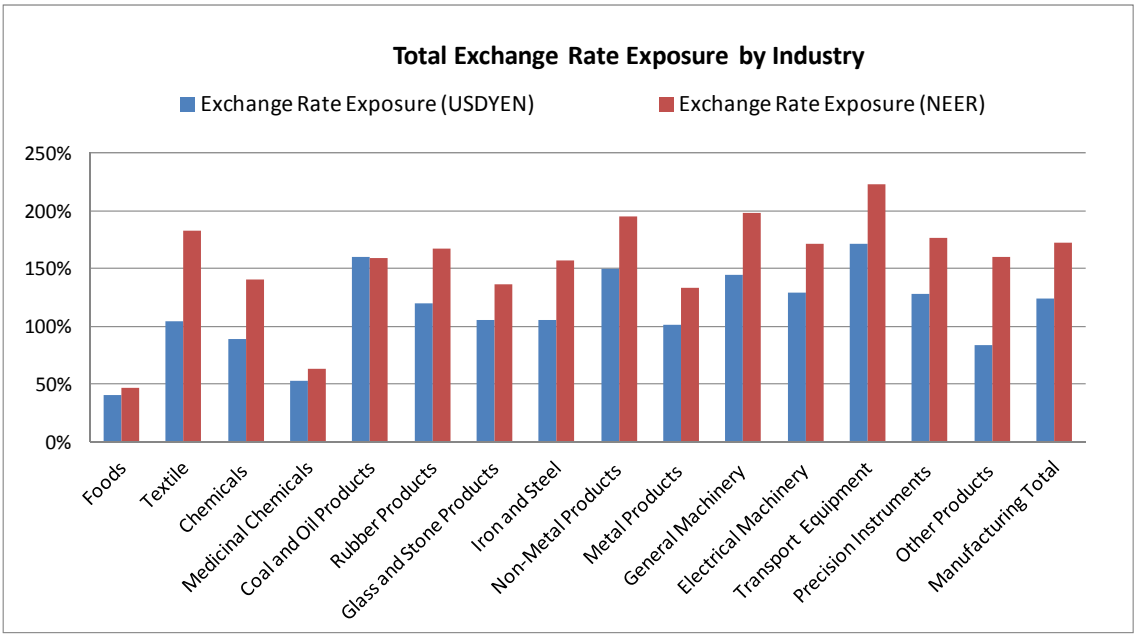
[11] The MSCI Japan Index is a free-float adjusted market capitalization weighted index that is designed to track the equity market performance of Japanese securities listed on Tokyo Stock Exchange, Osaka Stock Exchange, JASDAQ and Nagoya Stock Exchange. The MSCI Japan Index (Price Index) is calculated in JPY on a real time basis.

[12] Following the suggestion of Dominguez and Tesar (2006), we try to use an international index (MSCI World Price Index) by calculating the return in terms of the Japanese yen as a control variable. The estimated results are almost equal to those of the MSCI Japan Index.

[13] For these analyses, we use all estimated coefficients, either significant or not significant. Although some previous studies have devoted attention to statistical significance, small coefficients sometimes are insufficient to be estimated significantly. We might lose the case of small exchange rate exposure from our sample. For a robustness check, we conduct the same analysis using statistically significant coefficients only. We confirm that we obtained similar results.

Figure 2. Total Exchange Rate Exposure by Industry



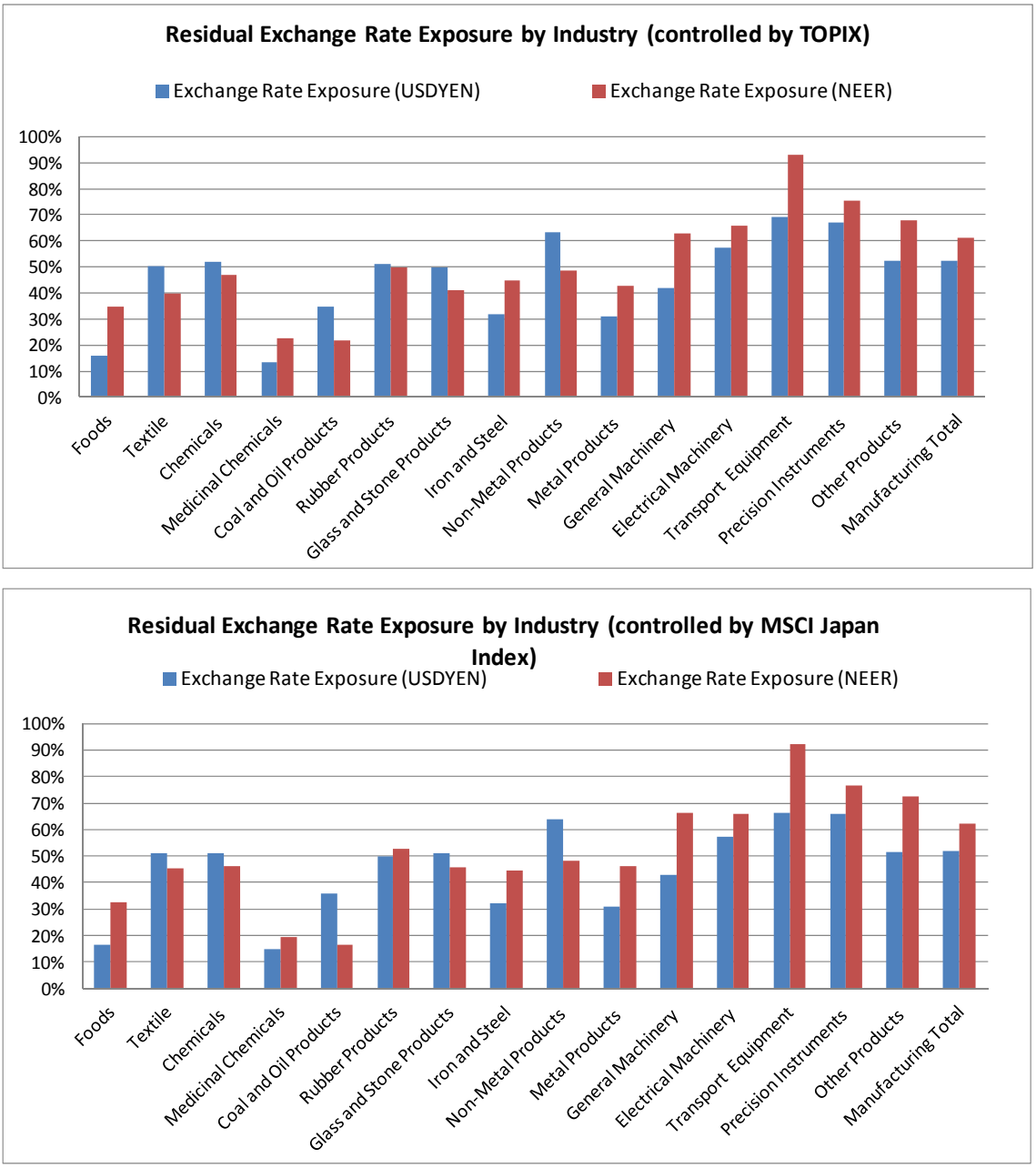
Authors' calculation

Source: Yen/USD exchange rate are from Datastream. NEER is from BIS.

Figure 3 presents the estimated residual exchange rate exposures using the yen/dollar exchange rate and NEER by BIS. All are less than 100% and are smaller than the total exchange rate exposure. Similar to the previous case, the residual exchange rate exposure of "Transport Equipment" is the highest among 15 industries. The second is "Precision Instruments", and "Electric Machinery" and "General Machinery" are the next except for "Other Products". These results are consistent with the fact that such Japanese representative manufacturing industries are facing severe competition with other countries.

Contrary to the previous figure, results of the size of two residual exchange rate exposures differ by industry. The residual exchange rate exposures estimated by NEER are larger than those of yen/dollar exchange rate in "Food", "Medicinal Chemicals", "Iron and Steel", "Metal Products", "General Machinery", "Electric Machinery", "Transport Equipment", "Precision Instruments" and "Other Products". It is particularly interesting that the residual exchange rate exposures estimated by yen/dollar exchange rate are greater than those of NEER in more basic material industries such as "Coal and Oil Products", "Glass and Stone" and "Non Metal Products". The estimated results controlled by TOPIX are mostly similar to those by the MSCI Japan index.

Figure 3. Residual Exchange Rate Exposure by Industry



Authors' calculation

Source: Yen/USD exchange rate and TOPIX are from Datastream. NEER is from BIS. MSCI Japan index is from Bloomberg.

4. Determinants of firms' foreign exchange exposure

In this section, we investigate the relation between the estimated exchange rate exposure and exchange rate risk management of Japanese firms based on the questionnaire survey. As we

presented the section 2, the RIETI Survey 2009 covers rich information related not only to the firms' foreign exchange rate risk management but also to the firms' choice of invoicing currency and price revision (pass-through) strategy. The survey results are classified by industry and by the firm size, using annual financial reports of sample firms, through which new evidence of Japanese firm's exchange rate risk management, such as the usage of financial and operational hedging and price revision are presented.

From the standpoint of exporting firms' exchange risk management, we hypothesize as follows:

1. Large share of foreign sales to total sales increases the exchange rate exposure.
2. High share of US$ invoicing increases the exchange rate exposure.
3. Financial and operational hedges reduce the exchange rate exposure.
4. Financial and operational hedges can be effective in reducing exchange rate exposure, especially for a firm that chooses mainly US$ invoicing.
5. High share of yen invoicing decreases the exchange rate exposure.
6. Pass through decreases exchange rate exposure.

Hypotheses 1 and 2 are examined in many previous studies. For example, Shapiro (1975), Levi (1983), and Jorion (1990) confirmed that the firm's currency exposure should be positively related to the ratio of foreign sales to total sales and the use of foreign currency hedging lessen a firm's foreign exchange rate exposure. Hypothesis 3 is also used in many previous studies. For example, Bartram, Brown and Minton (2010) demonstrate that financial hedging with FC debt appears to have a larger effect on exposure than the use of FX derivatives. Our contribution is expressed in Hypotheses 4 and 5, which examine the effectiveness of financial and operational hedge with the choice of invoicing currency.

As a dependent variable, we use the estimated exchange rate exposures of four kinds in section 3 as follows:

- $\beta^{Total,JPY/USD}i$, $\beta^{Total,NEER}i$: Firm i's total exchange rate exposure obtained using nominal exchange rate of yen/dollar and NEER
- $\beta^{Residual,JPY/USD}i$, $\beta^{Residual,NEER}i$: Firm i's residual exchange rate exposure obtained by TOPIX/MSCI Japan Index and nominal exchange rate of yen/dollar and NEER

As the basic explanatory variables in the right-hand-side, we first include a "size" of firm *i* measured by the log of total consolidated sales and "share of foreign sales" which is a proximity for foreign market exposure and which is calculated as total foreign sales of firms *i* divided by total consolidated sales. Additionally, we use each firm's share of US dollar invoicing from the firm's answer of RIETI Survey 2009 and four dummy variable as follows. The dummy variable for using marry/netting (Dummy of OH) takes 1 if a firm uses marry/netting and 0 if not. Dummy variable for using forward transaction (Dummy of FH) takes 1 if a firm uses forward

transaction and 0 if not. Dummy variable for executing price revision in 2008 (Dummy of PT) takes 1 if a firm revised the price attributable to the sudden appreciation of the Japanese yen and 0 if not. As another invoicing share variable, we also use "Dummy of USD Main Invoicing (yen Main Invoicing)" which takes 1 if the share of USD (yen) invoicing is larger than yen (USD) invoicing. [14]First, we examine the determinants of exchange rate exposure including the share of US dollar invoicing in the following regression model.

$$\begin{aligned}\beta^{Total,\ JPY/USD}i \quad &= \alpha_0 + \alpha_1 Log\ of\ Total\ Consolidated\ Sales_i + \alpha_2 Share\ of\ Foreign\ Sales_i \\ &+ \alpha_3\, Share\ of\ US\ Invoicing_i \\ &+ \alpha_4\, Dummy\ of\ OH_i + \alpha_5\, Dummy\ of\ FH_i + \alpha_6\, Dummy\ of\ PT_i \\ &+ \alpha_7\, Share\ of\ US\ Invoicing_i \bullet Dummy\ of\ OH_i \\ &+ \alpha_8\, Share\ of\ US\ Invoicing_i \bullet Dummy\ of\ FH_i \\ &+ \gamma_i\, Industry\ dummy_j \quad (j=1, \bullet\bullet\bullet, 15) \end{aligned} \tag{3}$$

$$\begin{aligned}\beta^{Residuall,\ JPY/USD}i \quad &= \alpha_0 + \alpha_1 Log\ of\ Total\ Consolidated\ Sales_i + \alpha_2 Share\ of\ Foreign\ Sales_i \\ &+ \alpha_3\, Share\ of\ US\ Invoicing_i \\ &+ \alpha_4\, Dummy\ of\ OH_i + \alpha_5\, Dummy\ of\ FH_i + \alpha_6\, Dummy\ of\ PT_i \\ &+ \alpha_7\, Share\ of\ US\ Invoicing_i \bullet Dummy\ of\ OH_i \\ &+ \alpha_8\, Share\ of\ US\ Invoicing_i \bullet Dummy\ of\ FH_i \\ &+ \gamma_i\, Industry\ dummy_j \quad (j=1, \bullet\bullet\bullet, 15) \end{aligned} \tag{4}$$

The estimated results are presented in Table 1. As expected, the coefficients of the share of foreign sales are positive and significant in all cases. We confirm that the large share of foreign sales to total sales increases the exchange rate exposure. Regarding the relation between the exchange rate exposure and US dollar invoicing, the coefficients of share of USD invoicing and USD Main Invoicing are positive and significant in several cases. Results show that a high share of US$ invoicing increases the exchange rate exposure. Contrary to our hypothesis 3, the coefficients of operational hedge and financial hedge are not negative. Some of the coefficients of financial hedging are positive and significant. In these cases, the cross-term coefficients of financial hedge and USD invoicing (or USD main invoicing) are negative and significant in most cases. These results suggest that firms with a high US$ invoicing share can reduce their exchange rate exposure using financial hedging. It is particularly interesting that the cross-term coefficients of operational hedge and USD main invoicing are negative and significant in the exchange rate exposure obtained by the yen/dollar exchange rate. The salient implication is that the exchange rate exposure obtained by the yen/dollar exchange rate can be reduced by a combined strategy of USD main invoicing and marry and netting. Unfortunately, the coefficients of pass through are not significant.

[14] Descriptive statistics of all variables are presented in the Appendix.

Table 1. Relation between Exchange Rate Exposure, Exchange Rate Risk Management and US dollar invoicing

Method: Least Squares with White Heteroskedasticity-Consistent Standard Errors & Covariance

Dependent Variable	Total Exchange Rate Exposure				Residual Exchange Rate Exposure							
	nominal exchange rate of yen/dollar		NEER		nominal exchange rate of yen/dollar, TOPIX		nominal exchange rate of yen/dollar, $MSCI_{Japan}$		NEER, TOPIX		NEER, $MSCI_{Japan}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Constant	0.1802	0.2324	0.4540	0.5756	0.4845 **	0.5428 **	0.5127 **	0.5707 **	0.4232 *	0.5183 **	0.4383 *	0.5400 **
	(0.1458)	(0.1343)	(0.3997)	(0.3951)	(0.2279)	(0.2356)	(0.2259)	(0.2328)	(0.2266)	(0.2195)	(0.2284)	(0.2220)
Log of total consolidated sales	0.5386 ***	0.5344 ***	0.0415	0.0385	-0.0284	-0.0276	-0.0296	-0.0288	-0.0290	-0.0314	-0.0303	-0.0329
	(0.1663)	(0.1655)	(0.0365)	(0.0366)	(0.0220)	(0.0219)	(0.0218)	(0.0216)	(0.0221)	(0.0222)	(0.0223)	(0.0224)
Share of Foreign Sales	0.6389 ***	0.6307 ***	0.9806 ***	0.9846 ***	0.4951 **	0.4814 ***	0.4571 **	0.4423 **	0.4024 *	0.4086 *	0.4179 *	0.4237 *
	(0.1611)	(0.1604)	(0.2966)	(0.2984)	(0.1964)	(0.1780)	(0.1983)	(0.1758)	(0.2305)	(0.2278)	(0.2338)	(0.2307)
Share of USD invoicing	0.5706 ***		0.6140 *		0.2767		0.2877		0.4200 ***		0.4768 ***	
	(0.2408)		(0.3114)		(0.1826)		(0.1822)		(0.1549)		(0.1550)	
USD Main invoicing		0.4469 **		0.3424		0.0839		0.0942		0.2308 *		0.2760 **
		(0.1853)		(0.2421)		(0.1444)		(0.1426)		(0.1177)		(0.1217)
Operational Hedge	0.0074	0.0316	-0.0375	-0.0010	0.0302	0.0159	0.0112	0.0088	0.1842	0.0953	0.1596	0.0815
	(0.1582)	(0.1125)	(0.2074)	(0.1493)	(0.1168)	(0.0891)	(0.1146)	(0.0880)	(0.1530)	(0.1113)	(0.1546)	(0.1130)
Financial Hedge	0.1917	0.1185	0.3774 **	0.2229	0.0159	0.0373	0.0130	0.0335	0.2731 **	0.1812 *	0.2845 **	0.1794 *
	(0.1372)	(0.1098)	(0.1782)	(0.1437)	(0.0960)	(0.0857)	(0.0960)	(0.0846)	(0.1092)	(0.0970)	(0.1116)	(0.0987)
Pass-through	-0.0952	-0.0837	-0.1103	-0.1010	0.0374	0.0424	0.0289	0.0356	0.0242	0.0177	0.0149	0.0099
	(0.0848)	(0.0838)	(0.1101)	(0.1098)	(0.0665)	(0.0655)	(0.0661)	(0.0647)	(0.0703)	(0.0695)	(0.0707)	(0.0701)
ShareUSD*Operational Hedge	-0.2080		0.0536		-0.2871		-0.2502		-0.4039 *		-0.3699	
	(0.2790)		(0.3602)		(0.2188)		(0.2158)		(0.2306)		(0.2315)	
ShareUSD*Financial Hedge	-0.3924		-0.8274 **		0.0639		0.0524		-0.4371 **		-0.5262 **	
	(0.2724)		(0.3551)		(0.2123)		(0.2115)		(0.1998)		(0.2030)	
USD Main*Operational Hedge		-0.3041 *		0.0130		-0.2320 *		-0.2159		-0.2457 *		-0.2310
		(0.1755)		(0.2296)		(0.1369)		(0.1353)		(0.1499)		(0.1518)
USD Main*Financial Hedge		-0.2021		-0.4685 *		0.0868		0.0776		-0.2095		-0.2742 *
		(0.1951)		(0.2574)		(0.1535)		(0.1517)		(0.1434)		(0.1476)
Industry Dummy	○	○	○	○	○	○	○	○	○	○	○	○
Adjusted R-squared	0.3095	0.3147	0.1786	0.1672	0.0775	0.0639	0.0694	0.0528	0.1044	0.0944	0.1055	0.0940

1) Estimated coefficient and standard error (in parentheses) are reported in each column.

2) Asterisk(s), ***, **, and * means that the estimated coefficients are statistically significant at less than 1%, 5%, and 10%, respectively.

Second, we examine the determinants of exchange rate exposure including the share of yen invoicing in the following regression model.

$$\beta^{Total,\ JPY/USD}i = \alpha_0 + \alpha_1 Log\ of\ Total\ Consolidated\ Sales_i + \alpha_2 Share\ of\ Foreign\ Sales_i + \alpha_3\ Share\ of\ Yen\ Invoicing_i + \alpha_4\ Dummy\ of\ OH_i + \alpha_5\ Dummy\ of\ FH_i + \alpha_6\ Dummy\ of\ PT_i + \gamma_i\ Industry\ dummy_j \quad (j=1, \bullet\bullet\bullet, 14) \tag{5}$$

$$\beta^{Residual,\ JPY/USD}i = \alpha_0 + \alpha_1 Log\ of\ Total\ Consolidated\ Sales_i + \alpha_2 Share\ of\ Foreign\ Sales_i + \alpha_3\ Share\ of\ Yen\ Invoicing_i + \alpha_4\ Dummy\ of\ OH_i + \alpha_5\ Dummy\ of\ FH_i + \alpha_6\ Dummy\ of\ PT_i + \gamma_i\ Industry\ dummy_j \quad (j=1, \bullet\bullet\bullet, 14) \tag{6}$$

For an invoicing variable, we also use "Dummy of Yen Main Invoicing" in which the share of yen invoicing is larger than that of USD invoicing.

Estimated results are presented in Table 2. As expected, the coefficients of both share of yen invoicing and yen main invoicing are negative and significant in most cases. We can confirm that the high share of yen invoicing decreases the exchange rate exposure.

Table 2. Relation between Exchange Rate Exposure, Exchange Rate Risk Management and yen invoicing

Method: Least Squares with White Heteroskedasticity-Consistent Standard Errors & Covariance

Dependent Variable	Residual Exchange Rate Exposure							
	nominal exchange rate of yen/dollar, TOPIX		nominal exchange rate of yen/dollar, $MSCI_{Japan}$		NEER, TOPIX		NEER, $MSCI_{Japan}$	
	(1)	(2)	(4)	(5)	(6)	(7)	(8)	(9)
Constant	0.7122 ***	0.7473 ***	0.7630 ***	0.7959 ***	0.6100 **	0.5755 **	0.6588 ***	0.6337 ***
	(0.2391)	(0.2324)	(0.2353)	(0.2293)	(0.2396)	(0.2347)	(0.2432)	(0.2368)
Log of total consolidated sales	-0.0287	-0.0312	-0.0307	-0.0333	-0.0320	-0.0310	-0.0347	-0.0341
	(0.0212)	(0.0212)	(0.0210)	(0.0209)	(0.0217)	(0.0218)	(0.0219)	(0.0220)
Share of Foreign Sales	0.4971 **	0.4779 **	0.4599 **	0.4390 **	0.4275 *	0.4242 *	0.4467 *	0.4425 *
	(0.1983)	(0.1926)	(0.1997)	(0.1936)	(0.2272)	(0.2263)	(0.2300)	(0.2286)
Share of Yen invoicing	-0.2020 *		-0.2206 **		-0.0415		-0.0481	
	(0.1130)		(0.1107)		(0.1258)		(0.1265)	
Yen Main invoicing		-0.2062 ***		-0.2202 ***		-0.0042		-0.0185
		(0.0769)		(0.0755)		(0.0900)		(0.0901)
Operational Hedge	-0.1057	-0.1252	-0.1083	-0.1281 *	-0.0046	0.0030	-0.0113	-0.0067
	(0.0793)	(0.0763)	(0.0778)	(0.0746)	(0.0958)	(0.0927)	(0.0969)	(0.0939)
Financial Hedge	0.0408	0.0340	0.0330	0.0264	0.1147	0.1192	0.0944	0.0975
	(0.0701)	(0.0703)	(0.0690)	(0.0691)	(0.0844)	(0.0843)	(0.0855)	(0.0854)
Pass-through	0.0187	0.0083	0.0112	0.0005	0.0137	0.0162	0.0075	0.0087
	(0.0673)	(0.0665)	(0.0670)	(0.0662)	(0.0730)	(0.0741)	(0.0737)	(0.0747)
Industry Dummy	○	○	○	○	○	○	○	○
Adjusted R-squared	0.0788	0.1031	0.0736	0.1012	0.0796	0.0789	0.0755	0.0748

1) Estimated coefficient and standard error (in parentheses) are reported in each column.

2) Asterisk(s), ***, **, and * means that the estimated coefficients are statistically significant at less than 1%, 5%, and 10%, respectively.

As a result, we confirm the following. Similar to previous studies, we confirm that Japanese firm's exchange rate exposure is positively related to the share of foreign sales to total sales. As expected, we confirmed that a high share of US$ invoice increases Japanese firms' exchange rate exposure. However, for firms with high US$ invoice share, the exchange rate exposure obtained by yen/dollar exchange rate can be reduced using operational hedging, and exchange rate exposure obtained by NEER can be reduced through financial hedging. This result is consistent with the conclusion of Ito et al. (2011). Furthermore, we confirm that yen invoicing itself reduces Japanese firm's foreign exchange exposure. Price revision (pass-through) might be effective to reduce a firm's total exchange rate exposure, but it is not statistically significant.

5. Conclusion

As described in this paper, we investigate the features of Japanese firms' exchange rate risk management from the results of 2009 RIETI survey. This is the first detailed investigation based on the questionnaire survey to test the effectiveness of exchange rate risk management of Japanese firms on their exchange rate exposure.

Results confirm the following characteristics. First, the scale of exchange rate exposures differs across industries and Japanese representative manufacturing industries have high exchange rate exposures. Second, firms with greater dependence on foreign sales have larger foreign exchange exposure. Third, the higher the US dollar invoicing share, the greater the foreign exchange exposure, but it is reduced using both financial and operational hedging. Fourth, yen invoicing itself reduces the foreign exchange exposure. These findings indicate that Japanese firms use operational and financial hedging strategies and price revision policy depending on their own choice of invoicing currency.

This is the first detailed investigation of the exchange rate risk management policy of Japanese firms. These findings present important implications not only for Japanese firms' exchange rate risk managers to build more efficient risk management schemes, but also for policymakers to support the current and future expansion of regional production network of Japanese firms. To support their exchange risk management more effectively, the government should steadily promote regulatory reform in foreign transactions. In addition, promoting yen invoicing is important especially for Japanese exporting firms.

Some of our results are not sufficiently strong because of insufficient items of questionnaire survey, which should be partially reinforced by another source such as firms' financial report. Because our sample firms are limited, we should estimate the listed firms' exchange rate exposure and check the relation between their exposure and risk management

from their financial report. Moreover, we must confirm whether we can obtain the same results if we add other control variable, such as foreign debt ratio, R&D investment, volatility of (foreign) sales, and number of foreign subsidiary. Particularly for operational hedges, we use only "marry and netting" as a proxy of operational hedges. However, more aspects reflect firms' operational hedges. These remain as issues to be investigated in future studies.

References

Adler, M., and Dumas, B., 1984. “Exposure to currency risk: definition and measurement,” *Financial Management* 13, 41–50.

Allayannis, G., Ihrig, J. and Weston, J. P., 2001, "Exchange-Rate Hedging: Financial vs. Operational Strategies," *American Economic Review Papers & Proceedings,* 91 (2), 391–395.

Bartram, S. M., Brown, G. W. and Minton, B. A., 2010, "Resolving the exposure puzzle: The many facets of exchange rate exposure," *Journal of Financial Economics*, 95 (2), 148–173.

Bodnar, G. and Wong, F., 2003. “Estimating exchange rate exposures: issues in model structure,” *Financial Management* 32 (1), 35–67.

Carter, D., Pantzalis, C. and Simkins, B. J., 2001, "Firmwide Risk Management of Foreign Exchange Exposure by U.S. Multinational Corporations," Working Paper Series. Risk Management eJournal 01/2001; DOI:10.2139/ssrn.255891.

Chiang, Yi-Chein and Lin, Hui-Ju, 2007, “Foreign Exchange Exposures, Financial and Operational Hedge Strategies of Taiwan Firms,” *Investment Management and Financial Innovation*, 4(3), 95–105.

Döhring, B., 2008, "Hedging and invoicing strategies to reduce exchange rate exposure: a euro-area perspective," Economic Papers 299, European Commission.

Dominguez, K., 1998, "The Dollar Exposure of Japanese Companies," *Journal of the Japanese International Economics*, 12(4), 388–405.

Dominguez, K and Tesar, L. L. 2006, “Exchange rate exposure,” *Journal of International Economics*, 68, 188–218.

Doukas, J.A., Hall, P. H. and Lang, L. H. P., 2003, “Exchange Rate Exposure at the Firm and Industry Level,” *Financial Markets, Institutions& Instruments*, 12(5), 291–346.

Friberg, R. and Wilander, F., 2008, "The Currency Denomination of Exports – A Questionnaire Study," *Journal of International Economics*, 75, 54–-69.

Goldberg, L. S. and Tille, C., 2008, “Vehicle Currency Use in International Trade,” *Journal of International Economics*, 76(2), 177–192.

Goldberg, L. S. and Tille, C., 2009, “Micro, Macro, and Strategic Forces in International Trade Invoicing,” NBER Working Paper No. 15470, National Bureau of Economic Research.

Grassman, S., 1973, “A Fundamental Symmetry in International Payments,” *Journal of International Economics*, 3, 105–116.

He, J. and Ng, L. K. 1998, “The Foreign Exchange Exposure of Japanese Multinational

Corporations," *Journal of Finance,* 53, 733–753.

Hommel, U., 2003, "Financial versus operative hedging of currency risk," *Global Finance Journal*, 14(1), 1–18.

Ito, T., Koibuchi, S., Sato, K., and Shimizu, J., 2010a, "Exchange Rate Risk Management and Choice of Invoice Currency of Japanese Firms – from the 2009 RIETI Questionnaire Survey Results," RIETI Discussion Paper Series 10-J-032 (in Japanese)

Ito, T., Koibuchi, S., Sato, K., and Shimizu, J., 2010b, "Why Has the Yen Failed to Become a Dominant Invoice Currency in Asia? A Firm-Level Analysis of Japanese Exporters' Invoicing Behavior," NBER Working Paper No. 16231.

Ito, T., Koibuchi, S., Sato, K., and Shimizu, J., 2012, "The Choice of an Invoicing Currency by Globally Operating Firms: A Firm-Level Analysis of Japanese Exporters," *International Journal of Finance & Economics,* 17(4), 305–320.

Jayasinghe, P., and Tsui, A. K., 2008 "Exchange rate exposure of sectoral returns and volatilities: Evidence from Japanese industrial sectors," *Japan and the World Economy*, 20(4), 639–660.

Kamps, A., 2006, "The Euro as Invoicing Currency in International Trade," ECB Working Paper No. 665, European Central Bank.

Page, S. A. B., 1977, "Currency of Invoicing in Merchandise Trade," *National Institute Economic Review*, 33, 1241–1264.

Pramborg, B., 2005, "Foreign exchange risk-management practices between Swedish and Korean firms," *Pacific-Basin Finance Journal*, 13, 343–366.

Pantzalis, C., Simkins, B. J., and Laux, P. A., 2001, "Operational Hedges and the Foreign Exchange Exposure of US Multinational Corporations," *Journal of International Business Studies* 32(44), 793–813.

Appendix: Descriptive statistics of all variables in section 4

	Basic Information		Hedge Methodology		
	Log of Total Consolidate Sale	Foreign Sales Share (%)	Financial Hedge*	Operational Hedge*	Pass Through*
Mean	11.34	37.04	1.00	0.42	0.43
Median	11.21	35.10	1.00	0.00	0.00
Maximum	16.12	88.50	1.00	1.00	1.00
Minimum	8.08	6.80	0.00	0.00	0.00
Std. Dev.	1.70	19.82	0.07	0.50	0.50
Observations	207	206	207	203	191

	Choice of Invoicing Currency			
	INVOICE in USD (%)	INVOICE in YEN (%)	USD MAIN*	YEN MAIN*
Mean	42.32	47.41	0.35	0.44
Median	40.00	50.00	0.00	0.00
Maximum	100.00	100.00	1.00	1.00
Minimum	0.00	0.00	0.00	0.00
Std. Dev.	32.40	34.96	0.48	0.50
Observations	197	197	197	197

	Total Exchange Rate Exposure		Residual Exchange Rate Exposure			
	yen/dollar	NEER	yen/dollar, TOPIX	yen/dollar, $MSCI_{Japan}$	NEER, TOPIX	NEER, $MSCI_{Japan}$
Mean	1.2370	1.7188	0.5220	0.5196	0.6115	0.6230
Median	1.1748	1.6519	0.4027	0.4091	0.5023	0.5037
Maximum	3.3893	4.9841	2.1892	2.2244	3.3997	3.2743
Minimum	0.0944	0.0192	0.0021	0.0114	0.0069	0.0008
Std. Dev.	0.6325	0.8091	0.4208	0.4130	0.5398	0.5374
Observations	227	227	227	227	227	227

Authors' calculation.

Note:

1. Financial Hedge is a dummy variable which takes 1 if a firm uses a forward transaction and takes 0 if not.
2. Operational Hedge is a dummy variable which takes 1 if a firm uses a marry & netting and takes 0 if not.
3. Pass through is a dummy variable which takes 1 if a firm changed a price due to the Yen's appreciation in 2008 and takes 0 if not.
4. USD MAIN is a dummy variable which takes 1 if the share of US dollar invoicing is higher than one of yen invoicing and takes 0 if not.
5. YEN MAIN is a dummy variable which takes 1 if the share of Yen invoicing is higher than one of US dollar invoicing and takes 0 if not.