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Investigating How Exchange Rates Impact Japan's Machinery Exports since 1990

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Abstract: Japan exports sophisticated capital goods. Since the Global Financial Crisis (GFC), Japanese companies have offshored the production of lower-end goods and parts and components to Asian countries. Because of this, several researchers argued that a weaker yen no longer stimulates machinery exports much because an increase in Japanese exports increases parts and components imports from overseas Asian subsidiaries. This paper finds that, after the GFC, a weaker yen no longer increases Japanese machinery exports to Asia but continues to stimulate exports outside of Asia. Thus, the weaker yen since 2020 does not help Asian firms to import vital Japanese capital goods but does increase the profitability of Japanese manufacturers and their exports to non-Asian countries.

Keywords: Japan; capital goods; export volumes

JEL Classification: F14; G10

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1. Introduction

Japan has a comparative advantage in producing machinery and capital goods. It manufactures excavators, machine tools, turbines, robots, machinery to manufacture semiconductors and textiles, and other capital goods. Japan has traditionally played an important role in exporting these goods to downstream Asian countries. Kwan (2004) noted that, if Asian firms are unable to obtain capital goods from Japan, they are frequently unable to obtain them at all.

Japan's machinery exports are sophisticated. Hidalgo and Hausmann (2009) developed a method to measure the sophistication of products. They observed that complex goods require advanced capabilities. These products are more likely to be made by countries with diverse export baskets. They defined an economy's complexity based on its ability to export varied and advanced products. They defined a product's sophistication based on its non-ubiquity. Iterating between measures of an economy's complexity and a product's ubiquity, they calculated product complexity indices (PCIs) for more than 1200 products. Higher PCI values indicate more advanced products.

These PCIs can be used to gauge the complexity of Japan's machinery exports in comparison to the other three leading machinery exporters, the U.S., China, and Germany. Taking a weighted average of Japan's top ten machinery exports in 2021, the average machinery PCI in 2021 equaled 1.53. The values for the U.S., China, and Germany were, respectively, 1.27, 1.02, and 1.10. Thus, Japan's machinery exports are advanced relative to comparable countries. Japan's total export basket has also been rated as the most complex in the world every year between 2000 and 2021.

Are these sophisticated exports sensitive to exchange rates? This question is relevant as the Japanese real effective exchange rate in 2024 is close to its lowest level in 50 years. Abiad et al. (2018) argued that more complex goods are harder to produce and, thus, have fewer substitutes. Because of this, they noted that the price elasticity of demand should be lower for more complex products and, thus, that exports of these goods should be less sensitive to exchange rates.

Baek (2013) employed an autoregressive distributed lag (ARDL) model and quarterly data over the 1991–2010 period to investigate Japan's machinery and transport equipment and other exports to South Korea. The ARDL coefficient indicates that real exchange rates do not impact Japan's exports to Korea in the long run. He explained this finding by noting that, since Korea relies on machinery from Japan, demand does not respond to exchange-rate-driven price changes. Walter et al. (2012) used an ARDL model and quarterly data over the 1989 to 2011 period to investigate Japan's exports of machinery and transportation and other goods to the U.S. They also found that real exchange rates do not impact Japan's machinery and transportation exports to the U.S.

Sato et al. (2013) examined how industry-specific real exchange rates affect Japanese exports of three electrical machinery industries (office machinery, electrical apparatuses, and communication equipment) and of transportation equipment. They employed a monthly vector autoregression (VAR) over the 2001–2013 period and Japan's exports to the world. They reported impulse-response functions indicating that a positive exchange rate shock (yen appreciation) produced long-lasting declines in exports for each category.

Chinn (2013) investigated Japan's exports to the world over the 1990 to 2012 period. His theoretical framework was the imperfect substitutes model, where exports are a function of the real exchange rate and gross domestic product in the importing countries. He used quarterly data and Johansen maximum likelihood techniques. He reported that exchange rate elasticities were correctly signed and varied between 0.4 and 0.7.

Tang (2014) examined trade between Japan, China, Hong Kong, Indonesia, Malaysia, the Philippines, Singapore, South Korea, Taiwan, and Thailand over the 1980–2009 period. His theoretical framework was also the imperfect substitutes model. He used annual data and panel dynamic ordinary least squares estimation (DOLS). For equipment goods exports, he found that the exchange rate coefficient was incorrectly signed.

Thorbecke (2015) investigated Japanese capital and equipment goods exports to 15 countries over the 1982–2009 period. He also used the imperfect substitutes model, annual data, and panel DOLS estimation. Using several specifications, he found that a 10 percent real appreciation of the yen decreases exports by about 5 percent.

The period after 1982 was eventful for the Japanese economy. Between 1981 and 1984, Japan agreed to a voluntary export restraint limiting the number of cars it exported to the U.S. In 1985, to reduce the U.S. trade deficit, Japan, France, West Germany, and the U.K. agreed in the Plaza Accord to let their currencies appreciate against the U.S. dollar. From the time the accord was signed in September 1985 until the middle of 1995, the yen appreciated from 240 to the U.S. dollar to below 88 to the dollar.

Japanese exporters lost price competitiveness. To cut costs, they relocated labor-intensive tasks to factories in the Association of Southeast Asian Nations (ASEAN) and China. The final goods were then exported around the world. Japanese final goods exports fell from 20% of world final goods exports in 1985 to 10% in 1995. Japanese outward foreign direct investment (FDI) increased from 0.5% of Japanese GDP in 1985 to more than 2.5% by the end of the decade. Urata and Kawai (1999) reported that Asia was a dominant recipient of Japanese FDI in the late 1980s and 1990s. Japanese exports of intermediate and capital goods (ICG) to China and ASEAN increased from 28% of Japanese ICG exports in 1985 to 40% in 1995. China and ASEAN's exports of final goods increased from 3% of world final goods exports in 1985 to above 10% in 1995.[1]

Bayoumi and Lipworth (1998) provided formal evidence on the determinants of Japanese FDI over the 1983–1995 period. In addition to examining the impact of the real exchange rate, they also investigated whether the motive for FDI was to use foreign subsidiaries to complement Japanese production or whether it was to supply the host country market. In the first case, FDI to a country should be related to capital formation in Japan since production in the two locations are complements. In the second case, FDI to a country should be related to capital formation in the host country since domestic and foreign firms in the host country both respond to host country market conditions. The authors reported that an appreciation of the yen increased FDI flows and that FDI flows were closely related to capital formation in Japan but not in the host country. These findings imply that the motive for Japanese FDI was vertical integration, where subsidiaries in other countries became part of the production process.

Yoshitomi (2007) described the trade that accompanies this vertical FDI as vertical intra-industry trade (VIIT). VIIT differs from trade in final goods modeled in traditional trade theory (e.g., wealthy economies exporting capital goods and developing economies exporting apparel). VIIT also differs from horizontal intra-industry trade between two wealthy nations (e.g., trade in two different types of automobiles). Under VIIT, firms slice the value chain across developed, emerging, and developing countries based on the comparative advantage. Each region's comparative advantage is determined by its endowment of capital and skilled and unskilled labor and by its physical and institutional infrastructure. For instance, a Japanese company might relocate lower-skilled tasks to lower-wage locations and perform complex tasks at higher-wage locations.

Thorbecke (2008) investigated how an appreciation of the yen relative to the U.S. dollar impacted Japanese total exports to the U.S. and Japanese exports of intermediate goods to East Asia over the 1982–2003 period. The results indicated that a 10% appreciation of the yen/dollar real exchange rate reduced Japanese exports to the U.S. by 4% and increased Japanese intermediate goods exports to East Asia by 8%. These findings imply that Japan reduced exports directly to the U.S. in response to yen appreciations but also provided more parts and components to downstream factories in Asia. These factories then exported the final goods to the U.S., Japan, and other countries. Thus, the yen appreciation furthered the division of labor in Asia, with Japan producing and exporting technology-intensive parts and components to downstream Asian countries where the final goods were assembled and re-exported.

Sasaki et al. (2022) observed that, when the yen appreciated during the 2008–2009 Global Financial Crisis (GFC), Japanese multinational corporations (MNCs) continued to relocate manufacturing overseas. This helped to offset the loss of price competitiveness from the appreciating yen, Then, as the yen began depreciating in 2012, Japanese firms did not reshore production but continued to produce abroad.

Shimizu and Sato (2015) noted that Japanese firms responded to the strong yen during the GFC by expanding the production of low-end products abroad and producing high-end products domestically. They employed Kalman filter methods to investigate the exchange rate pass-through to major machinery industries. Using monthly data from 1980 to 2014, they found that, when the yen was strong between 2009 and 2012, the degree of pass-through increased. They also reported that, as the yen weakened after 2012, firms chose to price to market rather than to pass-through depreciations into foreign prices. Keeping foreign currency prices stable rather than letting them fall as the yen depreciated reduced the stimulative impact of the depreciation on export volumes.

Shimizu and Sato (2015) also examined the relationship between the yen real effective exchange rate, industrial production in Japan and its trading partners, and the Japanese trade balance. Using an ARDL model and monthly data, they found evidence of a J-curve effect over the 1985–1998 period but not over the 1999–2014 period. They noted that, for several decades, Japanese firms had been increasing overseas production. Their production networks were centered in Asian countries. As the yen appreciated during the GFC, these firms accelerated the division of labor by relocating more production to Asia. Because of this, Sato and Shimizu noted that a weaker yen no longer stimulates machinery exports as much because an increase in exports increases the imports of parts and components from overseas subsidiaries in Asia.

If the production of parts and components has been relocated to Asian countries, then the yen exchange rate would have less of an impact on Japanese exports to these countries. A depreciation of the yen against the currency of an Asian country providing parts and components to Japan would increase the yen costs of these imported inputs. This increase in costs would mitigate the increase in price competitiveness arising from the impact of a weaker yen on Japanese value-added exported back to this country. Thus, if Japan has offshored more production to Asian countries after the GFC, a yen depreciation against an Asian country's currency would have less of a stimulative effect on exports to that country after 2009.

This paper investigates whether the influence of exchange rates on Japan's machinery exports has declined since the GFC. It also investigates whether the exchange rate mattered less for exports to Asian countries after the 2008–2009 GFC. To do this, it extends the model of Thorbecke (2015) to include the 2010–2020 period. The results indicate that, for the lion's share of machinery exports, exchange rates no longer matter for Japan's exports to Asian countries but do matter for Japan's exports to non-Asian countries. The weak yen after the COVID-19 pandemic thus will not help companies in Asian countries purchase vital capital goods from Japan but will benefit companies in other regions.

The next section discusses the data and methodology. Section 3 presents the results. Section 4 concludes.

2. Data and Methodology

To estimate export elasticities, Thorbecke's (2015) model is extended using recent data. Employing the imperfect substitutes model, he examined Japanese machinery exports to 15 countries over the 1982–2009 period. This paper also uses the imperfect substitutes model to guide the empirical specification, following Chinn (2013), Tang (2014), and many other researchers. The imperfect substitutes model posits that exports depend on the real exchange rate between the exporting and importing countries and on GDP in the importing countries. The same 15 countries that Thorbecke used are employed here and the sample period is extended to 2020.[2]

Following Chinn (2004) and other researchers, the model is treated as a semi-reduced form. Exchange rates are volatile and often have a life of their own (see, e.g., Obstfeld and Rogoff 2000). Thus, Chinn and others give a structural interpretation to the estimated exchange rate elasticities. This paper follows them.

Annual data on Japanese machinery and equipment exports are measured in U.S. dollars and obtained from the CEPII-CHELEM database. These are deflated using the U.S. Bureau of Labor Statistics deflator for Japanese exports. The results are almost identical when Japanese exports are deflated using the Bank of Japan's export price index for machinery exports converted to U.S. dollars using the yen/dollar exchange rate. Data on bilateral real exchange rates between Japan and the importing countries and on real GDP in the importing countries are also obtained from the CEPII-CHELEM database.

The CEPII-CHELEM database also disaggregates machinery and equipment exports into 12 categories. These are aeronautics, agricultural equipment, commercial vehicles, computer equipment, construction equipment, electrical apparatuses, electrical equipment, machine tools, precision instruments, ships, specialized machines, and telecommunications equipment. Exchange rate elasticities are also estimated for each of these subcategories.

Thorbecke (2015) estimated the relationship between machinery and equipment exports, real exchange rates, and GDP using panel DOLS. This technique is appropriate when the variables have unit roots and when there is a cointegrating relationship between the variables. Table 1 presents the results from a series of panel unit root tests for these variables. The results do not permit rejection of the null hypothesis of a unit root for real GDP. The results do, however, permit rejection of the maintained hypothesis of a unit root for real exchange rates and for most categories of machinery and equipment exports. The model, thus, cannot be estimated by panel DOLS. It is estimated instead with fixed effect estimation with real GDP included in first difference form and with the other variables included in levels. Both period and cross-sectional fixed effects are also included in the estimation.

Table 1. Panel Unit Root Tests.

Unit Root Test	**Real GDP**		**Real Exchange Rate**		**Machinery Exports**	
	Test Statistic	**Test Statistic**	**Test Statistic**	***p*-Value**	**Test Statistic**	***p*-Value**
Levin, Lin, and Chu t *	3.84	0.999	−5.31	0.000	−5.04	0.000
Breitung t-stat	6.83	1.000	−4.59	0.000	−0.744	0.228
Im, Pesaran, and Shin W-stat	5.23	1.000	−4.61	0.000	−3.61	0.000
Augmented Dickey–Fuller Fisher Chi-square	14.24	0.993	69.74	0.000	59.30	0.001
Phillips–Perron Fisher Chi-square	15.48	0.987	48.28	0.019	46.25	0.029
Unit Root Test	Electrical Apparatuses		Specialized Machinery		Precision Instruments	
	Test Statistic	*p*-value	Test Statistic	*p*-value	Test Statistic	*p*-value
Levin, Lin, and Chu t *	−4.15	0.000	−7.01	0.000	−1.48	0.068
Breitung t-stat	1.56	0.940	−4.91	0.000	1.55	0.939
Im, Pesaran, and Shin W-stat	−2.62	0.004	−4.77	0.000	−0.485	0.314
Augmented Dickey–Fuller Fisher Chi-square	54.13	0.004	70.50	0.000	38.03	0.149
Phillips–Perron Fisher Chi-square	61.75	0.001	69.61	0.000	41.96	0.072
Unit Root Test	Construction Equipment		Computer Equipment		Ships	
	Test Statistic	*p*-value	Test Statistic	*p*-value	Test Statistic	*p*-value
Levin, Lin, and Chu t *	−3.18	0.001	−3.05	0.001	−10.99	0.000
Breitung t-stat	−2.89	0.002	−0.744	1.000	−6.19	0.000
Im, Pesaran, and Shin W-stat	−2.38	0.009	−1.74	0.041	−9.30	0.000
Augmented Dickey–Fuller Fisher Chi-square	45.22	0.037	44.25	0.045	136.06	0.000
Phillips–Perron Fisher Chi-square	39.09	0.124	289.47	0.000	135.84	0.000
Unit Root Test	Machine Tools		Electrical Equipment		Commercial Vehicles	
	Test Statistic	*p*-value	Test Statistic	*p*-value	Test Statistic	*p*-value
Levin, Lin, and Chu t *	−6.04	0.000	−2.60	0.005	−4.59	0.000
Breitung t-stat	−2.00	0.023	−2.52	0.006	−3.49	0.000
Im, Pesaran, and Shin W-stat	−4.34	0.000	−3.54	0.000	−4.79	0.000
Augmented Dickey–Fuller Fisher Chi-square	71.13	0.000	64.34	0.000	74.49	0.000
Phillips–Perron Fisher Chi-square	58.45	0.014	57.96	0.002	66.64	0.000
Unit Root Test	Telecommunications Equipment		Aeronautics		Agricultural Equipment	
	Test Statistic	*p*-value	Test Statistic	*p*-value	Test Statistic	*p*-value
Levin, Lin, and Chu t *	0.14	0.557	−4.09	0.000	−0.80	0.212
Breitung t-stat	2.21	0.986	−0.96	0.162	−0.53	0.299
Im, Pesaran, and Shin W-stat	1.18	0.880	−5.97	0.000	−1.10	0.136
Augmented Dickey–Fuller Fisher Chi-square	25.87	0.682	97.10	0.000	45.06	0.038
Phillips–Perron Fisher Chi-square	26.73	0.638	104.35	0.000	35.20	0.236

Notes: The table presents test statistics for panel unit root tests of the null hypothesis of a unit root. The tests are discussed in Levin et al. (2002), Breitung (2000), Im et al. (2003), Maddala and Wu (1999), and Choi (2001). In each case, lag lengths are selected based on the Schwarz Information Criterion. A trend term is included in the test equations. *p*-value represents the probability value for the test of the maintained hypothesis of a unit root.

3. Results

Table 2 examines whether exchange rate changes impact export volumes. The table presents the results of estimating exchange rate elasticities for all machinery exports and for the 12 subcategories. Column (2) lists the share of each subcomponent in total machinery exports in 2020. Column (3) presents the results for the entire 1990–2020 sample period. The exchange rate matters for Japanese machinery exports. A 10% yen appreciation reduces exports by 7.6%. For the individual subcategories, 9 of the 12 categories exhibit statistically significant export declines in response to yen appreciations. Only the exchange rate coefficient on ship exports is incorrectly signed. Table A1 in the Appendix A presents the corresponding GDP elasticities.

Table 2. Panel ordinary least squares estimates of exchange rate elasticities for Japan's machinery exports to 15 countries (with standard errors in parentheses).

Export Category	**Share of Machinery Exports in 2020**	**Sample Period**			
		1990–2020	**1990–2000**	**2000–2010**	**2010–2020**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Machinery (All)	1.00	−0.764 ***	−0.577 ***	−0.601 ***	−0.274
		(0.115)	(0.176)	(0.120)	(0.171)
Electrical apparatuses	0.227	−0.660 ***	−0.665 ***	−0.215	0.354
		(0.146)	(0.191)	(0.174)	(0.279)
Specialized machines	0.206	−0.455 **	−0.745 ***	−0.283	0.387
		(0.207)	(0.214)	(0.213)	(0.460)
Precision instruments	0.142	−1.427 ***	−0.930 ***	−1.268 ***	−1.057 ***
		(0.170)	(0.155)	(0.217)	(0.396)
Construction equipment	0.075	−1.400 ***	−1.204 ***	−1.929 ***	−0.465
		(0.139)	(0.363)	(0.339)	(0.432)
Computer equipment	0.059	−1.871 ***	0.361	−1.541 ***	0.441
		(0.173)	(0.336)	(0.258)	(0.535)
Ships	0.052	0.955 **	−1.220	1.120	1.878
		(0.400)	(1.045)	(0.790)	(1.567)
Machine tools	0.052	−0.965 ***	−0.689 ***	−0.836 ***	1.717 *
		(0.180)	(0.257)	(0.232)	(0.906)
Electrical equipment	0.050	−0.429 ***	0.070	−0.531 **	−0.958 **
		(0.148)	(0.413)	(0.219)	(0.440)
Commercial vehicles	0.049	−0.904 ***	−2.286 ***	−0.966 **	0.522
		(0.251)	(0.608)	(0.396)	(0.756)
Telecommunications equipment	0.045	−0.329	0.896	0.698	−1.921 ***
		(0.311)	(0.807)	(0.574)	(0.422)
Aeronautics	0.032	−0.205	−0.900	0.162	−2.026 ***
		(0.341)	(0.644)	(0.597)	(0.739)
Agricultural equipment	0.010	−1.01 ***	−1.261 ***	−0.377	−1.170 **
		(0.191)	(0.473)	(0.292)	(0.564)

Notes: The table presents estimates of exchange rate elasticities from a panel ordinary least squares model of Japan's exports to 15 countries. Exports are measured in U.S. dollars and deflated using price deflators for Japanese exports obtained from the U.S. Bureau of Labor Statistics. The explanatory variables include the bilateral CPI-deflated real exchange rate between Japan and each of the importing countries and the first difference of real GDP in the importing countries. The 15 importing countries are Australia, Canada, China, France, Germany, Hong Kong, Indonesia, Malaysia, the Netherlands, Singapore, South Korea, Taiwan, Thailand, the U.K., and the U.S. Country and year fixed effects are included in the estimation. White standard errors are reported in parentheses. *** (**) [*] denotes significance at the 1% (5%) [10%] level.

The results for the 1990–2000 subsample in column (4) and the 2000–2010 subsample in column (5) also indicate that appreciations reduce exports. For total machinery exports, a 10% appreciation reduces exports by about 6% in both subsample periods. Many of the individual subcategories also exhibit decreases in exports in response to appreciations.

The results for the 2010–2020 subsample in column (6) no longer present strong evidence that appreciations reduce machinery exports. The exchange rate coefficient for total machinery exports is small and not statistically significant. For most of the large subcategories, exchange rate depreciations no longer increase exports.

The fact that exchange rates do not impact specialized machinery exports after 2000 is consistent with Baek's (2013) observation that downstream countries such as South Korea depend on machinery exports from Japan. Japan exports robots, semiconductor manufacturing machines, and other advanced machinery. As discussed in the introduction, according to Hidalgo and Hausmann's measure, Japan has the most sophisticated export basket, and specialized machinery exports are especially advanced. Abiad et al. (2018) noted that there are few substitutes for complex goods, and, thus, that their exchange rate elasticities should be small.

Commercial vehicle exports also ceased to respond to exchange rate changes after 2010. Nguyen and Sato (2019) found that Japanese transportation equipment exporters responded to yen depreciations during the depreciation that began in 2012 by pricing to market. This meant that, rather than lowering prices in the importing country's currency, they chose to keep foreign prices close to constant. Thus, they chose not to increase export volumes as the yen depreciated, but rather to increase profit margins.

Telecommunications equipment was very sensitive to exchange rates over the 2010–2020 period. Before the GFC, Japan was a leading producer of cellphones. However, as Sato et al. (2013) discussed, the sharp appreciation of the yen that started with the GFC combined with the sharp depreciation of the Korean won caused Japan's communication equipment exports to plummet and Korean communications exports to soar. Thorbecke (2023) reported that, by 2012, Samsung of Korea had become the largest phone manufacturer by sales. It continued to hold this position up to 2022.

Table 3 presents exchange rate elasticities separately for Asian and non-Asian countries.

Focusing on the 2010–2020 period, column (8) reports elasticities for Asian countries and column (9) for non-Asian countries. Column (8) for Asian countries continues to indicate that exchange rate depreciations do not stimulate exports for most categories. The coefficient for total machinery exports is small and statistically insignificant. Coefficients for 6 of the 12 subcategories are positive (incorrectly signed), with the coefficient on electrical apparatuses being positive and having a probability value of 0.055 and the coefficient on machine tools being positive and having a probability value of 0.035.

Column (9) for non-Asian countries, on the other hand, indicates that depreciations stimulate machinery exports. For total machinery exports, a 10% depreciation increases exports to non-Asian countries by almost 6%. There is also a statistically significant relationship between exchange rate depreciations and rising exports for 5 of the 12 subcategories. The results in columns (8) and (9) are consistent with Shimizu and Sato's (2015) hypothesis that the relocation of production to Asian countries has weakened the link between exchange rate depreciations and Japanese machinery exports to Asia.

Another factor driving the results in Table 3 is the surge in FDI that Shimizu and Sato (2015) reported as Japanese MNCs intensified the slicing up of the value chain to Asian countries after the GFC. Bayoumi and Lipworth (1998) found that a yen appreciation increases Japanese FDI. They also noted that increases in Japanese FDI to a country are accompanied by increases in Japanese capital goods exports as part of the initial investment. Thus, an appreciation of the yen can be associated with an increase in capital goods exports associated with the Japanese investment. Exports to Asia of categories that are clearly not related to equipping factories in Asia (e.g., aeronautics, agricultural equipment, and telecommunications equipment) responded as expected to exchange rate changes over the 2010–2020 period. Sectors that may be related to constructing and equipping factories in downstream Asian countries (e.g., specialized machinery, computer equipment, construction equipment, and machine tools) no longer respond as expected to exchange rate changes.

Table 3. Panel Ordinary Least Squares Estimates of Exchange Rate Elasticities for Japan's Machinery Exports to Asian and Non-Asian Countries (with Standard Errors in Parentheses).

Export Category	Sample Period:							
	1990–2020		1990–2000		2000–2010		2010–2020	
	Exports to:							
	Asian Countries	Non-Asian Countries	Asian Countries	Non-Asian Countries	Asian Countries	Non-Asian Countries	Asian Countries	Non-Asian Countries
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Machinery (All)	−0.953 ***	−0.295 ***	−0.350	−0.860 ***	−0.792 ***	−0.410 ***	−0.201	−0.583 ***
	(0.117)	(0.097)	(0.022)	(0.177)	(0.144)	(0.134)	(0.171)	(0.187)
Electrical apparatuses	−0.887 ***	−0.095	−0.388	−0.101 ***	−0.527 ***	0.098	0.515*	−0.329
	(0.149)	(0.117)	(0.244)	(0.211)	(0.201)	(0.190)	(0.266)	(0.263)
Specialized machines	−0.633 ***	−0.009	−0.630 **	−0.889 ***	0.402	−0.164	0.478	0.085
	(0.204)	(0.208)	(0.293)	(0.290)	(0.360)	(0.269)	(0.502)	(0.355)
Precision instruments	−1.627 ***	−0.930 ***	−0.750 ***	−1.154 ***	−1.534 ***	−1.000 ***	−1.113 ***	−0.770 **
	(0.167)	(0.103)	(0.190)	(0.203)	(0.258)	(0.196)	(0.422)	(0.370)
Construction equipment	−1.166 ***	−1.971 ***	−1.526 ***	−0.803 **	−2.160 ***	−1.699 ***	−0.158	−1.774 ***
	(0.141)	(0.159)	(0.508)	(0.372)	(0.371)	(0.339)	(0.437)	(0.420)
Computer Equipment	−2.273 ***	−0.822 ***	0.798	−0.188	−1.619 ***	−1.463 ***	0.343	0.764
	(0.186)	(0.179)	(0.405)	(0.344)	(0.310)	(0.269)	(0.593)	(0.459)
Ships	0.338	2.495 ***	−1.702	−0.613	−0.010	2.252 **	1.589	3.123
	(0.440)	(0.538)	(1.214)	(1.425)	(0.726)	1.100	(1.528)	(2.395)
Machine Tools	−1.059 ***	−0.733 ***	−0.477	−0.954 ***	−1.049 ***	−0.622 ***	2.050 **	0.726
	(0.186)	(0.222)	(0.377)	(0.262)	(0.262)	(0.265)	(0.961)	(0.827)
Electrical equipment	−0.392 **	−0.527 ***	0.496	−0.461	−0.745 ***	−0.348	−0.822 *	−1.316 **
	0.159	(0.194)	(0.479)	(0.417)	(0.238)	(0.238)	(0.450)	(0.506)
Commercial Vehicles	−1.087 ***	−0.450*	−2.256 ***	−2.323 ***	−1.374 ***	−0.557	0.943	−1.266
	(0.285)	(0.262)	(0.777)	(0.684)	(0.430)	(0.414)	(0.756)	(0.992)
Telecomm-unications equipment	−0.442	−0.047	1.808 *	−0.241	1.083	0.313	−2.132 ***	−1.024 **
	(0.314)	(0.338)	(0.992)	(0.684)	(0.609)	(0.577)	(0.443)	(0.394)
Aeronautics	−0.437	0.373	−0.763	−1.070	0.320	0.004	−2.196 ***	−1.301
	(0.358)	(0.403)	(0.801)	(0.852)	(0.800)	(0.393)	(0.732)	(0.971)
Agricultural equipment	−0.965 ***	−1.128 ***	−1.633 **	−0.798 *	−0.827 *	0.075	−1.117 *	−1.395 **
	(0.223)	(0.209)	(0.642)	(0.472)	(0.432)	(0.302)	(0.595)	(0.597)

Notes: The table presents estimates of exchange rate elasticities from a panel ordinary least squares model of Japan's exports to 15 countries. Exports are measured in U.S. dollars and deflated using price deflators for Japanese exports obtained from the U.S. Bureau of Labor Statistics. The explanatory variables include the bilateral CPI-deflated real exchange rate between Japan and each of the importing countries and the first difference of real GDP in the importing countries. Asian countries include China, Hong Kong, Indonesia, Malaysia, Singapore, South Korea, Taiwan, and Thailand. Non-Asian countries include Australia, Canada, France, Germany, the Netherlands, the U.K., and the U.S. Country and year fixed effects are included in the estimation. White standard errors are reported in parentheses. *** (**) [*] denotes significance at the 1% (5%) [10%] level.

4. Conclusions

Japan plays a vital role in global supply chains, exporting sophisticated capital goods to Asia and the rest of the world. The Japanese yen also began depreciating at the end of 2020, and, in 2024, it is close to its weakest level in 50 years. This paper investigates how the yen exchange rate impacts Japan's machinery exports.

Shimizu and Sato (2015) observed that, as the yen appreciated during the GFC, Japanese firms relocated production to Asia. If the production of parts and components has been relocated to Asian countries, then the yen exchange rate would have less of an impact on Japanese exports to these countries.

This paper finds that, after the GFC, the yen exchange rate does not impact Japan's machinery exports to Asian countries but does impact these exports to non-Asian countries. The weak yen since 2020, thus, may not benefit companies in Asian countries that depend on Japanese capital goods. It will benefit many Japanese machinery companies, however, by increasing their exports to non-Asian countries.

Japanese specialized machinery exports are no longer sensitive to exchange rates. This confirms what authors such as Abiad et al. (2018), Baek (2013), and others reported, that vital exports with few substitutes should have low price elasticities. Commercial vehicle exports are no longer sensitive to exchange rates after 2010. This is what one would suspect given Nguyen and Sato's (2019) finding that Japanese transportation equipment exporters responded to yen depreciations beginning in 2012 by pricing to market. By not lowering foreign currency prices as the yen weakened, exporters chose to increase profit margins rather than export volumes. Telecommunications equipment was very sensitive to exchange rates over the 2010–2020 period. Sato et al. (2013), Thorbecke (2023), and others reported that the yen appreciation and Korean won depreciation that started during the GFC caused Japanese communications equipment exports to plummet and Korean communication equipment exports to soar.

The yen appreciation during and after the GFC led to a surge of Japanese FDI to Asian countries. Japanese FDI to a country is often accompanied by Japanese capital goods exports to the country. The strong yen that led to more FDI to Asia would also increase Japanese exports of goods to build and equip factories. Sectors related to constructing and equipping factories in downstream Asian countries such as specialized machinery, computer equipment, construction equipment, and machine tools may have increased to accompany FDI to Asia as the yen appreciated. This might explain why the coefficients on machine tools and electrical apparatuses to Asia took on the wrong sign after 2010. Exports to Asia that are not related to equipping new factories such as telecommunications equipment, aeronautics, and agricultural equipment continued to respond as expected to exchange rate changes after 2010.

Ito et al. (2023) found that Japan has moved upstream in global value chains. This involves exporting not only capital goods to firms in downstream countries but also exporting parts and components. This paper has investigated the changing impact of exchange rates on Japanese capital goods exports. Future research should investigate how exchange rates impact Japanese exports of parts and components and other intermediate inputs. Thorbecke (2008) found that, during the surge of Japanese FDI to Asia after the Plaza Accord, Japanese parts and components exports to Asia continued to respond as expected to exchange rate changes. It would be interesting to investigate if this is also the case during the surge in Japanese FDI after the GFC. Future research should also investigate whether the knowledge spillovers from Japanese exports to downstream firms outside of Asia is comparable to the knowledge diffusion from Japanese exports to Asia. Finally, it should investigate the extent to which Japanese machinery exporters compete with firms in other countries that produce similar goods and the extent to which they co-operate by providing vital inputs.

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Appendix A. GDP Elasticities for Japan's Machinery Exports to 15 Countries

Table A1. Panel ordinary least squares estimates of GDP elasticities for Japan's machinery exports to 15 countries (with standard errors in parentheses).

Export Category	**Share of Machinery Exports in 2020**	**Sample Period**			
		1990–2020	**1990–2000**	**2000–2010**	**2010–2020**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Machinery (All)	1.00	1.855 **	2.131 ***	2.988 ***	3.091
		(0.746)	(0.644)	(0.922)	(0.669)
Electrical apparatuses	0.227	1.435	0.706	3.026 **	2.425 **
		(0.877)	(0.702)	(1.381)	(1.078)
Specialized machines	0.206	2.881 ***	3.820 ***	4.107 ***	5.102 ***
		(1.124)	(0.758)	(1.445)	(1.319)
Precision instruments	0.142	0.895	0.679	4.475 ***	2.064 *
		(0.861)	(0.546)	(1.157)	(1.229)
Construction equipment	0.075	6.679 ***	7.262 ***	2.022	8.051 ***
		(1.129)	(1.299)	(1.903)	(2.128)
Computer equipment	0.059	0.238	0.082	3.830 **	3.299 ***
		(1.221)	(1.021)	(1.470)	(0.535)
Ships	0.052	1.322	−5.425	7.386	13.409 *
		(3.287)	(3.320)	(4.632)	(7.105)
Machine tools	0.052	4.266 ***	3.827 ***	4.475 **	6.831 ***
		(1.194)	(0.987)	(1.806)	(2.560)
Electrical equipment	0.050	1.652	1.391	1.354	0.717
		(1.053)	(1.072)	(1.357)	(1.436)
Commercial vehicles	0.049	5.599 ***	4.766 **	3.433	3.067
		(1.594)	(2.078)	(3.253)	(2.560)
Telecommunications equipment	0.045	−1.485	0.061	0.801	−0.213
		(1.503)	(1.573)	(2.584)	(1.762)
Aeronautics	0.032	4.867 **	6.720 **	1.610	−2.197
		(1.999)	(2.704)	(3.953)	(3.706)
Agricultural equipment	0.010	4.178 ***	3.376 **	−4.690 *	7.663 ***
		(1.602)	(1.543)	(2.661)	(2.001)

Notes: The table presents estimates of GDP elasticities from a panel ordinary least squares model of Japan's exports to 15 countries. Exports are measured in U.S. dollars and deflated using price deflators for Japanese exports obtained from the U.S. Bureau of Labor Statistics. The explanatory variables include the bilateral CPI-deflated real exchange rate between Japan and each of the importing countries and the first difference of real GDP in the importing countries. The 15 importing countries are: Australia, Canada, China, France, Germany, Hong Kong, Indonesia, Malaysia, the Netherlands, Singapore, South Korea, Taiwan, Thailand, the U.K., and the U.S. Country and year fixed effects are included in the estimation. White standard errors are reported in parentheses. *** (**) [*] denotes significance at the 1% (5%) [10%] level.

Notes

[1] These data come from Thorbecke (2008) and Bayoumi and Lipworth (1998).

[2] These countries are Australia, Canada, China, France, Germany, Hong Kong, Indonesia, Malaysia, the Netherlands, Singapore, South Korea, Taiwan, Thailand, the United Kingdom, and the United States.

References

Abiad, Abdul, Kristina Baris, John Arvin Bernabe, Donald Jay Bertulfo, Sheila Camingue, Paul Neilmer Feliciano, Mahinthan Mariasingham, and Valerie Mercer-Blackman. 2018. *The Impact of Trade Conflict on Developing Asia*. (ADB Economic Working Paper No. 566). Manila: Asian Development Bank.

Baek, Jungho. 2013. Does the Exchange Rate Matter to Bilateral Trade between Korea and Japan? Evidence from Commodity Trade Data. *Economic Modelling* 30: 856–62. [CrossRef]

Bayoumi, Tamim, and Gabrielle Lipworth. 1998. Japanese Foreign Direct Investment and Regional Trade. *Journal of Asian Economics* 9: 581–607. [CrossRef]

Breitung, Jörg. 2000. The Local Power of Some Unit Root Tests for Panel Data. In *Advances in Econometrics, Vol. 15: Nonstationary Panels, Panel Cointegration, and Dynamic Panels*. Edited by Badi Baltagi. Amsterdam: JAI Press.

Chinn, Menzie D. 2004. Incomes, Exchange Rates and the U.S. Trade Deficit, Once Again. *International Finance* 7: 451–69. [CrossRef]

Chinn, Menzie D. 2013. *Export and Import Elasticities for Japan: New Estimates*. (La Follette School Working Paper No. 2013–004). Madison: La Follette School of Public Affairs.

Choi, In. 2001. Unit Root Tests for Panel Data. *Journal of International Money and Finance* 20: 249–72. [CrossRef]

Hidalgo, César A., and Ricardo Hausmann. 2009. The Building Blocks of Economic Complexity. *Proceedings of the National Academy of Sciences of the United States of America* 106: 10570–75. [CrossRef] [PubMed]

Im, Kyung So, M. Hashem Pesaran, and Yongcheol Shin. 2003. Testing for Unit Roots in Heterogeneous Panels. *Journal of Econometrics* 115: 53–74. [CrossRef]

Ito, Keiko, Kenta Ikeuchi, Chiara Criscuolo, Jonathan Timmis, and Antonin Bergeaud. 2023. Global Value Chains and Domestic Innovation. *Research Policy* 52: 104699. [CrossRef]

Kwan, Chi Hung. 2004. *Japan's Exports to China Increasing Not Despite but Because of the Yen's Appreciation*. (China in Transition Working Paper). Tokyo: Research Institute of Economy, Trade and Industry.

Levin, Andrew, Chien-Fu Lin, and Chia-Shang James Chu. 2002. Unit Root Tests in Panel Data: Asymptotic and Finite-sample Properties. *Journal of Econometrics* 108: 1–24. [CrossRef]

Maddala, Gangadharrao S., and Shaowen Wu. 1999. A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test. *Oxford Bulletin of Economics and Statistics* 61: 631–52. [CrossRef]

Nguyen, Thi-Ngoc Anh, and Kiyotaka Sato. 2019. Firm Predicted Exchange Rates and Nonlinearities in Pricing-to-market. *Journal of the Japanese and International Economies* 53: 1–16. [CrossRef]

Obstfeld, Maurice, and Kenneth Rogoff. 2000. Perspectives on OECD Economic Integration: Implications for U.S. Current Account Adjustment. In *Global Economic Integration: Opportunities and Challenges*. Kansas City: Federal Reserve Bank of Kansas City.

Sasaki, Yuri, Yushi Yoshida, and Piotr Kansho Otsubo. 2022. Exchange Rate Pass-through to Japanese Prices: Import Prices, Producer Prices, and the Core CPI. *Journal of International Money and Finance* 123: 102599. [CrossRef]

Sato, Kiyotaka, Junko Shimizu, Nagendra Shrestha, and Shajuan Zhang. 2013. Industry-specific Real Effective Exchange Rates and Export Price Competitiveness: The Case of Japan, China and Korea. *Asian Economic Policy Review* 8: 298–321. [CrossRef]

Shimizu, Junko, and Kiyotaka Sato. 2015. *Abenomics, Yen Depreciation, Trade Deficit, and Export Competitiveness*. (RIETI Discussion Paper Series 15-E-020). Tokyo: Research Institute of Economy, Trade and Industry.

Tang, Hsiao Chink. 2014. Exchange Rate Volatility and Intra-Asian Trade: Evidence by Type of Goods. *The World Economy* 37: 335–52. [CrossRef]

Thorbecke, Willem. 2008. Global Imbalances, Triangular Trading Patterns, and the Yen/dollar exchange rate. *Journal of the Japanese and International Economies* 22: 503–17. [CrossRef]

Thorbecke, Willem. 2015. Understanding Japan's Capital Goods Exports. *The Japanese Economic Review* 66: 536–49. [CrossRef]

Thorbecke, Willem. 2023. *The East Asian Electronics Sector: The Roles of Exchange Rates, Technology Transfer, and Global Value Chains*. Cambridge: Cambridge University Press.

Urata, Shujiro, and Hiroki Kawai. 1999. The Determinants of the Location of Foreign Direct Investment by Japanese Small and Medium-sized Enterprises. *Keizai Bunseki* 158: 1–40.

Walter, Jason, Jungho Baek, and Won W. Koo. 2012. International Trade and Macroeconomic Dynamics: The Case of U.S. Bilateral Trade with G-7 Countries. *Research in Economics* 66: 398–405. [CrossRef]

Yoshitomi, Masaru. 2007. Global Imbalances and East Asian Monetary Cooperation. In *Toward and East Asian Exchange Rate Regime*. Edited by Duck-Koo Chung and Barry Eichengreen. Washington, DC: Brookings Institution Press.

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