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The Short- and Long-Run Effects of Exchange Rate Changes on the Japanese Electronics Industry

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Abstract

The value of Japanese electronics exports has tumbled since the advent of the Global Financial Crisis, largely because export prices have fallen. This paper presents evidence that the appreciation of the yen between 2007 and 2011 caused yen export prices for electronics goods to fall by more than 20%. Yen export prices fell much more than yen costs over this period, implying that profit margins have been squeezed. This paper also reports that, in the long run, a 10% appreciation of the yen will reduce the volume of electronics exports by 10%. Japanese firms could mitigate the adverse impact of the strong yen by producing innovative products rather than competing based on price in commoditized industries.

Keywords: Exchange rate pass-through; exchange rate elasticities; yen

JEL classification: F32, F41

* I thank my colleagues at RIETI for helpful comments. Any errors are my own responsibility.
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1. Introduction

The value of Japan's electronics exports has exceeded $100 billion dollars in every year since 1993. Before the Global Financial Crisis almost 20 percent of Japan's exports were electronics goods. How have these exports been affected by the floods, earthquakes, and macroeconomic shocks that have roiled Japan in recent years?

Many Japanese electronics exports take place within East Asian production networks. Figure 1a shows the value of Japanese electronics parts and components exports to the primary Asian supply chain countries (China, Malaysia, the Philippines, Singapore, South Korea, Taiwan, and Thailand). The figure shows that the value of exports fell logarithmically by 100 percent between the collapse of Lehmann Brothers in September 2008 and the trough in January 2009. It also shows that the value of exports averaged about 25 percent below its pre-crisis level, even three and a half years after the Lehmann Brothers shock. In addition the figure shows that exports only declined 7 percent following the March 2011 earthquake and regained its pre-quake level by June 2011.[1] Figure 1b looks at the ASEAN countries. The figure shows that the decline associated with the 2011 Thai floods has been limited largely to exports to Thailand, and that the value of exports to other supply chain countries has not been affected.

Figure 2 examines the volume of electronic parts and components exports to ASEAN, China, and the NIEs (i.e., South Korea and Taiwan). The volume fell logarithmically by 88 percent between August 2008 and January 2009. It recovered quickly, though, and by 2010 had surpassed its pre-crisis level.

[1] Ando and Kimura (2011) report that the global financial crisis caused a much greater fall in Japanese exports than the East Japan earthquake.

The fact that the value of exports has not recovered its pre-crisis level while the volume exceeds its pre-crisis level implies that export prices have fallen. Indeed Bank of Japan data indicate that the yen price of electronic component and devices (ECD) exports has fallen by 56 percent between January 2005 and November 2011.

This paper seeks to understand the causes of this fall in export prices. To do so, it regresses changes in ECD export prices on current and lagged values of changes in exchange rates, production costs in the ECD sector, and other variables. The results indicate that ECD export prices in the short run are very sensitive to changes in exchange rates. The evidence implies that the appreciation of the yen between June 2007 and the end of 2011 caused the yen price of ECD exports to fall by about 25 percent.

A difficulty with interpreting this result is that trade in East Asian production networks is often invoiced in dollars. Ito *et al*. (2010) reported that Japanese firms in production networks invoice primarily in dollars in exports to Asian production subsidiaries. It is possible that Japanese multinational companies (MNCs) allow the yen export prices of parts and components to vary closely with changes in the exchange rate, but then adjust import prices when selling the assembled finished goods in final markets. For instance, if a Japanese company assembles a computer in China using parts and components from Japan and sells the final product in Europe, it may not adjust the dollar prices of parts and components shipped to China but may adjust the euro price of the computer sold in Europe to reflect exchange rate changes.

One way to test whether Japanese firms can pass through exchange rate changes for final electronics exports produced in production networks is to examine whether they can pass through exchange rate changes for final electronic goods produced in Japan. As Wakasugi (2009) notes, these final goods from Japan tend to be sophisticated, knowledge-intensive products produced by skilled workers. On the other hand, the final goods produced by Japanese MNCs in supply chain countries like China tend to be intensive in unskilled labor. If Japanese firms do not have pricing power over the higher end goods produced in Japan, they are unlikely to have pricing power over the more homogeneous goods assembled in lower wage countries. The results indicate that Japanese information and communication equipment (ICE) export prices are sensitive to exchange rate changes. The evidence implies that the appreciation of the yen between June 2007 and the end of 2011 caused the yen price of ICE exports to fall by more than 20 percent. As discussed below, yen export prices have fallen much more than yen costs over this period. Thus the strong yen has squeezed profit margins.

To shed further light on exchange rate pass-through this paper also examines several sub-sectors of the electronics industry. Katz (2012) noted that Japanese firms tend to compete against foreign firms based on price in many commoditized industries such as integrated circuits and color televisions. If this is true then yen prices would tend to adjust more for these items in order to keep foreign currency prices competitive. Results presented here indicate that export prices are more responsive to exchange rate changes in commoditized industries such as silicon wafers than in industries such as electronic computers and electromedical equipment that have greater product differentiation.

Finally this paper considers the long run effects of exchange rate changes on the Japanese electronics industry. Klitgaard (1999) reported that Japanese firms try to preserve profit margins in the long run by allowing foreign prices to rise. Thus over time exchange rate changes may affect the volume of exports more. To investigate this issue dynamic ordinary least squares (DOLS) techniques are employed to estimate a long run export function. As Chinn (2005) discussed, such an export function combines the exchange rate pass-through equation and the relationship between export prices and foreign demand. The results presented below indicate that long run exchange rate elasticities for final electronics goods equal approximately unity. These findings imply that increases in the value of the yen that persist will significantly decrease the volume of electronics exports.

The next section examines the short run pass-through of exchange rate changes into export prices. Section 3 investigates the longer run effect of exchange rate changes on the volume of electronics exports. Section 4 concludes.

2. Short run pass-through of exchange rates into export prices

Campa and Goldberg (2002, 2005) emphasized the need to pay attention to the microeconomic foundations of pricing behavior when investigating exchange rate pass-through. In theory, export prices should depend on exporters' costs and on demand conditions in the importing country. Campa and Goldberg modeled export prices as the product of marginal costs and the firms' markup. In their framework marginal cost depends on wages and other input costs and on the level of demand in the importing country. The markup depends on both industry specific conditions and on macroeconomic factors such as the exchange rate and the price of import competing goods in the importing country.

2.1 Data and methodology

Ceglowski (2010) gave empirical content to this model for Japanese export prices. She represented the first difference of Japanese export prices as a function of current and lagged values of the first difference of the exchange rate, foreign prices, domestic costs, and economic activity in the destination market:

$$\Delta p^{x}_{jt} = \beta_0 + \sum_{i=0}^{p} \beta_{1i}\, \Delta e_{jt-i} + \sum_{i=0}^{p} \beta_{2i}\, \Delta p^{f}_{t-i} + \sum_{i=0}^{p} \beta_{3i}\, \Delta c_{jt-i} + \sum_{i=0}^{q} \beta_{4i}\, \Delta y^{f}_{t-i} + u_t, \quad (1)$$

where p^{x}_{j} is the yen price of exports in industry *j*, e_j is the exchange rate, p^f measures foreign prices, c_j represents costs for industry j, y^f represents economic activity in the export market, and the variables are measured in natural logs.

The yen price of exports by industry is available from the Bank of Japan (BoJ). The two industries examined here are 1) electronic component and devices and 2) information and communication equipment. In addition, a variety of sub-sectors are examined. The exchange rate is the ratio of the yen-denominated export price to the contract-currency export price for the industry or sector. As Ceglowski (2010) discussed, the resulting exchange rate series reflect the composition of invoice currencies. The foreign price measure is calculated by multiplying the BoJ real effective exchange rate series by the product of the nominal effective exchange rate and the Japanese corporate goods price index. Many researchers have used this approach to obtain a trade-weighted foreign producer price index (see Ceglowski and the references contained therein). Costs are measured by the producer price index in industry *j*. Finally, economic activity in export markets is captured by the IMF measure for industrial production in industrialized countries.

A consistent time series for the yen price of electronic component and devices exports is available from the BoJ starting in January 2005. The sample period for the estimation thus extends from January 2005 to November 2011. Following Ceglowski (2010) the estimation begins with six lags of e_j, p^f, and c_j and three lags of y^f. To avoid overfitting the lag length is then progressively reduced by one down to a minimum of two lags and the Schwarz Criterion is used to choose between the models. For every variable two lags are selected.

As a robustness check, a model with six lags of e_j, p^f, and c_j and three lags of y^f is also estimated. As a second robustness check, a model is estimated with real wages in Japan included as an additional explanatory variable. Nominal wage data are obtained from the IMF *International Financial Statistics* and are deflated using the domestic corporate goods price index obtained from the BoJ. As a third robustness check, the BoJ nominal effective exchange rate (NEER) and the nominal yen dollar rate (N¥$) are used as exchange rate variable (e_j).

Figure 3a graphs the export price for ECD in yen and the contract currencies together with the domestic producer price index for ECD and the nominal yen/dollar exchange rate. Figure 3b graphs the export price for ICE in yen and the contract currencies together with the domestic producer price index for ICE and the nominal yen/dollar exchange rate. For both categories of goods, export prices have fallen steadily between 2005 and 2011. During 2006 and the first half of 2007, when the yen was weaker, makers of ICE raised yen export prices relative to yen costs (as proxied by the industry PPI) but ECD manufacturers did not. After June 2007, when the yen began appreciating, yen export prices for ECD fell 30 percent more than yen costs and yen export prices for ICE fell 20 percent more than yen costs. This suggests that the strong yen has reduced the profitability of the Japanese electronics industry.

2.2 Results

Table 1 presents the results from estimating equation (1) with the first difference of the yen export price for electronic components and devices as the dependent variable and with current values and two lags of the first difference of exchange rates, foreign prices, domestic costs, and foreign industrial production as independent variables. The specification in Table 1 is selected based on the Schwarz Criterion.

In Table 1 the constant term for the first difference regression is not significant, indicating that the clear downward trend in the levels that is evident in Figure 3a can be explained by economic variables. The coefficient on the contemporaneous first difference of the exchange rate is significant at the one percent level. It takes on a value of 0.957. The sum of the coefficients on the exchange rates in Table 1 equals 1.12 and the associated standard error equals 0.09. These findings indicate that, for this exchange rate measure, there is essentially a one-for-one response of export prices for electronic components and devices to exchange rate changes. Since the exchange rate measure (the ratio of the yen-denominated export price to the contract-currency export price for the industry) appreciated 24 percent between June 2007 and the end of 2011, these results imply that the exchange rate appreciation led to a 24 percent increase in ECD export prices.

There does not appear to be a robust relationship between export prices and the other variables in Tables 1. In Table 1, the coefficient on the contemporaneous value of Δp^f is statistically significant and takes on a value of 0.259. However, the sum of the coefficients on Δp^f is negative. The sum of the coefficients on current and lagged Δc_j equals 0.57. However, the associated standard error is 0.56. Results including the real wage rate and results including six lags of e_j , p^f, and c_j and three lags of y^f, available on request, corroborate the findings in Table 1.

Table 2 presents the results from estimating equation (1) using the nominal effective exchange rate instead of the ratio of the yen-denominated export price to the contract-currency export price.   Table 3 presents the results from estimating equation (1) with the nominal yen/dollar exchange rate instead of the yen-denominated export price/contract-currency export price ratio. In Tables 1 and 3 a decrease in the exchange rate variable represents an appreciation and in Table 2 an increase represents an appreciation.   Thus the sum of the coefficients on the exchange rate variable should be positive in Tables 1 and 3 and negative in Table 2, as they are.

The sum of the exchange rate coefficients in Table 2 equals -0.51with an associated standard error of 0.06; the sum in Table 3 equals 0.57 with an associated standard error of 0.04. These values are smaller than the values in Table 1. What is interesting, though, is that the NEER and the N¥$ rate appreciated much more between June 2007 and the end of 2011 than the exchange rate measure used in Table 1. The NEER appreciated 41 percent over this period and the N¥$ appreciated 46 percent, while the ratio of the yen-denominated export price to the contract-currency export price only appreciated 24 percent. The results in Table 2 imply that the 41 percent appreciation of NEER after June 2007 led to a 21 percent increase in ECD export prices and the results in Table 3 imply that the 46 percent appreciation of N¥$ led to a 26 percent increase in ECD export prices. Thus the evidence in Tables 2 and 3 confirm the results in Table 1 indicating that the strong yen caused yen export prices in the ECD industry to fall by more than 20 percent.

Table 4 presents the results of estimating equation (1) with the first difference of the yen export price for information and communications equipment as the dependent variable and with current values and two lags of the first difference of exchange rates, foreign prices, domestic costs, and foreign industrial production as independent variables. The specification in Table 4 was again selected based on the Schwarz Criterion.

In Table 4 the constant term for the first difference regression is again not significant, indicating that the clear downward trend in the levels that is evident in Figure 3b can be explained by economic variables. In addition, the coefficient on the contemporaneous first difference of the exchange rate takes on a value of 0.972 and is significant at the one percent level. The sum of the coefficients on the exchange rates in Table 4 equals 0.84 and the associated standard error equals 0.12. Since the ratio of the yen-denominated export price to the contract-currency export price for the ICE industry appreciated 28 percent between June 2007 and the end of 2011, these results imply that the exchange rate appreciation led to a 24 percent increase in ICE export prices.

The coefficient on the contemporaneous first difference of the producer price index for ICE equipment equals 0.53 in Table 4. It is statistically significant at the 5 percent level. This result indicates that changes in costs, as represented by changes in the producer price index for ICE, exert a statistically significant effect of export prices. Figure 3b suggests that there is a close relationship between the yen export price and the producer price index for ICE. There does not appear to be robust evidence that the other variables in Table 4 are affecting export prices. Results including the real wage rate and results including six lags of e_j , p^f, and c_j and three lags of y^f, available on request, corroborate the findings in Table 4.

Table 5 presents the results from estimating equation (1) using NEER as the exchange rate variable and Table 6 presents the results using N¥$. The sum of the exchange rate coefficients in Table 5 equals -0.47 with an associated standard error equals 0.06; the sum in Table 3 equals 0.49 with an associated standard error equals 0.06. The results in Table 4 imply that the 41 percent appreciation of NEER after June 2007 led to a 19 percent increase in ICE export prices and the results in Table 6 imply that the 46 percent appreciation of N¥$ led to a 23 percent increase in ICE export prices. Thus the evidence in Tables 5 and 6 confirm the results in Table 1 indicating that the strong yen caused yen export prices in the ICE industry to fall by 20 percent or more.

Why do exchange rate appreciations cause yen export prices for electronics goods to fall so much? Katz (2012) noted that Japanese electronics firms tend to compete with foreign firms based on price in commoditized industries such as integrated circuits and color televisions. If this is true then yen prices would have to adjust more for these items in order to keep foreign currency prices competitive.

The response of yen export prices to exchange rate changes are examined for the following industries: color TV receivers, display devices, electromedical equipment, electronic computers, integrated circuits, and silicon wafers. Katz (2012) noted that for Japanese firms, integrated circuits, color TV receivers, and display devices tend to be commoditized. Silicon wafers also fall in this category. On the other hand, electromedical equipment and electronic computers tend to be differentiated products.

The results are presented in Table 7. In all cases the sum of the coefficients on the exchange rate variables are statistically significant. The effect of exchange rate changes on export prices is smallest for electronic computer and electromedical equipment. For electronic computers the average effect across the three exchange rate measures is 0.53 and for electromedicinal equipment the average effect is 0.59. For the other four industries the average effect is greater than 0.80. In the case of silicon wafers the average effect equals 1.05. Thus exchange rate changes have a larger effect on yen export prices in commoditized industries than they do in differentiated industries.

The important implication of the results presented in this section is that yen export prices are very sensitive to exchange rate changes. These findings imply that the appreciation of the yen between June 2007 and the end of 2011 has caused yen export prices for electronics goods to fall by more than 20 percent. The response is more pronounced for commoditized industries than for differentiated industries. Since yen export prices have fallen much more than yen costs, the appreciation of the yen has significantly reduced profit margins for Japanese electronics firms.

3. Long run effects of exchange rate changes on export volumes

Klitgaard (1999) found that Japanese exporters hold foreign prices stable and allow profit margins to fall much more in the short run than in the long run. If this is true, then exchange rate changes may affect the volume of exports more in the longer run.

Estimating how exchange rates affect electronic parts and components exports is difficult. The intermediate goods flow to East Asian supply chain countries, where they are assembled and re-exported. Athukorala (2012) reported that much production sharing in the electronics industry involves multinational corporations and intra-firm trade. For such trade, Thorbecke (2012) found that a 10 percent appreciation in a supply chain country such as Japan would reduce final assembled exports from China by 15 percent.

Estimating how exchange rate changes affect final electronic exports from Japan is more straightforward. Riad *et al.* (2012) reported that most of the value-added of final goods produced in Japan comes from domestic inputs rather than from imported parts and components. Thus the Japanese yen rather than exchange rates in supply chain countries should be the key variable determining the price competitiveness of these exports. This section uses a long run model to estimate how exchange rate changes affect final electronics exports.

3.1 Data and methodology

According to the imperfect substitutes model of Goldstein and Khan (1985), exports can be represented as:

$$ex_t = \alpha_{10} + \alpha_{11}\ rer_t + \alpha_{12} rgdp_t + \varepsilon_t \qquad (2)$$

where ex_t represents real exports, rer_t represents the real exchange rate, $rgdp$ represents foreign real income, and the variables are measured in natural logs.

As Chinn (2005) discussed, equation (2) combines the exchange rate pass-through relation with an equation relating demand in the importing country with import prices relative to domestic prices. Chinn and others have noted that exchange rates tend to be more volatile than other macroeconomic variables and disconnected from the real economy. Thus, exchange rate changes are likely to be exogenous relative to relative prices and conditioning on the exchange rate in equation (2) is appropriate. If exchange rate pass through remains attenuated in the long run, then this will be reflected in a smaller value of the coefficient α_{11}.

Data on final electronics goods are taken from the CEPII-CHELEM database. They include the categories computer equipment, telecommunications equipment, and consumer electronics goods. These goods come from the SITC classification numbers 75 (excluding 751.3 and 759.1) and 761-4.

The data are measured in US dollars and deflated in two ways. The first employs the yen export price index for electric and electronic products from the Bank of Japan converted to dollar values using the yen/dollar exchange rate obtained from the Federal Reserve Bank of St. Louis FRED database. The second uses the US Bureau of Labor Statistics import price index for computer equipment. Since computer equipment is the largest of the three categories of Japanese final electronics goods exports in most years and makes up a majority of final electronics exports in many years, this may be a good deflator. The results below are very similar using the two deflators.

Japanese electronics exports to the major importing countries are examined. These are Australia, Canada, China, France, Germany, Hong Kong, Mexico, the Netherlands, the Philippines, Singapore, South Korea, Taiwan, Thailand, the United Kingdom and the United States.

Data on real income in the importing country ($rgdp_t$) and the real exchange rate between Japan and the importing country (rer_t) are obtained from the CEPII-CHELEM database. Real income is measured in 2005 dollars. The real exchange rate between Japan and country *j* is calculated by first dividing nominal GDP for Japan by GDP in PPP for Japan and doing the same for country *j*. The resulting ratio for Japan is then divided by the ratio for country *j*. This variable measures the units of consumer goods in Japan needed to buy a unit of consumer goods in country *j* (see Bénassy-Quéré, Fontagné, and Lahrèche-Révil, 2001). Higher values of rer represent a stronger yen.

As a robustness check, a CPI-deflated rer is calculated using data on bilateral nominal exchange rates and consumer price indices in Japan and the importing countries. These data are obtained from the IMF *International Financial Statistics*. Higher values of the real exchange rate again represent a stronger yen. As a second robustness check, the sample is truncated in 2008 to avoid any distortions caused by the collapse in exports in 2009 that is evident in Figure 4.

To specify the econometric model a battery of panel unit root tests is first performed on the levels and first differences of the variables ex_t, rer_t and $rgdp_t$.[2] The results, available on request, indicate in most cases that the variables are integrated of order 1 (I(1)). Kao residual tests for cointegration are then performed.[3] The results, also available on request, indicate that the null hypothesis of no cointegration can be rejected. A panel version of dynamic ordinary least squares estimation, a technique for estimating cointegrating relations, is thus employed.

DOLS involves regressing the left hand side variable on a constant, the right hand side variables, and lags and leads of the first difference of the right hand side variables. The export equations have the form:

$$\begin{aligned} ex_{j,t} = \beta_0 + \beta_1 rer_{j,t} + \beta_2 rgdp_{j,t} + \sum_{k=-p}^{p} \alpha_{1,k} \Delta rer_{j,t-k} + \\ \sum_{k=-p}^{p} \alpha_{2,k} \Delta rgdp_{j,t-k} + \mu_t + \mu_j + u_{j,t}, \\ t = 1, \cdots, T; \qquad j = 1, \cdots, N. \end{aligned} \tag{3}$$

Here $ex_{j,t}$ represents real electronics exports from Japan to country *j*, $rer_{j,t}$ represents the bilateral real exchange rate between Japan and country *j*, $rgdp_{j,t}$ equals real income in country *j*, μ_t is a period fixed effect, and μ_j is a country *j* fixed effect. The data set extends from 1990 to 2011. Because one lead and lag of the first differences of the variables is used in the DOLS estimation, the actual sample period extends from 1992 to 2010.

Figure 4 shows the volume of final electronics goods exports from Japan to the world. There was a 30 percent increase between 1995 and 2000 followed by a 10 percent drop in

[2] These tests include the Im, Pesaran, and Shin test, the ADF Fisher Chi-square test, the Phillips-Perron Fisher Chi-square test, the Levin, Lin, and Chu test, and the Hadiri test. These tests are discussed by Barbieri (2005).
[3] This test is discussed in Kao and Chiang (2000).

2001. These changes were probably associated with the dot-com bubble and its subsequent burst. Thorbecke and Komoto (2010) reported that the dot-com bubble and its subsequent burst had a large effect on Asian exports. There was then a 60 percent increase between 2002 and 2008 followed by a 30 percent drop in 2009. This was associated with the Global Boom and the subsequent Global Financial Crisis. These episodes suggest that including period fixed effects in the estimation might be important.

3.2 Results

Table 8 shows the results from estimating equation (3). Columns (1) and (2) show the results using the CEPII-CHELEM real exchange rate and columns (3) and (4) show the results using the CPI-deflated real exchange rate. In columns (1) and (3) exports are deflated using the Bureau of Labor Statistics price index and in columns (2) and (4) they are deflated using the Bank of Japan price index. The results are very similar using the two deflators.

In columns (1) and (2) the coefficients on rest of the world income and the real exchange rate are both significant at the 1 percent level. The values indicate that a 1 percent fall in income would reduce exports by 0.98 percent and a 1 percent appreciation of the yen would reduce exports by 1.12 percent. As a robustness check the model was also estimated with the sample truncated at 2008. The results, available on request, are very similar to the results over the whole sample period.

As a second robustness check columns (3) and (4) present results using the CPI deflated exchange rate. The coefficients on rest of the world income are significant at the 1 percent level and the coefficients on the real exchange rate are significant at the 5 percent level. The values indicate that a 1 percent fall in income would reduce exports by 1.00 percent and that a 1 percent appreciation of the yen would reduce exports by 0.76 percent.

The important implication of the results presented here is that an appreciation of the yen will reduce Japanese final electronics exports in the long run.[4] The results indicate that, if the steady state value of the yen is 10 percent higher, electronics exports will be about 10 percent less. Thus a strong yen over time will have a significant effect on the volume of final electronics goods exports from Japan.

4. Conclusion

This paper considers how Japanese exports within the electronic industry have been affected by the floods, earthquakes, and macroeconomic shocks that have roiled the Japanese economy in recent years. A visual examination of the data indicates that Japanese electronics exports within production networks have been able to quickly recover from the March 11, 2011 disaster. Japanese electronic parts and components exports to East Asia fell 7 percent after the earthquake, and recovered the pre-quake level by June 2011. The Thai floods of 2011 also seemed to have had only a localized effect, reducing parts and components exports to Thailand but not significantly reducing electronics parts and components exports to the rest of East Asia. On the other hand, the Global Financial Crisis caused the value of Japanese ECD exports to East Asia to fall logarithmically by 100 percent. After the crisis, the value of ECD exports has remained 25 percent below the pre-crisis values.

[4] To the extent that a stronger yen will cause producers to shift production overseas, the effect on total electronics exports will be less.

The volume of ECD exports, however, has exceeded the pre-crisis levels. This indicates that export prices for electronic components and devices have fallen. Between January 2005 and November 2011, these prices in yen terms have fallen 56 percent.

This paper investigates why export prices have fallen so much. To do this it regresses yen ECD export prices on exchange rates, ECD producer prices, and foreign activity and prices. The results indicate that the appreciation of the yen between June 2007 and the end of 2011 caused the yen price of ECD exports to fall by 25 percent.

It is possible that Japanese multinational companies allow the yen prices of parts and components to vary one-for-one with exchange rate changes, but then adjust import prices when selling the assembled finished goods in final markets. To test for this, this paper examines whether Japanese firms can pass through exchange rate changes for final electronics exports. The results indicate that Japanese information and communication equipment (ICE) producers can only pass-through between 20 and 50 percent of the changes in exchange rates into import prices in the importing countries' currencies. These findings imply that the appreciation of the yen since 2007 has caused the yen price of ICE exports to fall by more than 20 percent. Since yen export prices have fallen much more than yen costs, the appreciation of the yen has severely squeezed profit margins.

To understand why exchange rate changes affect export prices this paper also examines several sub-sectors of the electronics industry. The results indicate that yen export prices for commoditized industries such as silicon wafers and color TV receivers are more responsive to exchange rate changes than export prices for differentiated products such as electronic computers and electromedical equipment.

Finally, to examine how exchange rate changes affect exports in the longer run, this paper uses DOLS techniques to estimate an export demand function for final electronics goods. The results indicate that, if the yen is ten percent stronger, Japanese electronics exports would be about 10 percent less. Thus over time a strong yen will substantially reduce electronics exports.

Japanese electronics exports seem robust to supply side shocks such as earthquakes, floods, and natural disasters. On the other hand, they are vulnerable to macroeconomic factors and especially to appreciations of the yen. A strong yen causes profit margins to collapse in the short run and reduces export volumes in the longer run. If electronics firms can move away from producing commoditized goods such as color TV receivers towards innovating and producing differentiated products, the industry will be better able to weather exchange rate appreciations in the future.

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Table 1
OLS estimates of the change in the yen export price for Japanese electronic components and devices, 2005:01-2011:11.

Independent Variable	Coefficient	Standard Error
ΔExchange Rate	0.957***	0.059
ΔExchange Rate$_{-1}$	0.002	0.059
ΔExchange Rate$_{-2}$	0.158**	0.064
ΔForeign PPI	0.259***	0.097
ΔForeign PPI$_{-1}$	-0.156*	0.095
ΔForeign PPI$_{-2}$	-0.111	0.083
ΔECD PPI	0.226	0.364
ΔECD PPI$_{-1}$	0.024	0.279
ΔECD PPI$_{-2}$	0.317	0.270
ΔForeign IP	0.0165	0.126
ΔForeign IP$_{-1}$	-0.130	0.127
ΔForeign IP$_{-2}$	-0.041	0.145
Constant	-0.002	0.002
Adjusted R-squared	0.78	

Note: The exchange rate is the ratio of the yen-denominated export price to the contract-currency export price for the industry. White heteroskedasticity-consistent standard errors are reported.
*** (**) denotes significance at the 1% (5%) level.

Table 2
OLS estimates of the change in the yen export price for Japanese electronic components and devices, 2005:01-2011:11.

Independent Variable	Coefficient	Standard Error
Δ Nominal Effective Exchange Rate	-0.437***	0.051
Δ Nominal Effective Exchange Rate $_{-1}$	0.007	0.051
Δ Nominal Effective Exchange Rate $_{-2}$	-0.076	0.062
ΔForeign PPI	0.028	0.161
ΔForeign PPI$_{-1}$	-0.184	0.146
ΔForeign PPI$_{-2}$	0.005	0.134
ΔECD PPI	0.133	0.368
ΔECD PPI$_{-1}$	-0.077	0.310
ΔECD PPI$_{-2}$	0.435	0.351
ΔForeign IP	-0.035	0.180
ΔForeign IP$_{-1}$	-0.077	0.310
ΔForeign IP$_{-2}$	0.435	0.351
Constant	-0.003	0.003
Adjusted R-squared	0.64	

Note: White heteroskedasticity-consistent standard errors are reported.
*** (**) denotes significance at the 1% (5%) level.

Table 3
OLS estimates of the change in the yen export price for Japanese electronic components and devices, 2005:01-2011:11.

Independent Variable	Coefficient	Standard Error
ΔYen/dollar Exchange Rate	0.484***	0.029
Δ Yen/dollar Exchange Rate $_{-1}$	0.016	0.031
Δ Yen/dollar Exchange Rate$_{-2}$	0.066*	0.034
ΔForeign PPI	0.244**	0.098
ΔForeign PPI$_{-1}$	-0.153*	0.080
ΔForeign PPI$_{-2}$	-0.005	0.151
ΔECD PPI	0.237	0.377
ΔECD PPI$_{-1}$	0.082	0.270
ΔECD PPI$_{-2}$	0.323	0.265
ΔForeign IP	0.038	0.120
ΔForeign IP$_{-1}$	-0.159	0.132
ΔForeign IP$_{-2}$	-0.006	0.151
Constant	-0.003	0.002
Adjusted R-squared	0.77	

Note: White heteroskedasticity-consistent standard errors are reported.
*** (**) [*] denotes significance at the 1% (5%) [10%] level.

Table 4
OLS estimates of the change in the yen export price for Japanese information and communication equipment, 2005:01-2011:11.

Independent Variable	Coefficient	Standard Error
ΔExchange Rate	0.972***	0.083
ΔExchange $Rate_{-1}$	0.015	0.112
ΔExchange $Rate_{-2}$	-0.145***	0.055
ΔForeign PPI	0.289	0.178
ΔForeign PPI_{-1}	0.145	0.150
ΔForeign PPI_{-2}	-0.074	0.191
ΔICE PPI	0.529**	0.216
ΔICE PPI_{-1}	-0.0869	0.176
ΔICE PPI_{-2}	-0.168	0.157
ΔForeign IP	-0.023	0.204
ΔForeign IP_{-1}	-0.081	0.170
ΔForeign IP_{-2}	0.037	0.157
Constant	-0.002	0.003
Adjusted R-squared	0.71	

Note: The exchange rate is the ratio of the yen-denominated export price to the contract-currency export price for the industry. White heteroskedasticity-consistent standard errors are reported.
*** (**) denotes significance at the 1% (5%) level.

Table 5
OLS estimates of the change in the yen export price for Japanese information and communication equipment, 2005:01-2011:11.

Independent Variable	Coefficient	Standard Error
Δ Nominal Effective Exchange Rate $_{-1}$	-0.583***	0.046
Δ Nominal Effective Exchange Rate $_{-1}$	-0.022	0.072
Δ Nominal Effective Exchange Rate $_{-2}$	0.130***	0.043
ΔForeign PPI	-0.404	0.184
ΔForeign PPI$_{-1}$	0.209	0.172
ΔForeign PPI$_{-2}$	-0.007	0.172
ΔICE PPI	0.529**	0.226
ΔICE PPI$_{-1}$	-0.0869	0.176
ΔICE PPI$_{-2}$	-0.169	0.189
ΔForeign IP	0.068	0.196
ΔForeign IP$_{-1}$	-0.226	0.152
ΔForeign IP$_{-2}$	-0.026	0.143
Constant	-0.004	0.003
Adjusted R-squared	0.70	

Note: White heteroskedasticity-consistent standard errors are reported.
*** (**) denotes significance at the 1% (5%) level.

Table 6
OLS estimates of the change in the yen export price for Japanese information and communication equipment, 2005:01-2011:11.

Independent Variable	Coefficient	Standard Error
ΔYen/dollar Exchange Rate	0.556***	0.054
Δ Yen/dollar Exchange Rate $_{-1}$	0.028	0.056
Δ Yen/dollar Exchange Rate$_{-2}$	-0.092**	0.047
ΔForeign PPI	-0.086	0.212
ΔForeign PPI$_{-1}$	0.159	0.155
ΔForeign PPI$_{-2}$	-0.239	0.196
ΔICE PPI	0.434*	0.225
ΔICE PPI$_{-1}$	-0.054	0.190
ΔICE PPI$_{-2}$	-0.201	0.168
ΔForeign IP	0.195	0.195
ΔForeign IP$_{-1}$	-0.021	0.174
ΔForeign IP$_{-2}$	0.028	0.155
Constant	-0.003	0.003
Adjusted R-squared	0.67	

Note: White heteroskedasticity-consistent standard errors are reported.
*** (**) [*] denotes significance at the 1% (5%) [10%] level.

Table 7

OLS estimates of the effect of exchange rate changes on yen export price for various sectors, 2005:01-2011:11.

	Exchange Rate Variable		
Sector	Ratio of Yen Export Price To Contract Currency Export Price	Nominal Effective Exchange Rate	Yen/dollar Nominal Exchange Rate
Electronic Computers	0.65*** (0.22)	-0.54*** (0.18)	0.41** (0.20)
Electromedical Equipment	0.89*** (0.12)	-0.46*** (0.09)	0.41*** (0.10)
Color TV Receivers	0.99*** (0.15)	-0.81*** (0.14)	0.71*** (0.16)
Integrated Circuits	1.18*** (0.11)	-0.63*** (0.10)	0.71*** (0.08)
Silicon Wafers	1.23*** (0.16)	-0.93*** (0.13)	1.00*** (0.13)
Display Devices	1.34*** (0.14)	-0.51*** (0.07)	0.58*** (0.07)

Note: The values in the table are the sum of the coefficients on the contemporaneous first difference of the exchange rate (Δe_j) and the first differences lagged one and two months ($\Delta e_{j,-1}$ and $\Delta e_{j,-2}$). Heteroskedasticity-consistent standard errors are in parentheses.

Table 8
Panel DOLS estimates of Japan's final electronics goods exports to 15 countries.

	Exports deflated by:			
	BLS computer import price index (1)	BoJ electronics export price index (2)	BLS computer import price index (3)	BoJ electronics export price index (4)
Real GDP	0.98***	0.98***	1.00***	1.00***
	(0.09)	(0.09)	(0.07)	(0.07)
Bilateral RER	-1.12***	-1.12***		
(CEPII)	(0.24)	(0.24)		
Bilateral RER			-0.74**	-0.74**
(CPI)			(0.35)	(0.35)
Cross-section fixed effects	Yes	Yes	Yes	Yes
Period fixed effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.91	0.88	0.90	0.87
No. of observations	285	285	285	285
Sample Period	1992-2010	1992-2010	1992-2010	1992-2010

Notes: DOLS(1,1) estimates. Heteroskedasticity-consistent standard errors are in parentheses. The data extend from 1990 to 2011. Since the DOLS estimation uses one lead and lag of the first difference of the right-hand side variables the actual sample period extends from 1992-2010. *** (**) denotes significance at the 1% (5%) level.

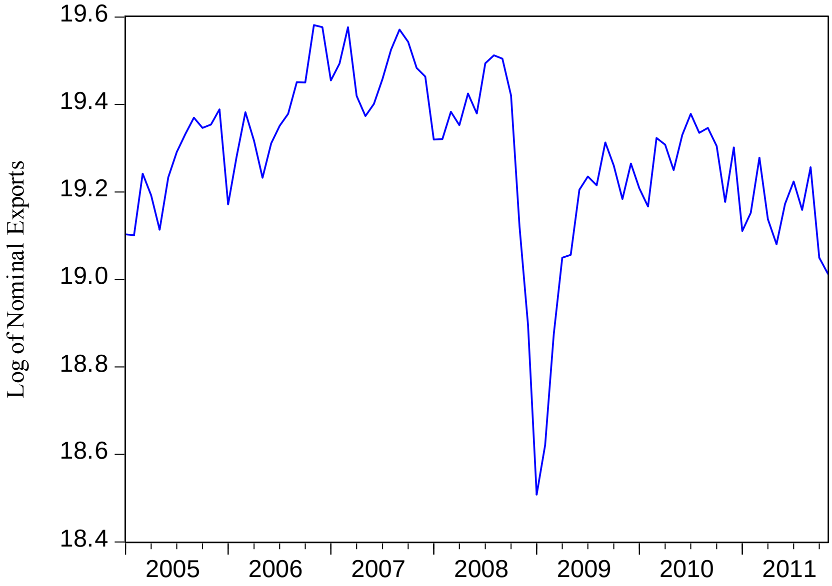

Figure 1a. The value of Japanese electronic parts and components exports to East Asia.
Note: Electronic parts and components exports come from HS 8540-8542.
East Asia includes China, Malaysia, the Philippines, South Korea, Singapore, Taiwan, and Thailand.
Source: Trade Statistics of Japan.

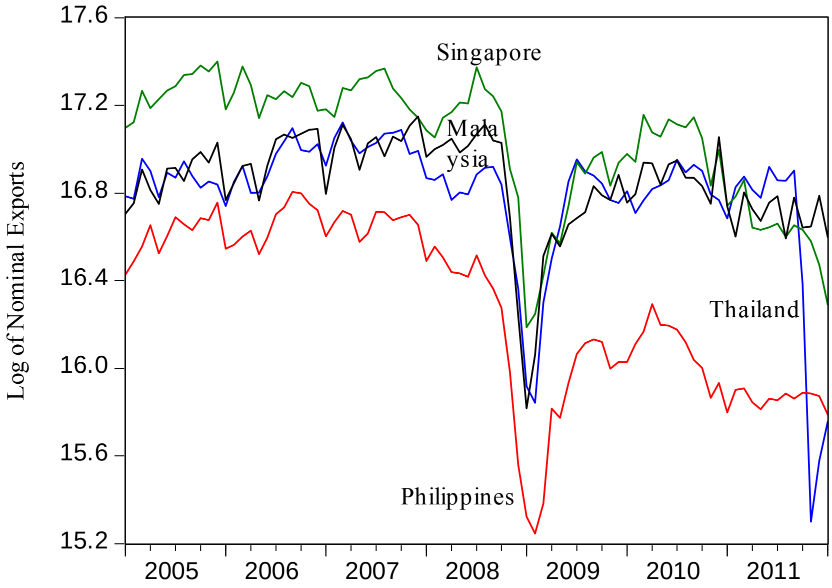

Figure 1b. The value of Japanese electronic parts and components exports to ASEAN countries.
Note: Electronic parts and components exports come from HS 8540-8542. *Source:* Trade Statistics of Japan.

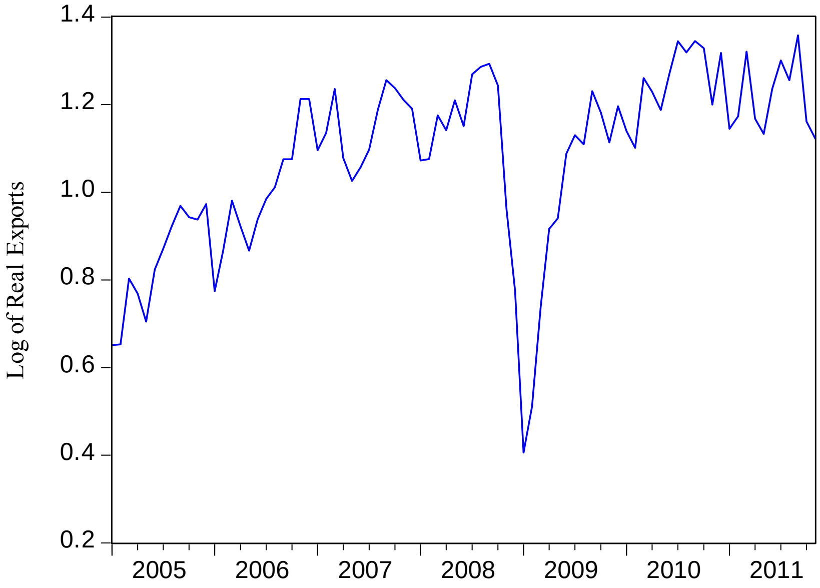

Figure 2. The volume of Japanese electronic parts and components exports to East Asia.
Note: Electronic parts and components exports come from HS 8540-8542. Value data are deflated using the export price index for Japanese electronic components and devices obtained from the Bank of Japan. East Asia includes China, Malaysia, the Philippines, South Korea, Singapore, Taiwan, and Thailand.
Source: Trade Statistics of Japan, Bank of Japan, and calculations by the author.

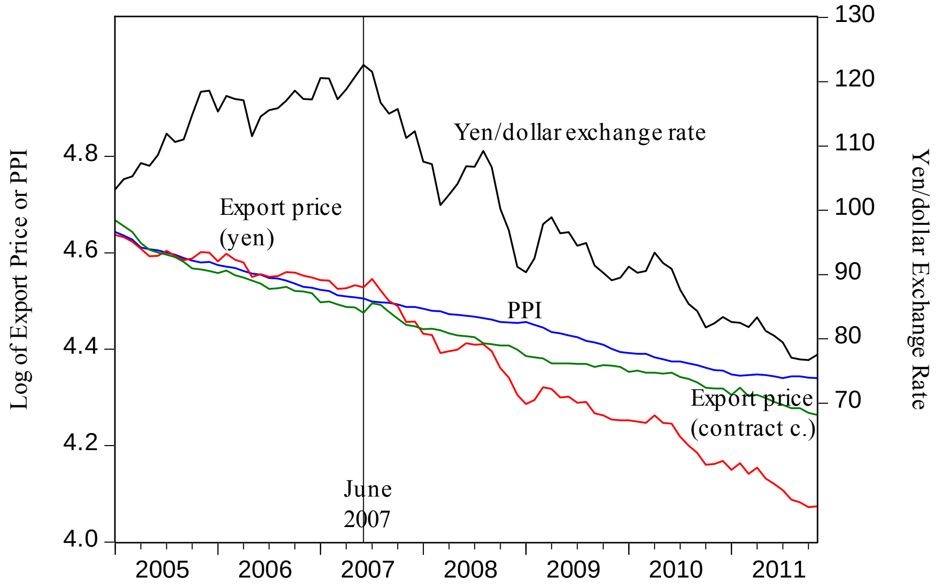

Figure 3a. The yen/dollar exchange rate and Japanese electronic components and devices producer price index, export prices in yen and export prices in contract currencies. *Source:* Bank of Japan.

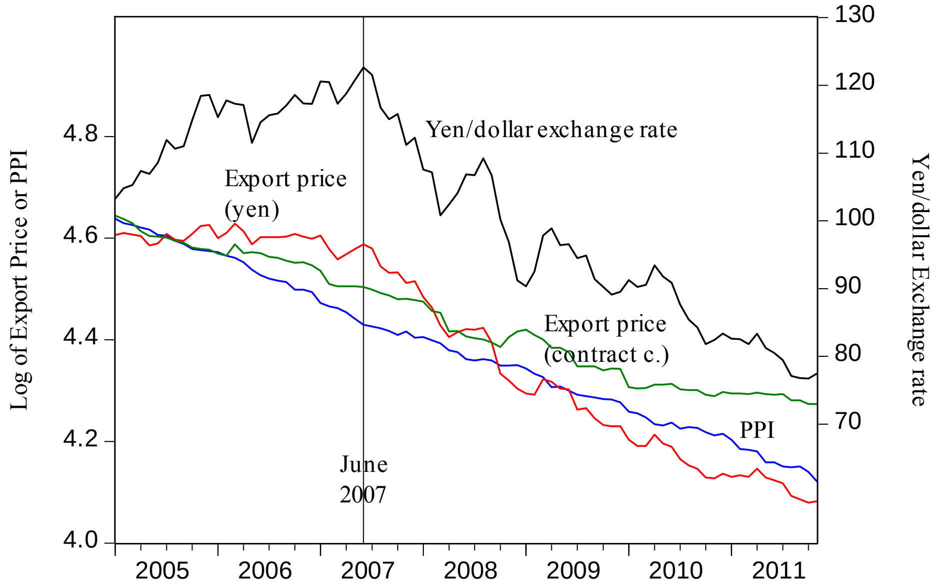

Figure 3b. The yen/dollar exchange rate and Japanese computers and finished electronic goods producer price index, export prices in yen and export prices in contract currencies. *Source:* Bank of Japan.

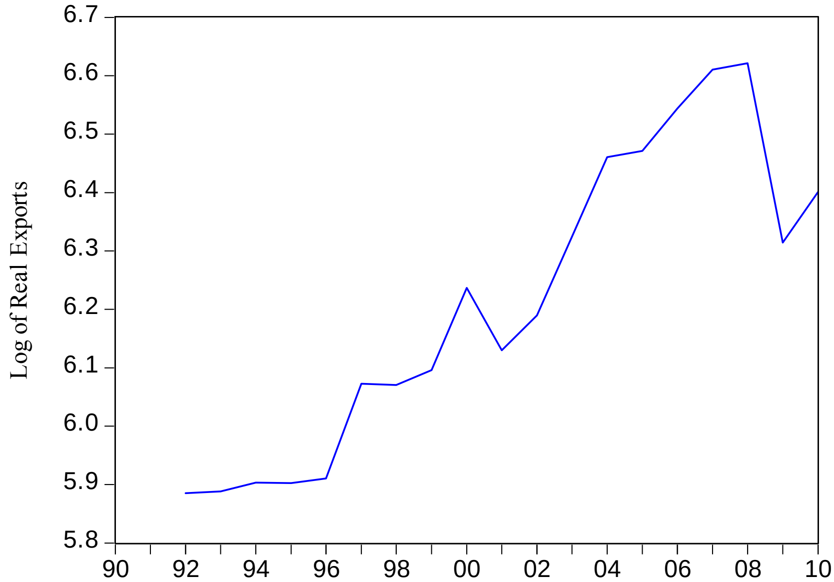

Figure 4. The volume of Japanese final electronics goods exports to the world.
Note: Final electronics goods exports are in the categories computer equipment, consumer electronics, and telecommunications equipment. These goods come from the SITC classification numbers 75 (excluding 751.3 and 759.1) and 761-4. Value data are deflated using the export price index for electric and electronic products from the Bank of Japan, converted to dollars using the yen/dollar exchange rate obtained from the Federal Reserve.
Source: CEPII-CHELEM database, Bank of Japan, Federal Reserve Bank of St. Louis FRED database, and calculations by the author.