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Global Value Chains and Exchange Rate Pass-Through into the Import Prices of Japanese Industries

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Abstract
With internationally fragmented processes of productions, i.e., global value chains, value-added components of a country's export include the importer's contributions as well as the contributions of third countries. The exchange rate sensitivity of export price reflects these value-added components. We examine the effect of value-added contributions of exporters and importers on the degree of exchange rate pass-through by focusing on the Japanese import prices by industry. Our results show that exchange rate pass-through increases for industries with a higher contribution of exporting countries' value-added and for industries with a lower contribution of the importing country's value-added. The differentials in value-added help explain the dynamics of exchange rate pass-through at the industry level.

Keywords: Exchange Rate Pass-through; Global Value Chains; Value-Added in Trade
JEL Classification: F14 (Empirical Studies of Trade); F61 (Microeconomic Impacts of Globalization).

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1 Introduction

To fully take advantage of international divisions of processes of production, multinational exporters import parts and components as well as materials from multiple source countries and export parts and components as well as final products to multiple destination countries. According to the World Bank, in 2020, the Global Value Chains (GVC hereafter) accounted for almost 50% of global trade. As a result, an imported product may contain value-added by several countries, including value-added in other countries and even value-added by an importing country itself, in addition to value-added by an exporting country. Consequently, the effect of a change in the bilateral exchange rate between an exporting country and an importing country on import prices becomes more complicated. The degree of spillovers on the import prices from a change in the exchange rate is defined as exchange rate pass-through (hereafter, ERPT) in the international finance literature. Variations of ERPT are known to reflect different aspects of market structures (Auer and Schoenle 2016), product characteristics (Chatterjee, Dix-Carneiro, and Vichyanond 2013)(Chen and Juvenal 2016), and the nature of exchange rate shocks (Shambaugh 2008). Understanding ERPT is essential for policymakers because the degree of ERPT on consumer price constitutes a contribution to domestic inflation.

In this study, we investigate the import prices of Japan with respect to a change in the exchange rate, considering the role of value-added in Japan as well as those in exporting countries. We focus on Japan because of the following reason. Inflation has been an important issue in Japan for at least the last ten years since the Bank of Japan (BOJ) formally adopted inflation targeting as its monetary policy target. Japan has been experiencing too low inflation that the economy has not yet fully enjoyed an economic boom since the burst of the bubble economy in the 90's. Especially after 2021, inflation caused by price hikes in food and energy, supply disturbances, and tight labor markets became a global issue. Japan, although lagging far behind other countries, started seeing a rise in consumer prices in 2022.

A few important features are found from the literature on exchange rate pass-through on Japanese imports; according to Sasaki, Yoshida, and Otsubo (2022), the ERPT to Japanese import prices is not complete but substantial, whereas the ERPT to consumer price is almost negligible. They also found that the ERPTs on import prices are time-varying and are different among industries. Their results indicate that the ERPT to Japanese import prices increased to 0.75 in 2017 from 0.65 in 2000 but with heterogeneity among industries (0.4 for Chemicals to 0.95 for Wood products). Although their findings are interesting and have important policy implications, the driving force for the dynamic behaviors of ERPT is not clearly explained.

For possible causes of the time-varying nature of ERPTs, Shambaugh (2008) points out that different structural shocks drive exchange rate movements at different points of time, and ERPTs, as a result, may differ. Yoshida, Zhai, Sasaki, and Zhang (2022) examine the dynamics of the ERPT on the Japanese consumer price index using the structural VAR model of Shambaugh (2008). They found out that a depreciation of the Japanese yen driven by weak domestic demand brought deflationary pressure on the consumer price, which is against the traditional view of the ERPT.

In this study, instead of looking at structural shocks for a possible cause of time-varying ERPTs in Japan, we focus on the possible role of global value chains in explaining heterogeneous degrees of ERPTs among industries, as well as the time-varying property of ERPTs in Japan. Focusing on industry-wise Japanese imports, we examine whether the distributions of the value-added components among countries affect the degree of exchange rate pass-through.

As a data source for the GVC indices, we rely on the TiVA database, estimated from the OECD's Inter-Country Input-Output (ICIO) tables. The most recent TiVA database covers 66 economies and 45 industries between 1995 and 2018[1].

With internationally fragmented processes productions or global value chains, value-added components of a country's export may include a third country's contributions and that of the importer. The exchange rate sensitivity of export price reflects these value-added components. We examine the effect of value-added contributions of exporters and importers on the degree of ERPT by focusing on the Japanese import prices by industries. As evidenced by an annual panel of nine industries between 1995 and 2017, we found that exchange rate pass-through increases for industries with a higher contribution of exporting countries' value-added and industries with a lower contribution of the importing country's value-added. The value-added components explain a substantial amount of the differences in the degree of ERPT among industries and demonstrate that ERPT dynamics that are increasing at the import price level.

The remaining structure of this paper is organized as follows. The next section describes how value-added indices used in this study are constructed. Section 3 provides empirical evidence, and the last section concludes.

[1] Other possible data sources include the WIOD and the RIETI firm-level survey data. The WIOD is originally funded by the European Commission and then later maintained by the GGDC, University of Groningen, but is no longer maintained. Therefore, the most recent year ends in 2014. The RIETI data does not provide value-added; however, it provides information on how much individual Japanese firms export and import.

2 Value-added for exporters, importers, and third countries

2.1 The value-added in gross exports

Most studies examine the role of firms participating in GVCs from the perspective of exporters and decompose the gross exports into their domestic and foreign value-added contents, (Koopman, Wang, and Wei 2014)(de Soyres, Frohm, Gunnella, and Pavlova 2021). The domestic valued-added can further be decomposed into three parts; domestic value-added sent directly to consumers in the destination market (i.e., directly consumed by the importing country), domestic value-added sent to third countries (intermediate goods or services re-exported to third countries), and domestic value-added re-imported back to the exporting country. One of the important distinctions in GVCs is where in a vertical stream of production an exporter is located, i.e., forward participation and backward participation (Borin, Mancini, and Taglioni 2021), (Antràs and Chor 2021). The percentage of foreign value added in gross export is used as a measure of backward participation. The backward participation shows how many imported intermediaries are used to produce a unit of exported goods. On the other hand, the percentage of re-exported value added in gross export is used as a measure of forward participation. This measure represents how much exports are used as intermediaries in the destination countries and re-exported to a third country or back home.

The GVC backward and forward participation at the global level between 2000 and 2014 is in the range of 20-25 percent and 15-20 percent, respectively (Borin et al. 2021). At the country level, there exists a wide discrepancy among exporters. For example, China's GVC backward and forward participation are higher than those of Japan and US, especially in forward participation (Wang et al., 2017). Even within some industries, we observe heterogeneity in subindustries. For example, subindustries in low or medium-technology manufacturing industries demonstrate a wide range of GVC participation from 30 percent to 60 percent (Cigna et al., 2022).

2.2 Literature review of exchange rate effect on trade: Studies using GVCs data

Ahmed, Appendino, and Ruta (2017) estimate the elasticity of exports to the real effective exchange rate (REER) for 46 countries between 1996 and 2012. They found that the elasticity decreased from 0.83 to 0.68 during the period. More interestingly, participation in the GVC has a negative impact on the REER elasticity: between 22% and 30% (the effect is larger for backward GVC than for forward GVC). Tan, Trieu Duong, and Chuah (2019) estimate the elasticity of exports to the REER and VREER for 8 ASEAN countries between 1995 and 2011.

FVA (Foreign Value Added) reduces the effect of exchange rate appreciations on real gross exports by 93% and offsets the effect of increased volatility by about 75%. The study finds evidence of a negative relationship between exchange rate appreciation and gross exports for ASEAN-8. Integration into GVCs almost completely offsets this effect: high FVA share in gross exports reduce the effect of exchange rate appreciation/depreciation by 93%.

Ha, Marc Stocker, and Yilmazkuday (2020) investigate ERPT estimating structural FAVAR for 55 countries (29 advanced and 26 EMDE) between 1974 and 2017. In this paper, ERPT is defined as the percentage increase in consumer prices associated with a 1% depreciation of the effective exchange rate after one year following a specific shock. This paper shows a positive correlation between the ERPT and the GVC participation (foreign value-added). Camatte, Daudin, Faubert, Lalliard, and Rifflart (2020) also examine how the transmission of the exchange rate to consumer prices is influenced by global value chains (see also Georgiadis et al. 2019).

2.3 The value-added in gross imports

In this study, we define the GVC from the perspective of importers and decompose the value-added of gross imports to original source countries. In analogy to the value-added concepts in gross exports in (de Soyres, Frohm, Gunnella, and Pavlova 2021), Figure 1 represents the overview of breakdowns of value-added in gross imports. First, the total value-added of gross imports is divided into three components: VAX, VAM, and VAT. The value-added by an exporting country is denoted as VAX. The value-added by an importing country is denoted as VAM and this measure captures re-imports. The value added by third countries, i.e., neither exporting nor importing country, is denoted as VAT.

TiVA provides a wide variety of value-added indices by utilizing the OECD's inter-country input-output tables(Guilhoto, Webb, and Yamano 2022). OVA_GI is a variable with five arguments as shown below.

$OVA\_GI(s,i,p,c,j)$ where s is a source country, i is an industry of imports, p is an importing country, c is an exporting country, and j is an exporting industry in country c. We sum over exporting industries js for each country c to obtain

$$OVA\_GI\_tot\_ind(s,i,p,c) = \sum_{j \in J(c)} OVA\_GI(s,i,p,c,j) \tag{1}$$

We also aggregate over all exporting countries to obtain

$$OVA\_GI\_world(s,i,p,) = \sum_{c \in C} OVA\_GI\_tot\_ind(s,i,p,c) \tag{2}$$

The value-added by the set of exporting countries, i.e., excluding countries not exporting to this importing country, is defined as

$$VAX(i,p) = \sum_{s \in C} OVA\_GI\_world(s,i,p) \tag{3}$$

The value-added by the importing country, Japan in this study, is defined as

$$VAM(i,p) = OVA\_GI\_world(Japan,i,p) \tag{4}$$

Nominal effective exchange rates by industries are constructed by the authors as the trade-value weighted average exchange rates. The matching of the TiVA industry classification[2] with the BOJ industry classification was necessary because the TiVA industry classifications are 45 industries whereas the BOJ industries are only 10. For each import price index, IPI, industry, the authors pick candidate TiVA industries, and examine (and compare) sub-industries category of IPI and corresponding industries descriptions in the ISIC file. Table 1 provides the list of the matched TiVA industries for each corresponding BOJ industry.

2.4 Why value added in an importing country matters for ERPT?

The effect of value-added in an importing country on ERPT can be related analogously to the role of the local distribution sector in the ERPT literature. The role of the distribution sector is emphasized in the macroeconomic model of Corsetti and Dedola (2005) besides many other causes for incomplete pass-through. The quality model of Chen and Juvenal (2016) and the multi-product model of Chatterjee, Dix-Carneiro, and Vichyanond (2013) also introduce local distribution sector in their models to show that ERPT will be lower for a higher quality product and core product, respectively. In these models, the import price in the importer's currency can be shown as the sum of the export price multiplied by the exchange rate and local distribution cost, c;

$$P^{imp} = \epsilon P^{ex} + c \tag{5}$$

where ϵ is the value of one unit of the exporter's currency in terms of importing country's currency so that an increase in ϵ indicates an appreciation of the exporter's currency. The local distribution cost is denominated in the importer's currency so that a change in exchange rate does not affect c.

If there is no distribution cost, i.e., c is equal to 0, total differentiation of the natural log of the equation with an assumption of no autonomous change in P^{ex}, an exchange rate pass-through on import price can be shown to be the following

[2] TiVA Industries are classified by ISIC Rev.4 (International Standard Industry classifications).

$$\frac{dlnP^{imp}}{dln\epsilon} = (1+\eta^{ex}) \in (0,1), \text{ where } \eta^{ex} = \frac{dlnP^{ex}}{dln\epsilon} \in (-1,0) \tag{6}$$

However, for non-zero distribution cost, an exchange rate pass-through on import price is shown as equation7 and is lower than ERPT in equation6.

$$\frac{dlnP^{imp}}{dln\epsilon} = \frac{\epsilon P^{ex}(1+\eta^{ex})}{\epsilon P^{ex}+c} \tag{7}$$

The presence of the local distribution sector decreases the share of consumer price that responds to a change in exchange rates. In the same vein, the parts and components produced in an importing country, i.e., value added in the importing country, also make import prices less responsive to a change in exchange rates. We can simply replace c by VAM[3]. Therefore, our testing hypothesis is that a higher VAX and a lower VAM contribute to a higher ERPT. More detailed derivations of equations 6 and 7 are shown in Appendix C.

2.5 Import price index and nominal effective exchange rate at the industry level

Many studies estimate exchange rate pass-through by using custom-level data. In these studies, the import (or export) prices are based on the unit value, i.e., the ratio of the value to the quantity. Even at the most disaggregated level such as HS 9-digit in Japan or HS 10-digit in the US, unit values are known to be unstable because distinctly different products, in kind or/and quality, are grouped in the same classification. In this study, on the contrary, we use the import price collected from importing firms responding to the specifically defined products as the survey conducted by the BOJ. By controlling import products to be consistent between different points of time, the import price index (IPI) by the BOJ is more adequate to track the responses of import prices to a change in the exchange rate. For the overall 10 industries, there are 37 corresponding subindustries, 96 commodity groups, and 258 commodities. The number of prices collected from importing firms each month is 1,576 for the IPI. The weights used for constructing the IPI are based on the value of international trade [4]. The monthly series is annualized by taking an average over 12 months from January to December.

For the construction of nominal effective exchange rate (NEER) at the IPI industry level, we follow the methodology used by Sasaki, Yoshida, and Otsubo (2022). For each of the 258

[3] For a special case of product of which 100 percent of value-added is generated at the importing country, equation5 is reduced to $p^{imp} = VAM$. Then, the import price is not affected by a change in the exchange rate.

[4] In constructing VAX and VAM, we also used the share of exporters in Japanese imports as weights. There may be a slight discrepancy between the weights used in calculating value-added variables and the import price index. We believe that should not affect the qualitative results of this paper.

categories of IPI commodities, the BOJ provides the corresponding products using the Harmonized System (HS) of international trade classification codes. There are 3,907 corresponding HS 9-digit codes for 258 IPI commodities. The construction of the industry NEER is described in the following steps. First, for each IPI industry, we sum the import values of the corresponding HS 9-digit codes by country and by year. After the selection criteria of 90 percent of total trade values for the corresponding industry, the number of countries is limited to the top 20. Second, the country weight for an industry-year is calculated as the ratio of the import value from this country to total Japanese imports for each IPI industry. Third, with the monthly nominal exchange rate of the top 20 trade partners and annual country weights, the monthly NEER is calculated for each IPI industry as the weighted average of the bilateral exchange rate series. Fourth, the annual average of industry NEER is taken over 12 months.

Following Gopinath, Boz, Casas, Díez, Gourinchas, and Plagborg-Møller (2020) and Amiti, Itskhoki, and Konings (2022), which focus on the role of the US dollars as the dominant currency, we alternatively use the NEER constructed as the weighted average of the exchange rate between exporting countries' currencies and the US dollar. We also use a bilateral dollar-yen exchange rate as a robustness check instead of the NEERs[5].

2.6 Control variables

The exchange rate pass-through equations, which will be defined in the next section, are in reduced forms. In a panel framework, individual and time effects can capture unobserved variables as described in Knetter (1989). Nevertheless, the inclusion of specifically defined foreign costs is expected to improve the overall fitness of regressions, especially with world export price to the Japanese market on the left-hand side variable. For the data source of the foreign costs, we use 'compensations of employees' (local currency unit), in the World Development Indicators, the World Bank[6]. For each industry and each year, with exporters' share to the Japanese market, the geometric average of labor cost is calculated. For each industry, the labor cost index is normalized to one in 1995.

[5]Bems and Johnson (2017) points out that the weights for effective exchange rate should be based on value-added, see alsoJohnson (2018).

[6]For China, labor cost is replaced by average monthly earnings, 2017 PPP, International Labor Organization and 2017 value is forecast by polynomial up to the second term. For Malaysia (Philippines), 1995 (1997) of compensation of employees is interpolated by polynomial up to the second term. For Indonesia and Saudi Arabia, labor cost is replaced by the wholesale price index, WDI, the World Bank. For Qatar, labor cost is replaced by CPI, WDI, the World Bank.

3 Empirical Model and Estimated Results

3.1 ERPT regression models

Conforming to the findings of time-varying exchange rate pass-through in the literature, we specify the exchange rate coefficients to vary with the value-added in exporting countries and in the importing country, i.e., Japan.

$$lnP_{it} = \alpha + (\beta_0 + \beta_1 VAX_{it} + \beta_2 VAM_{it})\, lnER_{it} + \epsilon_{it} \tag{8}$$

The dependent variable, P_{it}, is the import price for industry i at year t. VAX and VAM, defined in equations (3) and (4), respectively, are divided by gross imports. Alternatively, it can be expressed as interaction terms between value-added indices and the exchange rate.

$$lnP_{it} = \alpha + \beta_0 lnER_{it} + \beta_1 VAX_{it} lnER_{it} + \beta_2 VAM_{it} lnER_{it} + \epsilon_{it} \tag{9}$$

Because the nominal effective exchange rate, ER_{it}, is defined as the value of the exporters' currency in terms of the Japanese yen, the range of exchange rate pass-through is expected to fall within 0 and 1, i.e., $ERPT \in (0, 1)$. An increase in ER_{it} means an appreciation of the exporters' currency and the corresponding rise in import price denominated in the Japanese yen is expected. Note that we did not include the third country value-added because it sums up to unity when combined with VAX and VAM[7].

We also include the global labor cost in the regression as a control variable. LABC is constructed as described in subsection 2.6 and appendix B.3. The expected sign of labor cost coefficients, γ , is positive.

$$lnP_{it} = \alpha + \beta_0 lnER_{it} + \beta_1 VAX_{it} lnER_{it} + \beta_2 VAM_{it} lnER_{it} + \gamma lnLABC_{it} + \epsilon_{it} \tag{10}$$

3.2 Estimation results

The estimated results are summarized in Table 2. The data framework is in panel form with nine industries between 1995 and 2017. The first three columns are estimation results of equation (8) and the last column presents the result for estimating equation (9). The first column is estimated by the ordinary least square. Both VAX and VAM, interacting with the exchange rates, have correct signs and are statistically significant at the five percent level. The ERPT is higher as more added-values are generated in exporting countries and fewer values are originally

[7] Alternatively, a regression model with VAX and VAT, see Figure 1 and 2, can be estimated. However, it can be easily shown that parameters in equation 8 are the linear combinations of the parameters in this alternative equation. Therefore, we do not estimate a regression model with VAT.

generated in the importing country, Japan. The latter part is consistent with the results in (de Soyres, Frohm, Gunnella, and Pavlova 2021). In fact, (de Soyres, Frohm, Gunnella, and Pavlova 2021) only showed that VAM (i.e., fv in their paper), decreases ERPT, but they do not use VAX as we do. The statistical significance disappears for some variables when industry-fixed effects and time-fixed effects are included, but the estimated signs are always consistent with the expected signs whenever they are statistically significant.

In the last column, with the inclusion of global labor cost as a control variable, all coefficients are with correct signs and statistically significant at the one percent level (except for VAX with the ten percent level). The exchange rate pass-through is 65 percent when interaction terms are ignored. Additionally, a ten-percentage point increase in VAX raises another 1.7 percent on exchange rate pass-through while a one percent increase in VAM lowers ERPT by 2.6 percent.

3.3 Time-varying exchange rate pass-through

The exchange rate pass-through is about 65 percent in the specification (iv) when both VAX and VAM are hypothetically zero; however, we must also consider the effect of the levels of VAX and VAM on exchange rate pass-through. Because both VAX and VAM are time-varying, the total ERPT for each industry is also time-varying according to the following terms: $\beta_0 + \beta_1 VAX_{it} + \beta_2 VAM_{it}$. Figure 3 depicts the time-varying ERPTs for each industry. The following points are noteworthy. First, the Global Financial Crisis temporarily increased the ERPT for all industries. Second, after reverting to the pre-crisis level, the ERPTs of most industries are slowly increasing except for the petroleum industry. Third, the ERPT of the petroleum industry demonstrates unique dynamics while other industries follow similar patterns. Fourth, the degree of changes due to GVCs is substantial for the electronics industry, from 65 percent in 1995 to 77 percent in 2017.

We also note the large discrepancy in the level of ERPT among industries. The two industries with the highest ERPTs are foods & beverages and Wooden products. On the other hand, the two industries with the lowest ERPTs are electronics and general machinery. In this paper, these discrepancies are driven by the distribution of value-added between exporting and importing countries. Nevertheless, the ERPT literature also suggests alternative channels by which the level of ERPT is affected. One possible cause of the difference in ERPTs among industries may be the market share of the Japanese industry with respect to the world. Our rough calculation of Japanese industry's import shares in 2017 are 15.7 percent in foods & beverages, 13.7 percent in wooden products, 7.7 percent in electronics, and 7.0 percent in general machinery[8].

[8] We retrieved import values for each HS 2-digit industries for US, China, EU, Japan, Canada, Australia. The

3.4 Contract Currency Import Price

The import prices in this study are JPY-denomination import price series taken from the BOJ. The JPY-denomination import prices are calculated after converting foreign currency price, if contracted in foreign currency, to the Japanese yen price by nominal exchange rate. The BOJ also reports contract-currency import price series without converting foreign prices to Japanese yen prices. Because of the difference in constructing import prices, their dynamic movements sometimes show a large divergence. As an example, Figure 4 shows two series for the industry of beverages & foods and agricultural. The most significant deviation occurs after the global financial crisis or the so-called great trade collapse. All trade prices in the world fell because of shrunk demand for traded products. Import prices contracted in the US dollar, Euro, or JPY all fell. That appears in the blue line in Figure 4. In addition, the JPY experienced a long-lasting appreciation against the US dollar from 120 yen in 2008 to 80 yen in 2012. The import price in terms of the appreciated Japanese yen is even lower as shown in orange.

We replaced the JPY-currency import price by the contract-currency import price and re-estimated the regression as shown in Table 3. The estimated results are qualitatively similar to the results of JPY-denomination import prices. The estimated signs and statistical significance are the same, except for the coefficients on the exchange rate in the specification (iv). However, we observe an important difference when time-varying ERPTs by industry are depicted in Figure 5. The ERPTs are in general much higher when we use contract-currency import prices.

3.5 Dominant currency paradigm

The recent studies investigating transaction-level trade data emphasize that the majority of prices of exports and imports are not set in either local currency or producer currency. The dominant currency pricing (DCP), i.e., the US dollar for most countries, is the norm in international trade (Amiti et al., 2022, Gopinath et al., 2020)[9]. In Amiti, Itskhoki, and Konings (2022), the exchange rate pass-through is estimated for the Belgian firms with exchange rates of Euro against both destination-specific and the US dollar. The US dollar exchange rate is statistically and economically significant because of the large portion of US dollar invoices.

Shimizu, Ito, Sato, Ando, and Yoshimoto (2022) calculates the shares of invoicing currencies for Japanese exports and imports for trade partners that ranked among the top 34 in 2020. For

total of these economic regions approximately makes up the lion's share of world trade. With correspondence tables between HS classifications and TiVA industry classifications, we approximated the import share of the Japanese industries in the world.

[9] For the recent review on the dominant currency paradigm, see (Gopinath and Itskhoki 2022).

imports from the following countries, the shares of US dollars as invoicing currency in the second half of 2020 are 54.0% (Australia), 75.4% (Brazil), 50.6% (Canada), 6.4% (Switzerland), 28.8% (Chile), 72.7% (China), 9.2% (Germany), 8.3% (Spain), 15.2% (France), 25.4% (UK), 61.3% (Indonesia), 6.5% (Italy), 36.7% (Korea), 54.6% (Mexico), 63.5% (Malaysia), 27.2% (New Zealand), 49.0% (Thailand), 71.5% (USA), 65.4% (Vietnam). Except for Euro member countries, the dominance of the US dollar as invoicing currency in Japanese imports is prevalent.

Taking consideration of the dominant currency issues discussed above, we re-estimated the industry-wise ERPT with two alternative exchange rate indices. The estimated results are summarized in Table 4. The first three columns show the estimated results for the yen-denominated import price index and the last three columns for the invoice currency import price index. The first and fourth columns are the baseline results with the NEER in the previous subsections. They correspond to specification (iii) in Table 2 and 3, respectively. The second and fifth columns represent the estimated results with the NEER based on the bilateral exchange rates of US dollars in terms of exporters' currencies. The weights for bilateral exchange rates are based on the share of exporters in Japanese imports in each industry. Surprisingly, the estimated results are very similar. The third and sixth columns use the USD/JPY exchange rate. It can be interpreted as the special case of the baseline NEER where the weight of USD is 100 percent. Even with the consideration for the role of the dominant use of the US dollar, our results show that a higher degree of value-added in the importing country lowers the ERPT remain robust.

4 Conclusion

We found evidence that the breakdown of value-added among the originating countries is essential in understanding how import prices respond to a change in the exchange rate. If exporting countries are more self-sufficient in obtaining intermediary products from local suppliers, a change in the exchange rate is more likely to reflect on the import prices in the destination country. On the other hand, import prices are less responsive to a change in the exchange rate if exporting countries source more inputs from the destination country. More specifically in this study's framework, the ERPT on import prices is smaller if Japan exports parts and components to a country that exports final products back to Japan after integrating or assembling Japanese intermediate products in final exports.

These results are robust to the alternative selections of exchange rate indices. We obtained similar results even when we used exchange rates between exporting countries' currencies against the US dollar or between the Japanese yen and the US dollar. Moreover, The differentials in value-added help explain the dynamics of exchange rate pass-through at the industry level. The evolving roles of GVC participating countries in terms of value-added contributions can partly explain the unexplained drivers of ERPT dynamics in the previous literature.

Possible paths for further investigations include constructing the NEER based on VAX weights instead of gross exports. This is analogous to the discussion of making the use of invoice currency as more appropriate weight in the literature on the dominant currency paradigm. Disaggregating VAX by exporting countries is also promising. The most difficult part is that we need to construct industry import prices for each exporting country. This is possible if we use unit-prices aggregated over industries as in Sasaki and Yoshida (2018).

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A Appendix A: TiVA database

The TiVA database contains value added for each source country for a trade flow from an exporting country to an importing country. The current version in 2022 contains the sample from 1995 to 2017.

A.1 exporting countries

34 exporting countries and the world data are contained in the original sample, but Japan is excluded because it is an importing country. So in the regression analysis, there are 33 exporting countries. AUT, BEL, BRA, CAN, CHN, CZE, DNK, EST, FIN, FRA, DEU, GRC, HUN, IRL, ITA, JPN, KOR, LVA, LTU, LUX, NLD, NOR, POL, PRT, SGP, SVK, VNM, SVN, ESP, SWE, CHE, THA, GBR, USA, WLD

B Appendix B: Data constructions for Japanese imports analysis

B.1 Countries used for the construction of the trade-weighted index by industry

For each industry, at most top 21 countries with the largest share in the total imports between 1988 and 2017 are selected. Countries in parenthesis do not have continuous exchange rate series in the IFS, IMF and therefore are removed from the country list when the trade weights are calculated. See the detailed description in Sasaki, Yoshida, and Otsubo (2022)

(Ind 1, Food & Beverages)

AUS, BRA, CAN, CHE, CHL, CHN, COL, DEU, DNK, ESP, FRA, GBR, IDN, ITA, KOR, (LTU), MEX, MYS, NZL, THA, (TWN), (UKR), USA, VNM.

(Ind 2, Textiles)

BGD, CHN, GBR, HKG, IDN, ITA, (KHM), KOR, MMR, PAK, THA, USA, VNM

(Ind 3, Metals)

ARE, AUS, BRA, CAN, CHE,CHL, CHN, DEU, GBR, IDN, IND, (KAZ), KOR, MYS, PER, PHL, PNG, (RUS), SAU, THA, USA, VNM, ZAF, ZMB

(Ind 4, Woods)

AUS, CAN, CHL, CHN, IDN, NZL, MYS, (RUS), USA, VNM, ZAF

(Ind 5, Petroleum)

ARE, AUS, BRN, CAN, IDN, IRN, KOR, KWT, MYS, PNG, QAT, (RUS), SAU, USA

(Ind 6, Chemicals)
BEL, CAN, CHE, CHN, DEU, DNK, ESP, FRA, GBR, IND, IRL, ITA, KOR, NLD, PRI, SAU, SGP, SWE, THA, (TWN) , USA
(Ind 7, Machinery)
CHE, CHN, CRI, DEU, FRA, GBR, IRL, ITA, KOR, MEX, MLS, SGP, SWE, THA, (TWN), USA, VNM
(Ind 8, Electronics)
CHE, CHN, DEU, GBR, HKG, KOR, MYS, PHL, SGP, THA, (TWN), USA, VNM
(Ind 9, Transportation)
CHN, DEU, FRA, GBR, KOR, HUN, IDN, ITA, MEX, THA, USA, VNM, ZAF

B.2 Nominal Effective Exchange Rate

Bilateral nominal exchange rate series between Japan and its trade partners are taken from the IFS, IMF. The exchange rate is defined as the foreign currency value of the Japanese yen, so an increase in the exchange rate is an appreciation of the Japanese yen. The industry-wise nominal effective exchange rate is the geometric average of bilateral nominal exchange rates with the trade partner's share in Japan's imports in the corresponding industry. The selected countries in each industry are listed in the appendix B.1.

B.3 Global Labor Cost

Data Source: For the construction of the Global labor cost, we used (i) compensation of employees (local currency unit), WDI, World Bank. We replaced a country series of the first database with the following three databases by the priority given in the order if the series misses more than one year. Alternative data are the followings: (ii) average monthly earnings (2017PPP), ILO; (iii) Wholesale price index, WDI, WB; and (iv) consumer price index, WDI, WB. If a country series in the database (i) or (ii) misses only one year, we replaced the missing year data with the forecast from the regression of the series on the time trend and the squared time trend. In particular, the following replacements are made. For China, the ILO's average monthly earnings are used, and the data for 2017 is forecasted. For Malaysia, the data in 1995 is forecasted. For the Philippines, the data in 1997 is forecasted. For Indonesia and Saudi Arabia, the wholesale price index by the WDI is used. For Qatar, the consumer price index is used. The global labor cost for each industry is constructed by the geometric average of labor costs in countries listed in the appendix B.1 with Japan's import weights.

C Appendix C: the Derivation of Equation (6) and (7)

$$P^{imp} = \epsilon P^{ex} + c \tag{11}$$

If there is no distribution cost, i.e., c is equal to 0, total differentiation of the natural log of the equation with an assumption of no autonomous change in P^{ex}, an exchange rate pass-through on import price can be shown to be the following

$$lnP^{imp} = ln\epsilon + lnP^{ex} \tag{12}$$

$$dlnP^{imp} = dln\epsilon + \frac{\partial lnP^{ex}}{\partial ln\epsilon} dln\epsilon + dlnP^{ex} \tag{13}$$

$$dlnP^{imp} = (1 + \eta^{ex}) dln\epsilon, \tag{14}$$

where $\eta^{ex} = \frac{dlnP^{ex}}{dln\epsilon}$ is an exchange rate pass-through on export price in terms of the exporter's currency and is equal to minus one when an exporter fixes the price in terms of the destination's currency, i.e., local currency pricing (LCP), and is equal to zero when an exporter fixes the price in terms of exporter's currency, i.e., producer currency pricing (PCP). Now, we obtain equation 6 as equation 15.

$$\frac{dlnP^{imp}}{dln\epsilon} = (1 + \eta^{ex}) \in (0, 1), \tag{15}$$

When the distribution cost is non-zero,

$$dlnP^{imp} = \frac{\partial ln(\epsilon P^{ex} + c)}{\partial ln\epsilon} dln\epsilon + \frac{\partial ln(\epsilon P^{ex} + c)}{\partial lnP^{ex}} dlnP^{ex} + \frac{\partial ln(\epsilon P^{ex} + c)}{\partial c} dlnc \tag{16}$$

Assuming no autonomous change in P^{ex} and c, the last two terms in equation 16 drop.

$$dlnP^{imp} = \frac{\partial ln(\epsilon P^{ex} + c)}{\partial ln\epsilon} dln\epsilon \tag{17}$$

$$\frac{dlnP^{imp}}{dln\epsilon} = \frac{\partial ln(\epsilon P^{ex} + c)}{\partial ln\epsilon} \tag{18}$$

$$\frac{dlnP^{imp}}{dln\epsilon} = \epsilon \frac{\partial ln(\epsilon P^{ex} + c)}{\partial \epsilon} \tag{19}$$

$$\frac{dlnP^{imp}}{dln\epsilon} = \epsilon \frac{\frac{\partial(\epsilon P^{ex} + c)}{\partial \epsilon}}{(\epsilon P^{ex} + c)} \tag{20}$$

$$\frac{dlnP^{imp}}{dln\epsilon} = \epsilon\frac{(P^{ex} + \epsilon\frac{\partial P^{ex}}{\partial\epsilon} + 0)}{(\epsilon P^{ex} + c)} \tag{21}$$

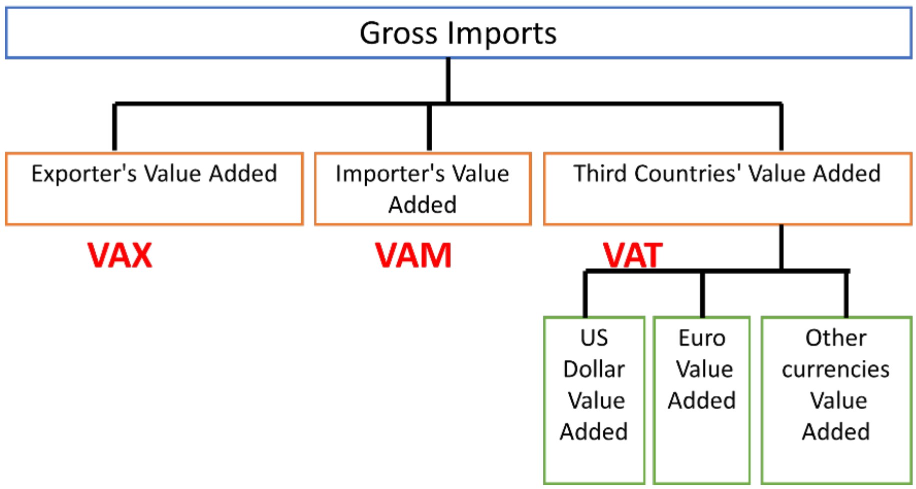
$$\frac{dlnP^{imp}}{dln\epsilon} = \epsilon\frac{(P^{ex} + P^{ex}\eta^{ex})}{(\epsilon P^{ex} + c)} \tag{22}$$

Now, we obtain equation 7 as equation 23.

$$\frac{dlnP^{imp}}{dln\epsilon} = \frac{\epsilon P^{ex}(1 + \eta^{ex})}{(\epsilon P^{ex} + c)} \tag{23}$$

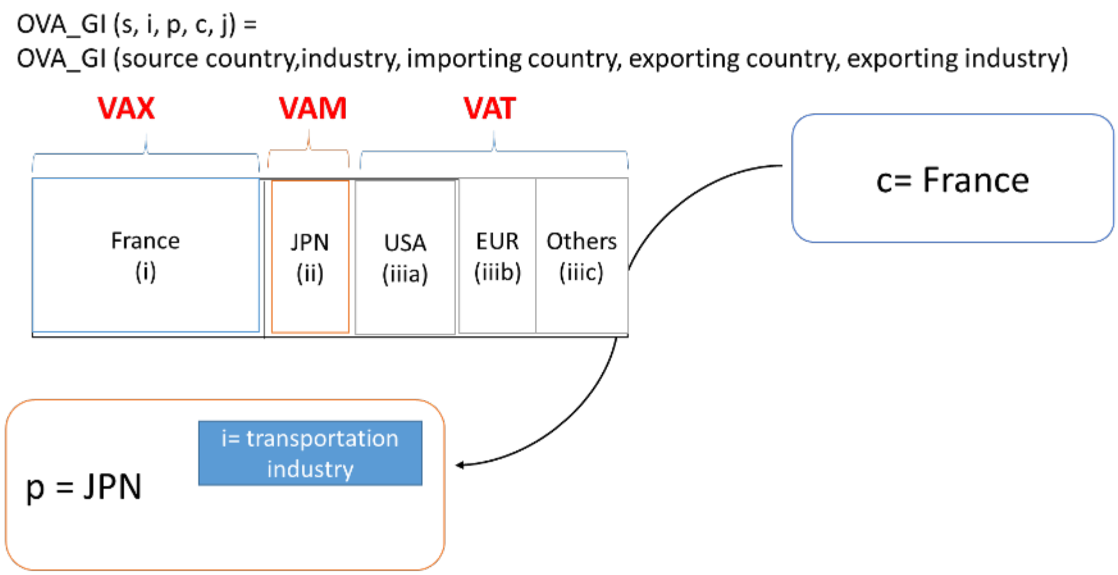
It is straightforward to show equation 23 is smaller than equation 15. Replacing c with VAM, we conclude that a larger value-added in the importing country reduces the ERPT on import price.

Figure 1: Decompositions of value added in nominal import



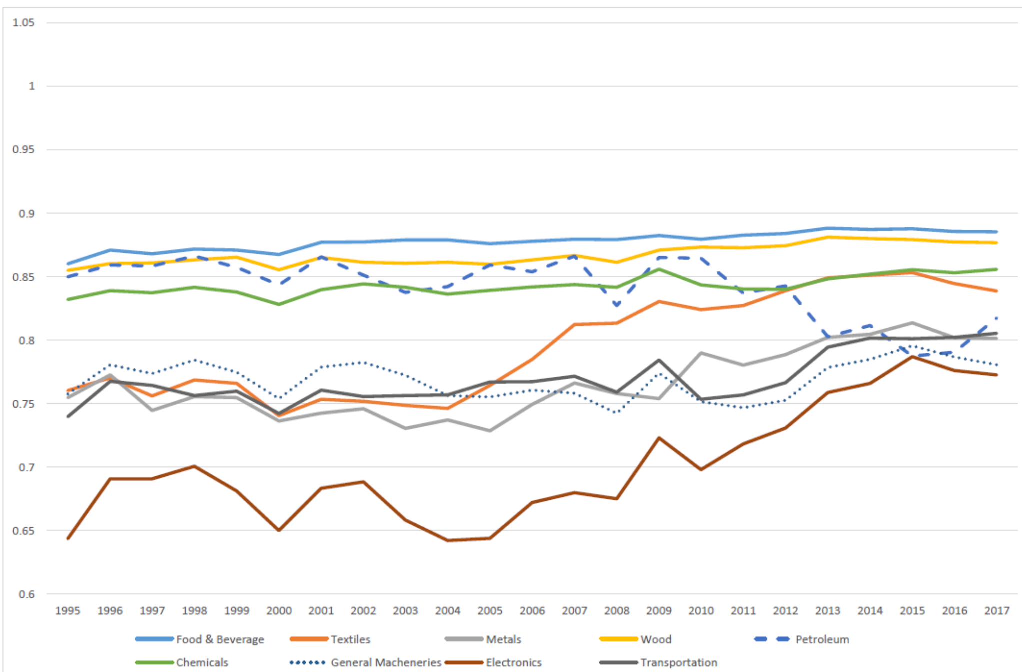
Note: The figure is created by the authors, following analogously to the gross exports decomposition illustrated by (de Soyres, Frohm, Gunnella, and Pavlova 2021).

Figure 2: The concept of GVC index



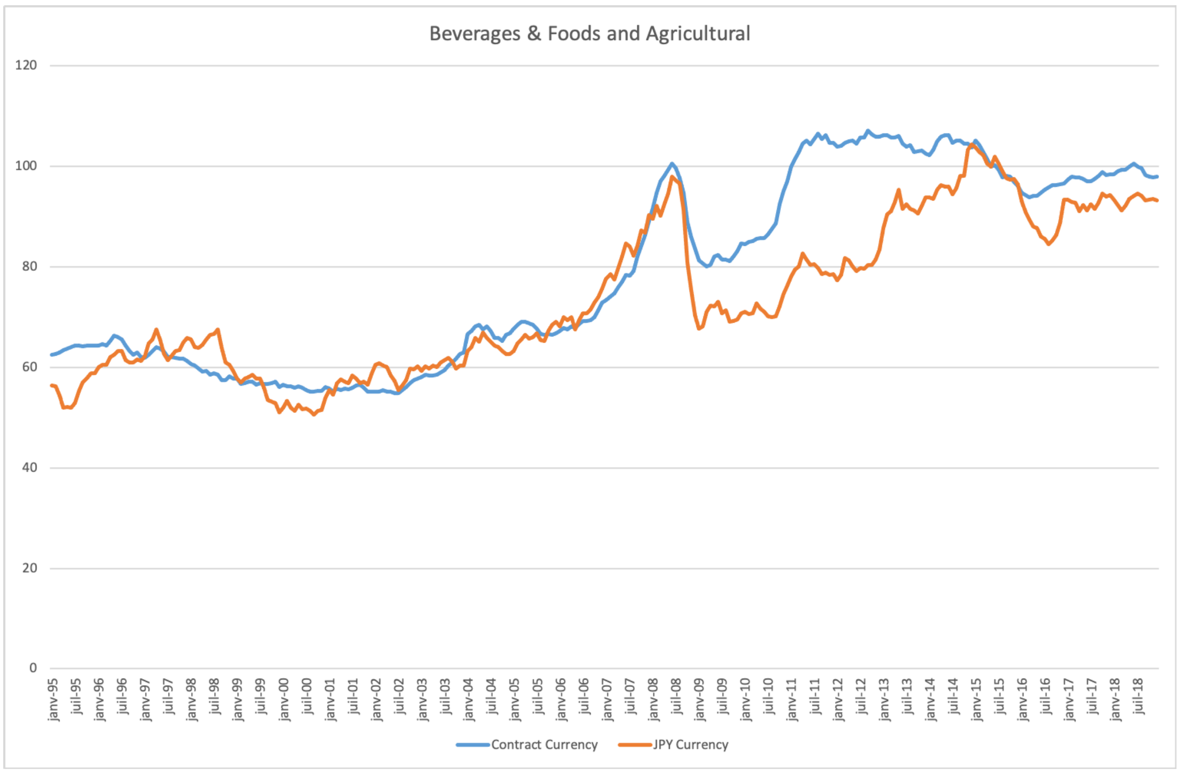
Notes: The figure is created by the authors. Data: The origin of value added in gross import value is decomposed into three parts: (i) exporters' value added (VAX); (ii) importers' (Japan) value added = reimports (VAM); (iii) third countries' value added (VAT).This can be further decomposed to iiia) US (VAT_US), iiib) Euro 11 (VAT_EUR), and iiic) all other combined (VAT_OT).

Figure 3: Time-varying ERPT driven by VAX and VAM



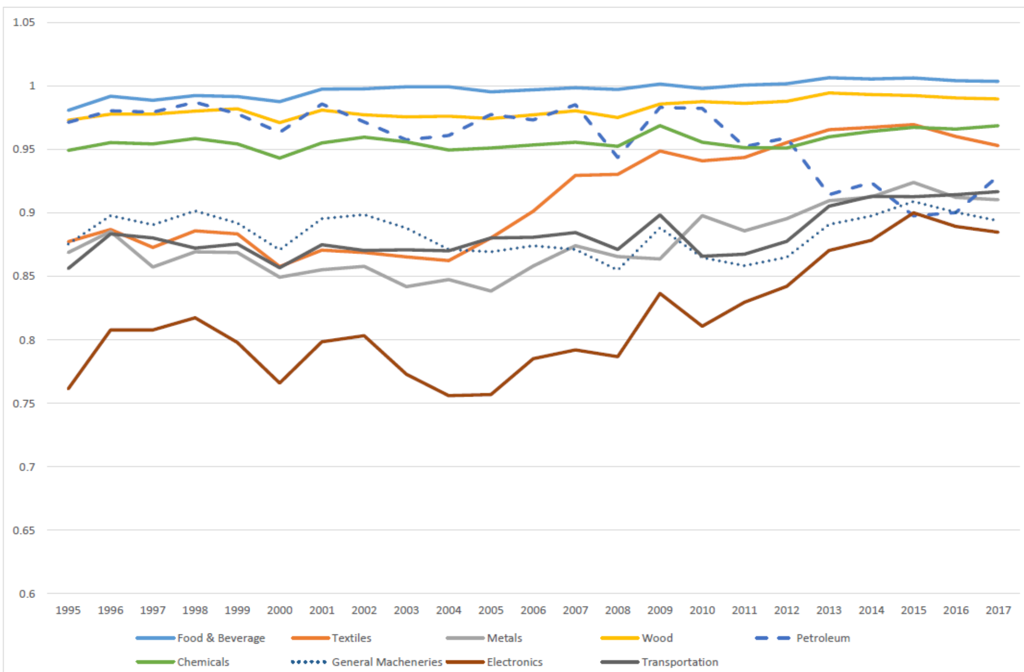
Notes: The time-varying ERPTs are based on the estimates in column (iii) of Table 2. In terms of equation (9), the ERPT is $\beta_0 + \beta_1 VAX_{it} + \beta_2 VAM_{it}$

Figure 4: JPY currency price vs contract currency price



Note: The beverages & foods and agriculture products for the foods industry is shown as an example. The blue line represents the import price based on invoice currency. Leaving aside endogenous price changes due to the pricing behaviors of exporters, this import index is less vulnerable to a change in the exchange rate. On the other hand, the orange line represents the import price index in terms of the Japanese yen by converting the price denominated in foreign currency as invoice currency with the past exchange rate.

Figure 5: Time-varying ERPT driven by VAX and VAM



Notes: The time-varying ERPTs in contract-currency import prices are based on the estimates in column (iii) of Table 3. In terms of equation (9), the ERPT is $\beta_0 + \beta_1 VAX_{it} + \beta_2 VAM_{it}$

Table 1: Corresponding table between BOJ IPI and OECD TiVA industries

IPI	IPI industry name	TiVA	ISIC industry name
1	Beverages & foods and agriculture products for food	D10T12	Food products, beverages and tobacco
2	Textiles	D13T15	Textiles, textile products, leather and footwear
3	Metals & related products	D24T25	Basic metals and fabricated metal products
4	Lumber & wood products and forest products	D16	Wood and products of wood and cork
5	Petroleum, coal & natural gas	D05T06	Mining and quarrying, energy producing products
6	Chemicals & related products	D20T21	Chemicals and pharmaceutical products
7	General purpose, production & business oriented machinery	D28	Machinery and equipment, nec
8	Electric & electronic products	D26T27	Computer, electronic and electronical equipment
9	Transportation equipment	D29T30	Transport equipment
10	Other primary products & manufactured goods		no exact match, but IPI(10) subindustries include D22, D23, D17T18.

Notes: Matchings are conducted by the authors as described in 2.3. The industry at the bottom, i.e., the tenth industry in IPI, cannot clearly be matched with any TiVA industries. We use only nine industries in the empirical sections.

Table 2: Exchange rate pass-through with value-added of exporters and the importer

	(i) OLS	(ii) Panel	(iii) Panel	(iv) OLS
VAX * ln ER	0.338***	0.894***	-0.0416	0.177*
	(0.0939)	(0.116)	(0.252)	(0.104)
VAM * ln ER	-1.742***	0.433	-5.178***	-2.597***
	(0.494)	(0.769)	(1.483)	(0.549)
ln ER	0.296*	-0.130	0.945**	0.651***
	(0.171)	(0.155)	(0.410)	(0.200)
ln LABC				0.159***
				(0.0489)
constant	6.905***	7.202***	7.913***	7.758***
	(0.807)	(0.747)	(1.593)	(0.831)
Observations	207	207	207	207
R-squared	0.260	0.244	0.332	0.297
industry	no	yes	yes	no
year	no	no	yes	no
Number of id_ind		9	9	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3: Robustness check: with invoice currency

	(i) OLS	(ii) Panel	(iii) Panel	(iv) OLS
VAX * ln ER	0.398***	0.980***	0.0210	0.241**
	(0.101)	(0.125)	(0.261)	(0.113)
VAM * ln ER	-1.227**	0.841	-5.066***	-2.063***
	(0.533)	(0.832)	(1.536)	(0.595)
ln ER	-0.204	-0.703***	1.008**	0.143
	(0.184)	(0.167)	(0.424)	(0.216)
ln LABC				0.156***
				(0.0530)
constant	4.902***	4.940***	8.634***	5.736***
	(0.870)	(0.807)	(1.650)	(0.900)
Observations	207	207	207	207
R-squared	0.229	0.258	0.398	0.261
industry	no	yes	yes	no
year	no	no	yes	no
Number of id_ind		9	9	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4: Dominant currency ERPT

VARIABLES	(1) yen denomination NEER(FC/JPY)	(2) yen denomination NEER(FC/USD)	(3) yen denomination USD/JPY	(4) invoice currency NEER(FC/JPY)	(5) invoice currency NEER(FC/USD)	(6) invoice currency USD/JPY
VAX*ln er	-0.0416	-0.0459	-0.0631	0.0210	0.0181	-0.00271
	(0.252)	(0.256)	(0.260)	(0.261)	(0.266)	(0.269)
VAM*ln er	-5.178***	-4.878***	-5.567***	-5.066***	-4.699***	-5.502***
	(1.483)	(1.514)	(1.509)	(1.536)	(1.574)	(1.562)
ln ER	0.945**	2.877**	0.961**	1.008**	2.047*	1.027**
	(0.410)	(1.127)	(0.409)	(0.424)	(1.172)	(0.424)
constant	7.913***	17.40***	7.673***	8.634***	13.83***	8.371***
	(1.593)	(4.507)	(1.501)	(1.650)	(4.686)	(1.554)
Observations	207	207	207	207	207	207
R-squared	0.332	0.308	0.342	0.398	0.371	0.408
Number of id_ind	9	9	9	9	9	9
industry	yes	yes	yes	yes	yes	yes
year	yes	yes	yes	yes	yes	yes

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

NEER(FC/JPY) Nominal Effective Exchange Rate is calculated as the weighted average of the bilateral exchange rate series with the Yen,

NEER(FC/USD) Nominal Effective Exchange Rate is calculated as the weighted average of the bilateral exchange rate series with the USD.

For USD/JPY we use bilateral dollar-yen exchange rate instead of the NEER