Understanding Japan's Capital Goods Exports

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Abstract

Japan is the leading supplier of sophisticated capital goods to East Asian countries. These goods embody advanced technologies and facilitate learning and productivity growth. Capital goods also represent 30%-40% of Japan's exports. This paper investigates the determinants of these exports. Results from dynamic ordinary least squares estimation indicate that exports depend on exchange rates, income in the importing countries, and downstream countries' exports to the rest of the world. Results from out-of-sample forecasts indicate that Japanese exports crashed in 2009 because of the perfect storm of a yen appreciation, a global slowdown, and a collapse in Asia's exports.

Keywords: Exchange rate elasticities, Capital goods, Japan
JEL classification: F10, F40

1. Introduction

Japan is upstream in East Asian value chains. It ships large quantities of sophisticated capital and intermediate goods to China, ASEAN, South Korea and Taiwan. These goods are then frequently used to produce goods for re-export (IMF, 2012).

Firms in developing and emerging Asia benefit from importing capital goods from Japan. Kwan (2004) notes that many Asian countries rely on Japan for capital goods, and if they cannot import these goods from Japan they often cannot obtain them at all.[1] While this was clearly true before the 2008 Lehman Brothers shock, even now Japan remains the leading supplier of capital and equipment goods to East Asia.[2] According to the CEPII-CHELEM database, in 2011 Japan exported $112 billion of these goods to East Asia. This is more than the sum of China's and South Korea's capital exports to East Asia. For specialized machinery such as semiconductor manufacturing machinery and industrial robots (ISIC code 2929), Japan exported $26.5 billion to East Asia in 2011. This compares with $4.8 billion in exports of these goods from China and $2.8 billion from South Korea.[3] Even the two leading capital goods exporters outside of Asia, Germany and the U.S., each provided less than $10 billion of these goods to the region. Thus Japanese capital goods exports remain essential for providing cutting edge tools and equipment to workers in downstream Asian countries.

Firms in East Asia have also been able to assimilate new technologies when they import Japanese capital goods. As Yoshitomi (2003) observes, this occurs because Japanese firms often provide firms in other Asian countries with detailed engineering instructions. Ozawa (2007) discusses how Japanese firms transmit a 'package' of capital, managerial skill, and technical

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[1] While many of these goods are available from German or American companies, Asian firms remain reliant on Japanese capital goods. Future research should investigate why this is so.

[2] East Asian here includes China, Indonesia, Malaysia, Singapore, South Korea, Taiwan, and Thailand.

[3] These data come from the CEPII-CHELEM database.

knowledge to producers in emerging and developing Asia. Bhagwati (1998) describes how firms

in developing Asia learn by engaging in reverse engineering of technologically-intensive imports.

He notes that technical progress often begins when firms take apart and reassemble these

imported products. After this, they make marginal improvements in products and processes and

finally begin innovating and inventing. Importing Japanese capital goods that embody advanced

technologies thus facilitates learning and productivity growth in the region.

While almost 50 percent of Japan's capital and equipment goods exports flows to East

Asia, another 40 percent goes to OECD countries. Japan also imports about one-third of its

capital goods exports from OECD countries.[4] Firms in developed economies often have specific

needs for equipment goods that firms in other countries can meet better than firms in their own

countries. For instance, a firm may prefer a Komatsu excavator to a Caterpillar digger or a

Siemens turbine to a Mitsubishi turbine. There are thus gains from horizontal intra-industry trade

that accrue to companies in Japan and other Northern countries.

Capital and equipment goods are also a crucial component of Japan's overall export

structure. Since 1983, between 30 and 40 percent of the value of Japan's exports have been

capital goods. When these exports fell 32 percent in 2009, they contributed to a collapse in firms'

operating profits and a loss of employment in Japan.

This paper seeks to understand the determinants of Japan's capital goods exports. To do

this it employs a panel data set including Japan's capital exports to major trading partners and a

variety of specifications. In some specifications exports are explained using the real exchange

rate and income in the importing countries, in others using variables such as East Asian re-

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[4] According to the CEPII-CHELEM database, the value of Japan's capital and equipment goods exports in 2010
equaled $232 billion and the value of capital and equipment goods imports equaled $98 billion. Exports to East
Asia equaled $107 billion and exports to OECD countries equaled $88 billion. Imports from OECD countries
equaled $32 billion.

exports to the rest of the world. In every case, the evidence indicates that there is a long run cointegrating relationship between the variables. The results indicate that Japanese capital goods exports are sensitive to exchange rates, income in the importing countries, and exports from East Asia.

When the sample is truncated in 2008 and actual out-of-sample observations on exchange rates, income, and other independent variables from 2009 are used to forecast capital goods exports in 2009, the forecasted drop is larger than the actual drop. These results imply that the combination of the collapse in Asia's exports, the worldwide recession, and the appreciation of the yen caused a perfect storm for Japanese capital goods exports in 2009.

In previous work Nishimura and Hirayama (2013), using an autoregressive distributed lag (ARDL) model over the 2002-2011 period, find that the exchange rate coefficients for Japanese exports to China take on the wrong sign. The reported coefficients are usually not statistically significant. They also find that when China's real exports are also included as an explanatory variable, the exchange rate coefficients usually take on the right sign. The parameters remain statistically insignificant though. In addition they report that the coefficients on China's real exports are largest for Japanese electric machinery and precision machinery exports, indicating that Japanese machinery exports are especially important for producing goods in China for re-export.

Baek (2013), using an ARDL model over the 1991-2010 period, reports that exchange rates do not affect Japan's machinery and transport equipment exports to Korea in the long run. This category represents half of Japan's exports to Korea. Baek posits that the price elasticity for these goods is zero because Japanese machinery exports are essential for Korea to produce goods for re-export.

Walter, Baek, and Woo (2012), using an ARDL model over the 1989-2011 period, examines Japanese exports of agricultural goods, materials and chemicals, machinery and transportation equipment, and manufactured goods to the U.S. In every case, they find that the exchange rate does not affect Japanese exports.

Crane, Crowley, and Quayyum (2007), employing Johansen maximum likelihood estimation over the 1981–2006 period, find that a 10 percent appreciation in the Japanese real effective exchange rate would reduce Japanese aggregate exports by 3.4 percent. They also report that a 10 percent increase in income in importing countries would increase exports by 17 percent. [5]

Chinn (2013), also using Johansen maximum likelihood estimation over the 1990–2012 period, reports that a 10 percent appreciation in the Japanese real effective exchange rate would reduce Japanese aggregate exports by between 3 and 7 percent. In addition he finds that a 10 percent increase in income in importing countries would increase exports by between 10 and 40 percent.

Tang (2014) investigates exports of primary, intermediate, equipment, and consumption goods among 18 East Asian, South Asian, and ASEAN countries. Using panel dynamic ordinary least squares (DOLS) estimation and annual data over the 1980 – 2009 period, he finds that for intermediate, equipment, and consumption goods a depreciation in the exporting country is associated with a decrease in exports (i.e., the coefficient takes on the wrong sign). He also reports that exchange rate volatility deters trade, with the effect being strongest for intermediate and equipment goods.

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[5] Bénassy-Quéré, and Lahrèche-Révil (2003) and Thorbecke (2008a) use gravity models to investigate the effects of exchange rate changes on exports. However, as Anderson et al. (2013) note, the theoretical foundation for including exchange rates in gravity models is unclear.

A contribution of this paper is to investigate the factors affecting exports specifically from Japan, a key upstream country, to downstream countries. Valuable papers such as Tang (2014) combine upstream and downstream countries. There is a paucity of work investigating the factors affecting the flow of capital goods from Japan specifically to downstream Asian countries within East Asian production networks. This paper seeks to fill this void.

The next section discusses the data and methodology employed in this paper. Section 3 presents the results. Section 4 concludes.

2. Data and Methodology

A workhorse model to estimate trade elasticities is the imperfect substitutes framework of Goldstein and Khan (1985). In this model exports are a function of the real exchange rate and real income:

$$ex_t = \alpha_{10} + \alpha_{11} \, rer_t + \alpha_{12} \, rgdp_t^* + \varepsilon_t \qquad (1)$$

where ex_t represents the log of real exports, rer_t represents the log of the real exchange rate, and $rgdp_t^*$ represents the log of foreign real income.

Equation (1) comes from a partial equilibrium model that takes the real exchange rate and real income as given. Great care must thus be taken in interpreting the estimated parameters.[6] Chinn (2013) uses this framework to investigate Japanese exports. He treats equation (1) as a "semi-reduced form" model and gives a structural interpretation to the resulting parameter

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[6] I am indebted to colleagues for this point.

estimates. For instance, he uses the exchange rate coefficients to examine whether the Marshall-Lerner condition applies to Japan. This paper follows his approach, albeit cautiously.

For Japanese capital goods exports to East Asia, there are reasons to modify this model. This can be seen in Figure 1. Figure 1a shows Japanese capital goods and intermediate goods exports to East Asian supply chain countries and Figure 1b shows these exports to the rest of the world. The East Asian supply chain countries are China, Indonesia, Malaysia, Singapore, South Korea, Taiwan, and Thailand. Figure 1 makes clear that Japanese capital goods exports to East Asia are closely related to Japanese intermediate goods exports to East Asia, while Japanese capital goods exports to the rest of the world are somewhat decoupled from Japanese intermediate goods exports to the rest of the world. Japanese capital goods exports to East Asia are thus closely linked to East Asian supply chains.

Ozawa (2007) notes that there is a complementary relationship between Japanese FDI and Japanese exports to Asia. As wages in Japan increase and as new products became more capital and knowledge intensive, Japanese firms transfer the location of production to lower wage Asian countries. Japan then exports sophisticated parts and components and capital goods to the assembly countries, implying that there is a complementary relationship between exports and FDI.

These inputs from Japan are then used in the supply chain countries to produce goods for re-export. Japanese exports of intermediate and capital goods to Asia thus depend on exports from these countries to the rest of the world.   In other words, as Kamada and Tamagawa (2005) note, import demand in Asian countries is partly derived from their exports. They observe that, because of this, exchange rate elasticities often take on the wrong sign. An exchange rate

depreciation in downstream Asia can increase its exports and thus increase its demand for intermediate and capital goods imports that are used to produce these exports.

Many report estimated elasticities in Asia that have a counterintuitive sign. For instance, Cheung, Chinn, and Fujii (2010), Cheung, Chinn, and Qian (2012) and Garcia-Herrero and Koivu (2007) report that an appreciation of the renminbi is often associated with a decrease in Chinese imports. Tang (2014) finds that an appreciation in the importing country is correlated with a decrease in imports for intra-Asian trade in intermediate, equipment, and consumption goods.

These authors frequently explain the counterintuitive signs by noting that a depreciation in a downstream country can increase exports and thus increase the demand for imported inputs. To control for this, many authors include exports in the import demand functions for Asian countries. These include Cheung, Chinn, and Qian (2012), Ahuja *et al.* (2012), Nishimura and Hirayama (2013), Baak (2014), Thorbecke (2008b), and others. Cheung et al., for instance, find that without including exports in the import function, the coefficient on the exchange rate takes on the wrong sign and is statistically significant. Including exports causes the coefficient on imports to be correctly signed and statistically significant in many specifications. Thorbecke reports a tight relationship between the import of electronic parts and components and the export of final electronics goods in East Asian countries. Following these authors, exports from Asian countries is sometimes included as an explanatory variable for Japanese capital goods exports to Asia.

Kwan (2004) also observes that Japanese capital goods to Asia often have few substitutes, implying that price elasticities may be lower for Japanese exports to Asia. It may thus make

sense to estimate price elasticities separately for Asian supply chain countries and for other countries.

Equation (1) is thus modified. In some specifications Japanese exports to Asian supply chain countries are modeled as a function of exports from supply chain countries to the world.[7] In other specifications the coefficients on Asian and non-Asian exchange rates and GDP are estimated separately.

Data on Japanese capital and equipment goods exports are obtained from the CEPII-CHELEM database. These goods come from the following categories: aeronautics, agricultural equipment, arms, commercial vehicles, computer equipment, construction equipment, electrical apparatus, electrical equipment, precision instruments, ships, specialized machines, and telecommunications equipment.

The value of Japanese capital and equipment goods exports averaged $140 billion between 1990 and 1999 and $185 billion between 2000 and 2010. It also fell logarithmically by 32 percent between 2008 and 2009.

A panel data set is constructed over the 1980-2010 period including all of the countries that imported substantial quantities of capital goods from Japan. It is desirable to exclude minor importers of capital goods because these countries can have very large percentage changes in imports from year to year due to idiosyncratic factors such as an individual firm's decisions rather than due to macroeconomic factors such as those in equation (1). The primary importing countries over the sample period are Australia, Canada, China, France, Germany, Hong Kong,

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[7] Modeling Japanese exports to East Asian processor economies as a function of processor economies' exports to the rest of the world would be appropriate if there were a recursive relationship between the variables, with exports from processor economies depending on demand conditions in the rest of the world and exports of inputs from Japan to East Asia depending on the flow of exports out of the processor economies. The IMF (2005) argues that this might be the case.

Indonesia, Malaysia, the Netherlands, Singapore, South Korea, Taiwan, Thailand, the United Kingdom, and the United States.

Data on the value of capital and equipment goods exports are obtained from the CEPII-CHELEM database and are measured in U.S. dollars.[8] They are deflated using the Bank of Japan (BoJ) export price deflator, converted to U.S. dollars using the nominal yen/dollar exchange rate obtained from the Federal Reserve Board. In a second specification they are deflated using the capital goods import price index from the U.S. Bureau of Labor Statistics (BLS).

As in Tang (2014), data on the bilateral real exchange rate between Japan and the importing countries are measured in purchasing power parity terms and are obtained from the CEPII-CHELEM database. An increase in the exchange rate represents an appreciation of the yen. Data on real GDP in the importing country are calculated by converting GDP expressed in each country's constant national prices in 2005 by the country's nominal exchange rate relative to the dollar in 2005. These data are also obtained from the CEPII-CHELEM database. The CEPII-CHELEM data are described in detail at www.cepii.fr.

Data on real exports from East Asian and other importing countries to the world are obtained from the CEIC database. The original source was the International Monetary Fund IFS database or the country's own national statistics.[9]

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[8] The original Japanese export data were converted to U.S. dollars using the nominal exchange rate. The CEPII-CHELEM database did not use industry deflators in constructing the export series. Thus dividing the export data by the product of the nominal exchange rate and the export price deflator effectively creates a real export series measured in Japanese yen.

[9] In the case of Taiwan, data on real exports could not be found. In this case nominal data from the CEPII-CHELEM database were used and deflated by the consumer price index.

In principle, a producer price index (PPI) deflated real exchange rate would be preferable for explaining capital goods exports.[10] Unfortunately, data on the PPI are not available for several of the leading importing countries over the sample period.

Table 1 presents the results for a battery of panel unit root tests for the levels and first differences of real capital goods exports, the CEPII real exchange rate, and real income. [11] The results indicate that in most cases the variables are integrated of order 1 (I(1)).[12]

Kao residual cointegration tests are then performed for the variables.[13] The results in Table 2 indicate that the null hypothesis of no cointegration can be rejected in every specification. Panel dynamic ordinary least squares (DOLS) 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:

$$ex_{j,t} = \beta_0 + \beta_1 rer_{j,t} + \beta_2 rgdp^*_{j,t} + \sum_{k=-p}^{p} \alpha_{1,k} \Delta rer_{j,t-k} + \sum_{k=-p}^{p} \alpha_{2,k} \Delta rgdp^*_{j,t-k} \qquad (2)$$

$$+ \mu_j + \mu_t + u_{j,t},$$

$$t = 1, \cdots, T; \qquad j = 1, \cdots, N.$$

Here $ex_{j,t}$ represents real capital goods exports from Japan to importing country j, $rer_{j,t}$ represents the bilateral real exchange rate between Japan and country j, $rgdp^*_{j,t}$ equals

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[10] I am indebted to Dr. Masayuki Morikawa for this suggestion.

[11] These tests include the the Breiting t-test, the Im, Pesaran, and Shin test, the ADF Fisher Chi-square test, the Phillips-Perron Fisher Chi-square test, and the Levin, Lin, and Chu test. These tests are discussed by Barbieri (2005).

[12] In the case of capital exports deflated by the Bank of Japan export price deflator and the real exchange rate, the series only appear to be I(1) when a trend term is included.

[13] This test is discussed in Kao (1999).

real income in country j, μ_j is a country j fixed effect, and μ_t is a time fixed effect. As discussed above, other variables are also included in some specifications.

The data set extends from 1988 to 2010. Because one lead and lag of the first differences is used in the DOLS equation, the actual sample period for the estimation extends from 1990 to 2009. One model is also estimated over the 1990 to 2008 period to examine whether the results are robust to excluding the Great Trade Collapse of 2009.

3. Results

Table 3 reports the results of estimating equation (2) over the 1982-2009 period using exports deflated by the BoJ export price index. The results are very similar using exports deflated by the BLS capital goods deflator, so these findings are not presented. The coefficients are always of the expected sign and statistically significant at the 1 percent level.

In the first column, the coefficient of the real exchange rate equals -0.45. This implies that a 10 percent appreciation of the yen relative to the local currency would reduce a country's capital imports from Japan by 4.5 percent. The coefficient on real GDP in the importing countries equals 1.21. This implies that a 10 percent increase in GDP would increase capital goods imports by 12.1 percent.

In the second column, exchange rate elasticities are estimated separately for East Asian importers and for non-East Asian importers. The coefficient for Asian importers equals -0.45 and the coefficient for non-Asian importers equals -0.57. The coefficient on real GDP in column (2) equals 1.17.

Columns (3) and (4) differ from columns (1) and (2) because real GDP for East Asian importers and non-East Asian importers are included separately. In addition, in column (4) the

exports of East Asian importers are also included as an explanatory variable. The coefficient on real GDP in East Asian importing countries in column (3) now equals 1.05 and the coefficient on real GDP for non-East Asian importers now equals 0.67.[14]

In column (4) the coefficient on the exports of East Asian importers equals 0.32. This implies that a 10 percent increase in exports from one of these countries will increase imports of Japanese capital goods on average by 3.2 percent. The coefficients on GDP for both East Asian and non-East Asian countries are now smaller, equaling 0.54 in both cases.

The positive coefficient on exports combined with the smaller coefficient on GDP may reflect the fact that exports are much more volatile than other components of GDP such as consumption. In other words, exports may be picking up part of the effect of GDP in the importing country on import demand. Alternatively, exports may be capturing the channel discussed above whereby an increase in exports in downstream Asian countries increases their demand for imported inputs.

One way to choose between these hypotheses is to examine the relationship between Japanese consumption exports and exports in downstream Asian countries.[15] Consumption exports are intended for the domestic market in the importing country rather than for providing inputs to produce goods for re-export. Thus if exports in downstream countries are picking up the effect of GDP on import demand, they should affect the demand for consumption goods as well as for capital goods. On the other hand, if they are capturing the relationship between

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[14] A Wald test allows rejection of the null hypothesis that the coefficients are equal.

[15] Data on Japanese consumption exports are obtained from the CEPII-CHELEM database. They are deflated using the BoJ export price index. Consumption goods include: beverages, carpets, cars, cereal products, cinematographic equipment, clocks, clothing, consumer electronics, domestic electrical appliances, knitwear, miscellaneous manufactured articles, pharmaceuticals, photographic equipment, preserved fruit and vegetable products, preserved meat and fish products, soaps and perfumes (including chemical preparations), sports equipment, toiletries, toys, and watches.

exports in downstream Asian countries and the demand for imported inputs, they should affect

Japan's capital goods exports more than its consumption goods exports.

Results are presented below for Japanese real consumption goods exports ($consumpex$)

and real capital goods exports ($capitalex$):

$$consumpex_t = -0.46^{***} \ rer_t + 0.67^{***} rgdp_t^* + 0.13 \ Asiaex_t + \cdots . \qquad (3)$$
$$ (0.10) \qquad\quad (0.21) \qquad\quad (0.07)$$

Adjusted $R^2 = 0.94$, Sample period=1982-2009, No. of countries = 15, No. of observations = 419

$$capitalex_t = -0.59^{***} \ rer_t + 0.55^{***} rgdp_t^* + 0.32^{***} Asiaex_t + \cdots . \qquad (4)$$
$$ (0.10) \qquad\quad (0.11) \qquad\quad (0.03)$$

Adjusted $R^2 = 0.94$, Sample period=1982-2009, No. of countries = 15, No. of observations = 419

There is a strong and statistically significant relationship between Japan's capital exports

and exports in downstream Asian countries ($Asiaex$) but not between Japan's consumption

exports and exports in downstream Asia. These findings support Kamada and Tamagawa's

(2005) observation that the demand for imported inputs in Asia is partly derived from Asian

exports.

Returning to Table 3, one implication of the results above is that, when estimating

elasticities for upstream countries in production networks, it can be useful to include exports in

the downstream country. Exports exert an independent effect on imported inputs apart from the

effect of GDP in the importing country. Thorbecke (2008b) reported a tight relationship between

the export of final electronics goods from Asian supply chain countries and the import of

electronics parts and components. The results in Table 3 indicate that there is also a strong

relationship between total exports from downstream Asian countries and their imports of capital

goods from Japan.

Column (5) reports results for exchange rates of Asian importers and non-Asian importers separately. The coefficient for Asian importers equals -0.56 and the coefficient for non-Asian importers equals -0.74. A Wald test allows rejection at the 10 percent level of the null hypothesis that these coefficients are equal.

Ordinarily one would expect price elasticities to be smaller for trade over longer distances because transportation costs account for a larger share of the final price of the export good.[16] However, there is more product differentiation for Japan's trade with emerging Asia than for Japan's trade with non-Asian OECD countries. Many of Japan's exports to emerging Asia cannot be produced in the importing countries whereas Japan's trade with OECD countries often involves horizontal intra-industry trade. The greater product differentiation for Japan's trade with Asia and the inability of Asian countries to obtain substitutes elsewhere causes the price elasticity for Japan's exports to Asia to be smaller than the price elasticity for Japan's exports outside of Asia.

Column (6) includes exports from non-Asian importers as an additional explanatory variable.[17] The coefficient on exports of Asian importers equals 0.32, as it does in every specification. The coefficient on exports of non-Asian importers equals 0.14. These results imply that an increase in exports from non-Asian importers is also associated with an increase in capital goods imports, although the relationship is not as strong as it is for exports from Asian importers.

There are several implications of the results presented in this section. First, Japanese capital goods exports are sensitive to exchange rates. Second, unlike many of the results reported in Section 1, the estimated price elasticities of between -0.45 and -0.74 are well within the range of normal elasticities (see, e.g., Crane, Crowley, and Quayyuum, 2007). Third, exports outside of East Asia appear more sensitive to exchange rate changes than exports to East Asia.

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[16] I am indebted to seminar participants and other colleagues for the discussion in this paragraph.
[17] I am indebted to Prof. Taiji Furusawa for this suggestion.

Fourth, demand for Japanese capital goods in China, Indonesia, Malaysia, Singapore, South Korea, Taiwan, and Thailand depends in turn on the ability of these countries to export.

It is interesting to examine whether the model can explain the collapse of Japanese capital goods exports in 2009. Exports to the 15 countries in the sample fell 32 percent in value terms and 31 percent in volume terms.

To investigate the export collapse of 2009 the model is re-estimated with the sample truncated in 2008. The results, presented in Table 4, are very similar to the results in Table 3. This implies that the findings in Table 3 are not sensitive to excluding the Great Trade Collapse of 2009. Actual out-of-sample observations for the independent variables in 2009 are then used to forecast the drop in capital goods exports in 2009.

Table 4 presents the predicted drops according to each model and the root mean squared error (RMSE) measure of the forecast error for 2009. Both measures indicate that the specifications in columns (3), (4), and (5) far outperform the other models. By the RMSE criterion, the value in column (5) is about 10 percent less than the value in column (3) and just slightly less than the value in column (4). One implication of these findings is that, for Japanese capital exports, the standard export function presented in equation (1) can be improved upon by adding other variables such as exports of downstream countries and by disaggregating between East Asian supply chain importers and other importers.

Model (3) predicts a drop of 35.6 percent, model (4) a drop of 37.1 percent, and model (5) a drop of 39.8 percent. Thus all three of the preferred models predict larger drops than actually occurred. The combination of the crash in Asia's exports in 2009, the worldwide recession, and the appreciation of the yen can thus explain the fall in Japanese capital goods exports.

Other factors also may have contributed to the fall in Japanese exports during the crisis. Chor and Manova (2011) report that financially constrained sectors experienced larger drops in exports. Bems, Johnson, and Yi (2012), surveying several papers, conclude that credit constraints played an important secondary role in the Great Trade Collapse. Future research should investigate the extent to which credit supply shocks and other factors helped to cause the drop in Japanese capital goods exports.

4. Conclusion

This paper investigates the determinants of Japan's capital goods exports. To do this it uses a panel data set including exports to 15 leading importers and dynamic ordinary least squares techniques. The results indicate that an appreciation of the yen, a fall in income in importing countries, and a drop in exports from downstream East Asia countries would all cause capital goods exports to fall.

Other papers have investigated Japanese aggregate exports, Japanese exports to specific countries, and Asian exports between upstream and downstream countries. Chinn (2013), for instance, finds aggregate price elasticities for Japanese exports of between 0.3 and 0.7. Baek (2013) investigates Japanese machinery and transport equipment exports to Korea, and finds that these are not affected by exchange rate changes. Tang (2014) examines equipment goods exports between Asian countries and reports that exchange rate elasticities take on the wrong sign.

The contribution of this paper is to examine capital goods exports specifically from Japan, a key upstream supplier, to downstream Asian countries and other importers. The estimated exchange rate elasticities range from -0.45 to -0.74, indicating that an appreciation of the yen matters for these exports. The results also indicate that Japan's capital goods exports to Asian

countries depend in turn on those countries' exports to the rest of the world. The evidence implies that the response of Japanese capital goods exports to the exports of downstream Asian countries is independent of the response of Japanese capital goods exports to GDP changes in downstream countries.

The Japanese yen began depreciating in November 2012. Automakers in South Korea complained that the depreciation of the yen is hurting their price competitiveness and profitability. The South Korean finance minister warned that the depreciation of the yen is a flashing red light for Korean exporters (Kim, 2013). Many have complained that Japan is engaging in a currency war with its Asian neighbors. Less discussed, however, has been the salutary effect that the weaker yen can have on emerging East Asian countries that are in a complementary relationship with Japan. The results in this paper indicate that, if sustained, the depreciation of the yen will substantially increase steady state capital exports to Asia and the rest of the world. This will benefit Japanese firms. It will also benefit firms in East Asia by allowing them to acquire vital inputs and assimilate new technologies and firms in the developed world by facilitating the gains from intra-industry trade.

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Table 1
Results of unit root tests

Level, intercept included	(1)	(2)	(3)	(4)	(5)
Capital exports deflated by BLS capital goods deflator		-2.90**	0.67	38.56	71.76**
Capital exports deflated by BoJ export price deflator		-3.66**	-1.97**	52.66**	88.31**
Real exchange rate		-2.83**	-2.81**	51.43**	37.44
Importer's real GDP		-4.37**	0.48	27.98	43.38
Exports from East Asia		0.06	3.36	2.37	2.43
Exports from Non-East Asian Countries		-0.19	3.24	2.58	4.18
Level, trend and intercept included	(1)	(2)	(3)	(4)	(5)
Capital exports deflated by BLS capital goods deflator	0.24**	-3.16**	-2.27**	49.09**	47.37**
Capital exports deflated by BoJ export price deflator	0.65	-2.32**	-1.55	39.41	75.63**
Real exchange rate	1.46	-3.18**	-0.44	37.56	16.27
Importer's real GDP	0.63	1.40	0.68	28.91	10.51
Exports from East Asia	-0.53	0.77	1.06	7.25	7.99
Exports from Non-East Asian Countries	-0.33	0.16	0.87	9.16	9.26
First difference, intercept included	(1)	(2)	(3)	(4)	(5)
Capital exports deflated by BLS capital goods deflator		-14.91**	-15.96**	257.53**	315.88**
Capital exports deflated by BoJ export price deflator		-11.96**	-14.67**	234.96**	280.86**
Real exchange rate		-12.96**	-11.97**	185.65**	199.96**
Importer's real GDP		-12.22**	-11.04**	167.65**	156.38**
Exports from East Asia		-10.84**	-9.65**	103.99**	101.63**
Exports from Non-East Asian Countries		-12.54**	-11.25**	122.04**	125.70**
First difference, trend and intercept included	(1)	(2)	(3)	(4)	(5)
Capital exports deflated by	-4.37**	-12.61**	-15.12**	225.65**	787.71**

	(1)	(2)	(3)	(4)	(5)
BLS capital goods deflator					
Capital exports deflated by BoJ export price deflator	-3.91**	-9.49**	-13.91**	206.62**	714.14**
Real exchange rate	-7.60**	-12.94**	-11.65**	167.69**	240.32**
Importer's real GDP	-5.15**	-11.25**	-9.95**	140.57**	250.14**
Exports from East Asia	-2.06**	-9.51**	-8.30**	80.64**	78.63**
Exports from Non-East Asian Countries	8.57	23.90	-8.08**	95.59**	137.88**

(1) Breitung t-statistic (null hypothesis: unit root)
(2) Levin, Lin, and Chu t-statistic (null hypothesis: unit root)
(3) IM, Pesaran, and Shin W-statistic (null hypothesis: unit root)
(4) ADF test-Fisher Chi-square statistic (null hypothesis: unit root)
(5) PP test-Fisher Chi-square statistic (null hypothesis: unit root)
Note: Lag selection is based on the Schwartz Information Criterion.
** denotes significance at the 5% level.

Table 2.
Results of Kao residual cointegration tests

Specification	t-statistic
Exports deflated by BLS capital goods deflator, Real exchange rate, Real GDP	-5.00***
Exports deflated by BoJ export price deflator, Real exchange rate, Real GDP	-4.52***
Exports deflated by BLS capital goods deflator, Real exchange rate (Asian importers), Real exchange rate (non-Asian importers), Real GDP	-4.65***
Exports deflated by BoJ export price deflator, Real exchange rate (Asian importers), Real exchange rate (non-Asian importers), Real GDP	-4.23***
Exports deflated by BLS capital goods deflator, Real exchange rate, Real GDP (Asian importers), Real GDP (non-Asian importers), Exports (Asian importers)	-4.77***
Exports deflated by BoJ capital goods deflator, Real exchange rate, Real GDP (Asian importers), Real GDP (non-Asian importers), Exports (Asian importers)	-4.36***
Exports deflated by BLS capital goods deflator, Real exchange rate (Asian importers), Real exchange rate (non-Asian importers), Real GDP (Asian importers), Real GDP (non-Asian importers), Exports (Asian importers)	-4.83***
Exports deflated by BoJ export price deflator, Real exchange rate (Asian importers), Real exchange rate (non-Asian importers), Real GDP (Asian importers), Real GDP (non-Asian importers), Exports (Asian importers)	-4.27***
Exports deflated by BLS capital goods deflator, Real exchange rate, Real GDP (non-Asian importers), Exports (Asian importers)	-4.59***
Exports deflated by BoJ export price deflator, Real exchange rate, Real GDP (non-Asian importers), Exports (Asian importers)	-4.20***
Exports deflated by BLS capital goods deflator, Real exchange rate (Asian importers), Real exchange rate (non-Asian importers), Real GDP (non-Asian importers), Exports (Asian importers)	-4.49***
Exports deflated by BoJ export price deflator, Real exchange rate (Asian importers), Real exchange rate (non-Asian importers), Real GDP (non-Asian importers), Exports (Asian importers)	-5.20***

Note: The table contains t-statistics from Kao residual cointegration tests of the null hypothesis of no cointegration.
    Lag selection is based on the Schwartz Information Criterion.
*** denotes significance at the 1% level.

Table 3
Panel DOLS Estimates of Trade Elasticities for Japanese Capital Goods Exports

	(1)	(2)	(3)	(4)	(5)	(6)
Real Exchange Rate	-0.45*** (0.10)		-0.53*** (0.10)	-0.59*** (0.10)		
Real Exchange Rate (Asian Importers)		-0.45*** (0.10)			-0.56*** (0.11)	-0.48*** (0.10)
Real Exchange Rate (Non-Asian Importers)		-0.57*** (0.12)			-0.74*** (0.11)	-0.62*** (0.10)
Real GDP	1.21*** (0.07)	1.17*** (0.08)			0.51*** (0.11)	0.73*** (0.13)
Real GDP (Asian Importers)			1.05*** (0.07)	0.54*** (0.12)		
Real GDP (Non-Asian Importers)			0.67*** (0.15)	0.54*** (0.15)		
Exports (Asian Importers)				0.32*** (0.06)	0.32*** (0.04)	0.32*** (0.10)
Exports (Non-Asian Importers)						0.14*** (0.04)
Cross-section Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Period Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.94	0.93	0.94	0.94	0.94	0.94
Sample Period	1982-2009	1982-2009	1982-2009	1982-2009	1982-2009	1982-2009
No. of Importing Countries	15	15	15	15	15	15
No. of Observations	420	420	420	420	419	419

Notes: Heteroskedasticity-consistent standard errors are in parentheses. Japanese exports are deflated using the Bank of Japan export price deflator, converted to U.S. dollars using the nominal yen/dollar exchange rate obtained from the U.S. Federal Reserve Board. Asian importers include China,

Indonesia, Malaysia, Singapore, South Korea, Taiwan, and Thailand. Non-Asian importers include Australia, Canada, France, Germany, Hong Kong, the Netherlands, the United Kingdom, and the United States. Exports from Asian exporters (non-Asian importers) represent real exports from each of the 7 Asian importers (8 non-Asian importers) to the world.

*** denotes significance at the 1% level.

Table 4
Panel DOLS Estimates of Trade Elasticities for Japanese Capital Goods Exports

	(1)	(2)	(3)	(4)	(5)	(6)
Real Exchange Rate	-0.48*** (0.10)		-0.56*** (0.09)	-0.62*** (0.10)		
Real Exchange Rate (Asian Importers)		-0.46*** (0.10)			-0.58*** (0.11)	-0.50*** (0.10)
Real Exchange Rate (Non-Asian Importers)		-0.61*** (0.13)			-0.78*** (0.11)	-0.64*** (0.12)
Real GDP	1.25*** (0.07)	1.19*** (0.09)			0.55*** (0.12)	0.78*** (0.14)
Real GDP (Asian Importers)			1.07*** (0.08)	0.59*** (0.12)		
Real GDP (Non-Asian Importers)			0.68*** (0.16)	0.55*** (0.16)		
Exports (Asian Importers)				0.31*** (0.07)	0.31*** (0.05)	0.31*** (0.05)
Exports (Non-Asian Importers)						0.14*** (0.04)
Cross-section Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Period Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.94	0.94	0.94	0.94	0.94	0.94
Sample Period	1982-2008	1982-2008	1982-2008	1982-2008	1982-2008	1982-2008
No. of Importing Countries	15	15	15	15	15	15

No. of Observations	405	405	405	405	404	404
Predicted Drop in 2009 (percent)	16.4	18.9	35.6	37.1	39.8	16.4
Actual Drop in 2009 (percent)	31.3	31.3	31.3	31.3	31.3	31.3
RMSE	0.321	0.317	0.290	0.270	0.266	0.283

Notes: Heteroskedasticity-consistent standard errors are in parentheses.   Japanese exports are deflated using the Bank of Japan export price deflator, converted to U.S. dollars using the nominal yen/dollar exchange rate obtained from the U.S. Federal Reserve Board. Asian importers include China, Indonesia, Malaysia, Singapore, South Korea, Taiwan, and Thailand. Non-Asian importers include Australia, Canada, France, Germany, Hong Kong, the Netherlands, the United Kingdom, and the United States. Exports from Asian exporters (non-Asian importers) represent real exports from each of the 7 Asian importers (8 non-Asian importers) to the world.   RMSE represents the root mean squared error measure of the model's forecast error for 2009. *** denotes significance at the 1% level.
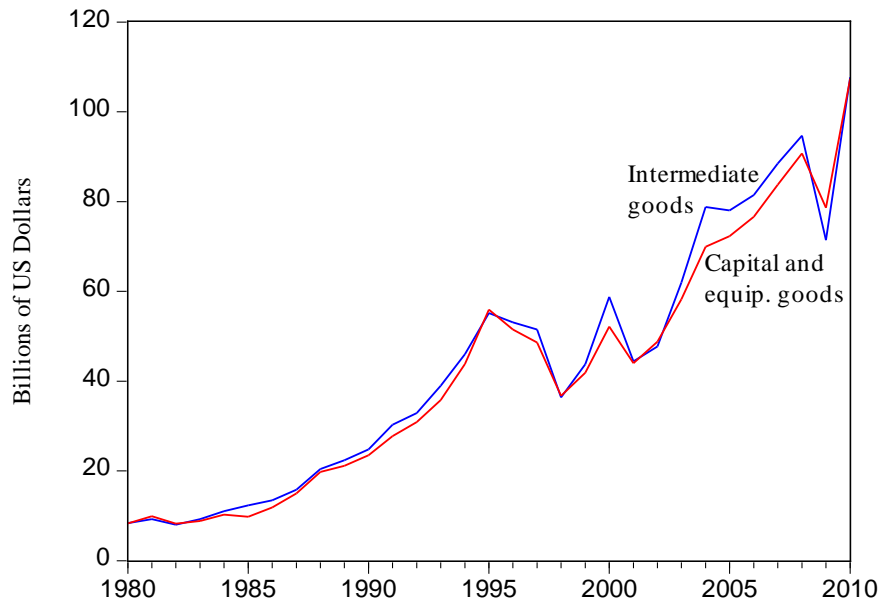
Figure 1a. The value of Japanese capital and equipment goods exports and intermediate goods exports to East Asia.

Note: East Asia includes China, Indonesia, Malaysia, Singapore, South Korea, Taiwan, and Thailand.
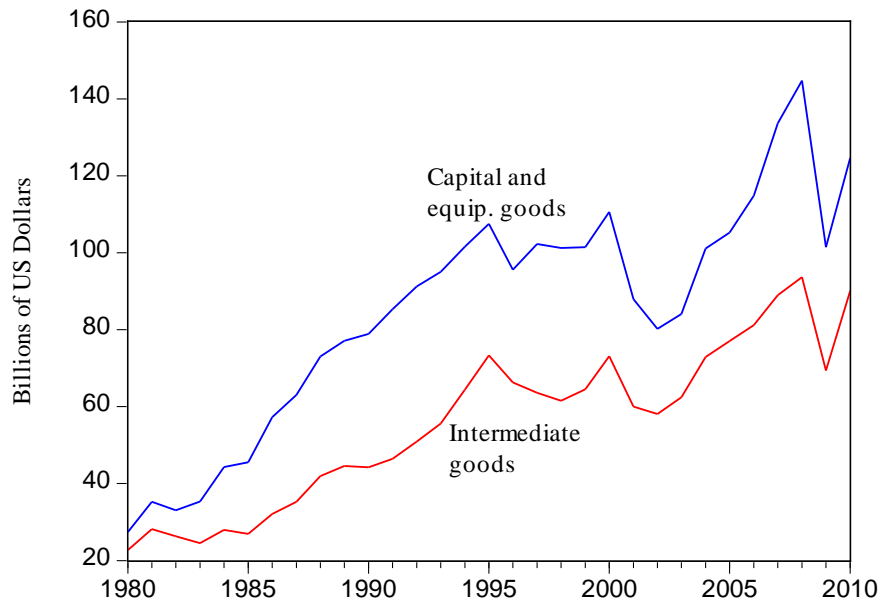
Source: CEPII-Chelem Database

Figure 1b. The value of Japanese capital and equipment goods exports and intermediate goods exports to non-East Asian countries.

Note: Non-East Asian importers include all countries except those listed in Figure 1a.

Source: CEPII-Chelem Database