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Investigating How Exchange Rates Affected the Japanese Economy after the Advent of Abenomics[1]

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Abstract

News of aggressive monetary easing by the Bank of Japan in late 2012 contributed to a 45 percent depreciation of the Japanese yen relative to the U.S. dollar. This paper investigates how the depreciation affected the Japanese economy. Exports responded much less than predicted, especially for sectors related to transportation equipment. Imports also responded less than predicted, and the sum of export and import elasticities are too small to meet the Marshall-Lerner condition. The depreciation raised returns for many Japanese stocks, with the response being largest for automobile stocks. The depreciation also raised aggregate Japanese stock returns by twice as much after 2013 as before. This indicates that responses that corporate Japan made to swings in the yen such as transferring production abroad have been good for profitability.

Keywords: Japan, Abenomics, Trade elasticities, Exchange rate exposures

JEL classification: F14, G10

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1. Introduction

Shinzo Abe became Japanese prime minister at the end of 2012 and unveiled an economic program known as Abenomics. One pillar of this program called on the Bank of Japan to print unlimited quantities of yen to reach its inflation target (Keohane, 2012). The Japanese yen subsequently depreciated by 45% against the U.S. dollar (see Figure 1). How did changes in the yen during this period affect the Japanese economy?

The Japanese yen had appreciated by almost 50% against the U.S. dollar between the middle of 2007 and the beginning of 2012. Sato and Shimizu (2015) noted that Japanese firms may have responded to the soaring yen by transferring production of low-value added products to subsidiaries abroad and by producing only differentiated and high-value-added products in Japan. The depreciation of the yen starting in 2012 may then have impacted Japanese firms differently after firms had taken these steps than it would have before. If Japanese firms exported higher-value added products after 2012, their pricing behavior could have changed (Sato and Shimizu, 2015). These differentiated products may be more competitive abroad, and Japanese firms may have had greater ability to price-to-market (i.e., keep foreign currency prices constant) when the yen depreciated. In this case, their profit margins rather than their export volumes would increase. In addition, repatriated earnings from outsourced production would be worth more in yen terms when the yen depreciated and this would increase the profitability of Japanese firms.

Japanese firms do not only compete with foreign firms but also cooperate with them by purchasing parts and components, primary goods, and capital goods from abroad. When the yen depreciates, Japanese firms can either purchase less of these inputs, purchase the same quantity at higher costs, or purchase lower quality imported inputs. Any of these should harm domestic firms.

If Japanese firms are competing with foreign firms, then a yen depreciation should increase their profitability. If they are cooperating by purchasing imported inputs, then a depreciation should decrease their profitability. Since finance theory indicates that stock prices equal the expected present value of future cash flows, the response of stock prices to exchange rate changes can shed light on whether they were cooperating or competing after the advent of Abenomics. If they are both competing and cooperating, the response of stock prices to exchange rates can indicate which of these effects predominate.

Table 1 sheds light on the competitive and cooperative structure of Japanese trade. It reports Japan's exports and imports by sector. Japan's major export categories by order of importance are: machinery, vehicles, electronics, chemicals, and information and communication technology (ICT) services. Japan's major import categories by order of importance are: machinery, electronics, agriculture, minerals, crude oil, textiles, and ICT services. Japan runs a surplus of 2.7% of GDP in vehicles, 1.8% of GDP in machinery, and 0.6% of GDP in electronics. It runs deficits of 1.4% of GDP in minerals and in agriculture, 1.1% of GDP in crude oil, and 0.8% of GDP in textiles. Its overall balance in goods trade is 1.9% of GDP and in goods and services trade 1.7% of GDP.

Chinn (2013) sought to explain Japan's exports and imports employing Johansen maximum likelihood techniques over the 1990q1 to 2012q3 period. For exports he reported exchange rate elasticities of between 0.4 and 0.7 and GDP elasticities of between 1 and 4. For imports, he reported exchange rate elasticities of about unity for imports excluding mineral fuels and GDP elasticities of between 2.9 and 6.7. He concluded that the sum of the export and import elasticities exceed unity, implying that the Marshall-Lerner condition holds in the long run.

Sato and Shimizu (2015) investigated the relationship between yen depreciations, the trade deficit, and Japanese competitiveness. Using both an autoregressive distributed lag model and an error correction model and monthly data they found evidence of a J-curve effect in Japan over the 1985-1998 period but not over the 1999-2014 period. They also used Kalman filter techniques and monthly data over the 1980 to 2014 period to estimate exchange rate pass through. They reported that during the yen appreciation period between 2009 and 2012 the degree of pass-through increased. Then as the yen depreciated after 2012 they found that rather than passing through the depreciations into foreign currency prices they increased the degree of pricing to market.

Sasaki and Yoshida (2018) investigated why Japan continued running trade deficits in 2013 and 2014 even after the yen was depreciating. They constructed price and quantity indices for Japanese exports and imports disaggregated by country and industry over the 1988-2014 period. They found that many factors contributed to continuing trade deficits after the yen depreciated. For instance, depreciations led to more than proportionate increases in import prices. In addition, the income elasticity of import demand increased. They noted that the increase in the income elasticity of imports for Japan relative to other countries could cause Japan's trade balance to continue deteriorating.

Iwaisako and Nakata (2017) employed monthly vector autoregressions over the 1977 to 2014 period to investigate Japanese exports. Their model included the real effective exchange rate, the growth rate of aggregate exports, two measures of global demand, the price of crude oil and the growth rate of world oil production. They found using impulse response functions that exports fell in response to a yen appreciation. They also reported using variance decompositions that exchange rate innovations explained less of the variance of export growth over the 2000–2014 period than over the 1977 – 1999 period. Finally, they found that global demand shocks exerted important effects on exports.

Ito et al. (2016) investigated the exposure of Japanese sectoral stock returns to exchange rates. They employed monthly data over the 2005-2009 period. Controlling for returns on the aggregate Japanese stock market, they reported that the transportation equipment, precision instrument, and machinery industries were damaged by exchange rate appreciations but that the chemical, coal & oil, and food sectors were less exposed.

This paper uses two methods to investigate how exchange rate changes after 2012 affected Japanese industries. First it estimates export and import functions ending in both 2012 and 2018. For the estimates ending in 2012, it employs actual out-of-sample values of the explanatory variables to examine how exports and imports would be expected to respond and compares this with the actual responses. Second, it estimates sectors' stock market exposures to exchange rates for the period before 2013 and for the 2013-2018 period. The results indicate that exports are much less than predicted for many key sectors such as transportation equipment during the latter depreciation period, but that depreciations still increase profitability for these sectors. Other sectors such as biotechnology and pharmaceuticals were damaged by depreciations after 2012.

The next section presents estimates of export and import elasticities. Section 3 presents estimates of the exposures of stock returns to exchange rate exposure. Section 4 concludes.

2. Estimating Trade Elasticities for Japanese Exports and Imports

2a. Data and Methodology

The theoretical model motivating the empirical work is the imperfect substitutes model (see Goldstein and Khan, 1985). Imported goods are assumed to be imperfect substitutes for domestic goods. In this framework demand for domestic imports depends on the price of imports in the importing country's currency relative to the price of domestic goods and on domestic income. The supply of exports from abroad depends on the price of the foreign country's exports (the domestic country's imports) in the foreign currency relative to the foreign price index. Rose (1991) showed that equating import demand and export supply yields the export function:

$$lnX_t = \beta_0 + \beta_1 lnRER_t + \beta_2 lnY_t * \qquad (1),$$

where X represents real exports, RER is the real exchange rate and Y* is foreign real GDP. An appreciation of the exporting country's real exchange rate should reduce exports and an increase in the importing country's GDP should raise exports. Rose similarly derived import functions in the imperfect substitutes framework:

$$lnIm_t = \alpha_0 + \alpha_1 lnRER_t + \alpha_2 lnY_t \qquad (2),$$

Where Im represents imports. An appreciation of the importing country's real exchange rate and an increase in its real GDP should raise imports.

Quarterly data on the quantity of aggregate and sectoral exports and imports for Japan and on the IMF CPI-deflated real exchange rate are obtained from the CEIC database[2]. To

[2] For Japanese service exports and imports, data are obtained from the Federal Reserve Bank of St. Louis FRED database.

explain Japanese exports, data on real GDP in the G20 countries are obtained from the OECD database. To explain Japanese imports, data on Japanese real GDP are obtained from the Federal Reserve Bank of St. Louis FRED database.[3]

Augmented Dickey-Fuller tests indicate in many cases that these variables are integrated of order one. Dynamic ordinary least squares (DOLS), a technique that is appropriate for estimating cointegrating relations, is thus employed. Stock and Watson (1993) showed that DOLS yields consistent and efficient estimates. Montalvo (1995) found that the DOLS estimator has smaller bias and root mean squared error than other cointegrating regression estimators when the sample size is too small to justify applying asymptotic theory. Equation (1) can be estimated by the following DOLS regression:

$$X_t = \beta_0 + \beta_1 rer_t + \beta_2 y_t{}^* + \sum_{k=-K}^{K} \gamma_{1,k} \Delta rer_{t+k} + \sum_{k=-K}^{K} \gamma_{2,k} \Delta y_{t+k}{}^* + \varepsilon_t \qquad (3),$$

where K represents the number of leads and lags of the first differenced variables and the other variables are defined above. Following Stock and Watson's suggestions, K is set equal to 1 and a time trend is included in the estimation. Equation (2) is estimated by an analogous regression:

$$IM_t = \alpha_0 + \alpha_1 rer_t + \alpha_2 y_t + \sum_{k=-K}^{K} \phi_{1,k} \Delta rer_{t+k} + \sum_{k=-K}^{K} \phi_{2,k} \Delta y_{t+k} + \varepsilon_t \qquad (4).$$

Following Chinn (2005), equations (3) and (4) are treated as semi-reduced form regressions. The exchange rate is assumed to have a life of its own and to be more exogenous then the relative price of exports or imports used to derive equations (1) and (2). Thus a structural interpretation is given to the parameters in equations (3) and (4).

Data over the 1998Q1 to 2012Q4 period are employed to estimate equations (3) and (4). The results are then combined with actual out-of-sample values of the right-hand-side variables

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[3] The website for the OECD is www.oecd.org and for FRED is fred.stlouisfed.org.

to forecast exports and imports over the next five and a half years. The forecasted values are then compared to the actual values. In addition, equations (3) and (4) are estimated over the 1998Q1 to 2018Q2 period.

2b. Results

Table 2 reports the export elasticities. Columns (2) and (4) present elasticities over the 1998-2012 period and columns (6) and (8) present elasticities over the 1998-2018 period. Columns (3), (5), (7), and (9) present the corresponding standard errors. Column (10) presents the average of the difference between actual exports and forecasted exports over the 2013-2018 period.

The first sector reported is total goods exports. Column (2) indicates that the exchange rate elasticity over the 1998-2012 period equals -0.46 and column (4) indicates that the GDP elasticity equals 2.27. These values are within the range reported by Chinn (2013) over the 1990-2012 period. Column (6) indicates that the exchange rate elasticity falls to 0.02 when the sample period is extended to the 1998-2018 period and the GDP elasticity rises to 5.18. Column (10) indicates that exports on average were 12% less than predicted over the 2013-2018 period using values estimated over the 1990-2012 period and actual out-of-sample values of the independent variables over the 2013-2018 period. Goods exports thus did not respond to exchange rates as predicted during the Abenomics period.

The second sector reported is total services exports. Column (2) indicates that the exchange rate elasticity over the 1998-2012 period equals -0.72 and column (4) indicates that the GDP elasticity equals 1.05. Column (6) indicates that the exchange rate elasticity equals -0.70 when the sample period is extended to the 1998-2018 period and the GDP elasticity equals 0.71.

Column (10) indicates that services exports on average were 3% more than predicted over the 2013-2018 period using values estimated over the 1990-2012 period and actual out-of-sample values of the independent variables over the 2013-2018 period. Services exports thus responded to exchange rates as predicted during the Abenomics period.

With goods exports no longer responding to exchange rate depreciations after 2012 and services exports continuing to respond, one would expect services exports to become a larger share of total exports. Figure 2 indicates that this is the case. Services exports rose from 14.7% of total exports in 2012 to 22.5% in 2019. In 2019, 31.7% of service exports were ICT services, 22.0% were travel and tourism, 12.5% were transport, and 7.9% were insurance and finance.

Table 2 indicates that one reason for the shortfall of goods exports comes from sectors related to motor vehicles. When the end of the sample switches from 2012 to 2018, the exchange rate elasticity changes from -0.67 to +0.31 for rubber tires and tubes, from -1.68 to -0.59 for passenger cars, from -1.21 to -0.27 for transportation equipment, from -1.20 to -0.62 for buses and trucks, and from -0.38 to +0.32 for parts of motor vehicles. Actual exports average 35% less than predicted for rubber tires and tubes, 32% less than predicted for passenger cars, 28% less than predicted for transportation equipment, 23% less than predicted for buses and trucks, and 17% less than predicted for parts of motor vehicles. Sato and Shimizu (2015) noted that as the yen appreciated between 2008 and 2012, Japanese transportation equipment firms transferred low value-added production abroad and exported differentiated and high-value-added products from Japan. Then after the yen depreciated at the end of 2012 they kept the foreign currency prices of these high value added goods constant. If this is so then the depreciation should affect profits, an issue that the next section on stock market exposures investigates.

For chemicals, Table 2 indicates that when the sample end switches from 2012 to 2018, the exchange rate elasticity changes from -0.41 to +0.09. Japanese chemical companies relocated much less advanced chemical production to China. Thorbecke, Salike, and Chen (2020) found that exchange rate elasticities are less for more sophisticated chemical exports. The change in the composition of Japanese chemical exports can this help explain why they stopped responding to exchange rates after 2012.

Many types of machinery exports were not very sensitive to exchange rates before Abenomics and held up well afterwards. Table 2 indicates that electrical machinery exports, machinery other than electrical machinery, metal working machinery, and textile machinery were not affected by exchange rates in either sample period. Electrical machinery exports were 8% less than expected over the 2013-2018 period, machinery exports other than electrical machinery were 5% less than predicted, metal working machinery exports were 3% more than predicted, office machinery exports were 9% more than predicted, and textile machinery exports were 22% more than predicted. One reason why these exports may not be sensitive to exchange rates is that Japanese machinery exports are vital for many countries.

Table 3 presents results analogous to Table 2 for imports. The first sector reported is for total goods imports. Column (2) indicates that the exchange rate elasticity over the 1998-2012 period equals 0.31 and column (4) indicates that the GDP elasticity equals 3.60. The exchange rate elasticity is less than the values of about unity that Chinn (2013) found over the 1990-2012 period. The GDP elasticity is within the range of 2.9 to 6.7 that Chinn reported over the 1990-2012 period. Column (6) indicates that the exchange rate elasticity remains about the same (0.33) when the sample period is extended to the 1998-2018 period and the GDP elasticity falls to 3.15. Column (10) indicates that imports on average were 9% less than predicted over the

2013-2018 period using values estimated over the 1990-2012 period and actual out-of-sample values of the independent variables over the 2013-2018 period. Thus both goods exports and goods imports fell short of predicted values after 2012.

The second sector reported is for total services imports. Column (2) indicates that the exchange rate elasticity over the 1998-2012 period equals 0.06 and column (4) indicates that the GDP elasticity equals 1.20. Column (6) indicates that the exchange rate elasticity becomes -0.42 when the sample period is extended to the 1998-2018 period and the GDP elasticity falls to 0.40. Column (10) indicates that imports on average were 21.9% less than predicted over the 2013-2018 period using values estimated over the 1990-2012 period and actual out-of-sample values of the independent variables over the 2013-2018 period. Japan thus imported many more services imports than predicted during the weak yen period.

Several important categories of goods imports were far less than predicted. These include, with percentage shortfalls in parentheses: precision instruments (-0.34), machinery excluding electrical machinery (-0.33), electrical machinery (-0.24), manufactured goods (-0.18), semiconductors (-0.16), and non-ferrous metals (-0.11). Exchange rate elasticities also increased for machinery including electrical machinery, inorganic chemicals, manufactured goods, semiconductors, and other categories. This points to the weakening yen during the Abenomics period causing a fall in imports.

The exchange rate elasticity for crude oil is close to zero for both sample periods. Hamilton (2009) observed that the price elasticity of demand for oil is low. Table 3 indicates that the same is true for the exchange rate elasticity. Japan needs crude oil, and continues to import it even when the yen depreciates. Thus, as Fernand and Trehan (2005) noted, higher oil prices impose a tax on oil-importing countries such as Japan.

Chemical and foodstuff imports increase moderately when the exchange rate appreciated. In the first sample period the exchange rate elasticity equaled 0.36 for both categories and in the second period the elasticity for chemicals equaled 0.31 and the elasticity for foodstuffs equaled 0.21.

Medicinal and pharmaceutical imports and telephony and telegraphy imports both saw their exchange rate elasticities fall when the sample extends to 2018. The medicinal and pharmaceutical imports were 27% more than expected over the 2013 – 2018 period and telephone and telegraphy imports were 29% more than expected. Japan maintained strong imports in both categories even as the exchange rate depreciated. Medicinal and pharmaceutical imports are crucial, especially as Table 1 indicates that Japan does not have a comparative advantage in this sector, and demand for imported smartphones soared over this period.

Comparing the results in Tables 2 and 3, it is clear that the Marshall-Lerner condition does not hold. Over the 1998-2012 period the sum of the absolute value of the elasticities for goods equals 0.77 and over the 1998-2018 period the sum of the elasticities for goods equals 0.31. For services, the corresponding values are 0.78 over the 1998-2012 period and 0.28 over the 1998-2018 period. Thus a yen depreciation will not improve Japan's trade balance.

3. Estimating Exchange Rate Exposures for Japanese Sectors

*3a***.** *Data and Methodology*

Many papers have investigated firms' exposure to exchange rates. For Japan these include Jayasinghe and Tsui (2008) and Ito et al. (2016). The methodology involves regressing firms' or sectors' stock returns on the change in the exchange rate and the return on the overall stock market. While the return on the overall stock market is used to control for economy-wide influences, Cox, Ingersoll, and Ross (1985) and others have argued that several macroeconomic variables should be used to capture the influence of economy-wide factors. Chen, Roll, and Ross (1986) noted that, while only earthquakes and similar phenomena are exogenous, causality should flow from macroeconomic variables on the right-hand-side of the regressions to firm or sectoral stock returns on the left-hand-side and that the causality flowing in the other direction should be second order.

This paper employs four macroeconomic variables to explain Japanese stock returns. These are: the return on Japan's aggregate stock market, the return on the world stock market, the change in the spot price of Dubai crude oil, and the yen/dollar exchange rate. The return on Japan's stock market captures the impact of the overall economy on sectoral stock returns (see Brown and Warner, 1980, 1985). Similarly the return on the world stock market controls for the influence of the world economy on stock returns. The change in the log of Dubai spot prices captures the impact of oil prices on Japanese sectors. Table 1 indicates that Japan is dependent on crude oil imports.

Data on the returns on 33 sectors, the returns on the Japanese aggregate stock market, the return on the world stock market, the changes in the spot prices of Dubai crude oil, and the yen/dollar nominal exchange rate are obtained from the Datastream database. The data are daily. Two sample periods are employed: 22 January 2001 to 31 December 2012 and 1 January 2013 to 30 June 2018.[4] The first sample period has 3,116 observations and the second has 1,434 observations.

The estimated equations take the form:

$$\Delta R_{i,t} = \alpha_0 + \alpha_1 \Delta R_{m,t} + \alpha_2 \Delta R_{m,World,t} + \alpha_3 \Delta P_{oil,t} + \alpha_4 \Delta er_t \ , \qquad (5)$$

[4] In cases when stock return data are unavailable on 22 January 2001, the data are employed beginning on the first date they are available.

where $\Delta R_{i,t}$ is the change in the log of the stock price index for sector *i*, $\Delta R_{m,t}$ is the change in the log of the price index for the Japanese aggregate stock market, $\Delta R_{m,World,t}$ is the change in the log of the price index for the world stock market, $\Delta P_{oil,t}$ is the change in the log of the spot price of Dubai crude oil, and Δer_t is the change in the log of the Japanese yen/U.S. dollar exchange rate. Heteroskedasticity and autocorrelation consistent standard errors are reported.

3b. Results

Table 4 presents sectors' exchange rate exposures. Column (2) presents exposures over the 22 January 2001 to 31 December 2012 period and Column (4) presents exposures over the 1 January 2013 to 30 June 2018 period. Columns (3) and (5) present the corresponding standard errors. The top row presents results for the Japanese aggregate stock market. In both periods a yen depreciation causes aggregate stock returns to increase. Up until 31 December 2012, a 1% yen depreciation causes stock returns to rise by 0.631%. After 31 December 2012, a 1% yen depreciation causes stock returns to rise by 1.117%.

Table 4 indicates that several key sectors benefit from depreciations during the Abenomics period. The sector that benefits the most is automobiles, followed by auto parts. The exposure of automobile stocks to the yen is almost the same in the earlier and later periods. Thus even though depreciations no longer stimulate automobile exports, they still increase automaker profits after 2012.

The electronic parts and components and semiconductor sectors also gain from yen depreciations after 2012. Many types of semiconductors have become commoditized (Katz, 2012), and depreciations increase the price competitiveness of Japanese exports. Some types of Japanese electronic parts and components exports, such as Sony's image sensors, are differentiated products.

Producers of these goods have more pricing power. This might explain why producers of electronic parts and components other than semiconductors benefit less from depreciations than semiconductor producers.

Two other sectors that benefit from depreciations after 2012 are agricultural machinery and iron & steel. In both cases their coefficients became larger and more positive during the second sample period.

While sectors with positive exchange rate coefficients point to competition between these sectors and the rest of the world, those with negative coefficients are in cooperative relations. The biotechnology and the pharmaceutical sectors were harmed by depreciations after 2012. For biotechnology, a 1% depreciation reduces returns by 0.598% and for pharmaceuticals a 1% depreciation reduces returns by 0.224%. Table 3 indicates that medicinal and pharmaceutical imports were 27% more than predicted during the 2013-2018 period. The table also indicates that imports were no longer sensitive to exchange rates during this latter period. This implies that Japanese firms continued importing these goods even as the yen depreciated. Importing these products when the yen is weak reduces the profits of Japanese firms.

Several other sectors also had negative exchange rate exposures over the 2013-2018 period, indicating that they are harmed by yen depreciations. These include home improvement retail, household furnishings, telecommunications services, travel and tourism, software, cosmetics, and food retail and wholesale. A 1% depreciation reduces home improvement retail stocks by 0.426%, household furnishings stocks by 0.267%, telecommunications services stocks by 0.202%, travel and tourism stocks by 0.191%, software stocks by 0.175%, cosmetics stocks by 0.159%, and food retail and wholesale stocks by 0.126%. These sectors thus cooperate with firms abroad by purchasing imports, and a weaker yen hurts their profitability.

While the yen depreciation thus benefitted the overall stock market and key industries such as automobiles and electronic parts and components, it also harmed several sectors. The hardest hit were the biotechnology and pharmaceutical sectors. Table 1 indicates that Japan does not have a comparative advantage in the pharmaceutical sector and that it relies on imports.

4. Conclusion

The Japanese yen appreciated by almost 50% against the U.S. dollar between the middle of 2007 and the beginning of 2012. Sato and Shimizu (2015) noted that Japanese firms may have responded to the soaring yen after 2007 by transferring the production of low-value added products to subsidiaries abroad and producing only differentiated and high-value-added products in Japan. Starting at the end of 2012, the yen depreciated and returned to the same value it had in the middle of 2007 (see Figure 1). The depreciation beginning at the end of 2012 was closely related to Prime Minister Abe's policy of encouraging the Bank of Japan to increase the quantity of yen in order to reach its inflation target.

This paper investigates how the yen depreciation associated with Abenomics affected the Japanese economy. To do this it investigates how exchange rates impact exports, imports, and stock prices before and after 2013. The results indicate that, over the 1998-2012 period, a 1% yen depreciation increases goods exports by 0.46% and decreases imports by 0.31%. Extending the sample period to 1998-2018, the results indicate that a 1% yen depreciation has no impact on goods exports and decreases goods imports by 0.33%. The findings also indicate that, over the 1998-2012 period, a 1% yen depreciation increases services exports by 0.72% and does not affect services imports. Extending the sample period to 1998-2018, the results indicate that a 1% yen depreciation increases services exports by 0.70% and is associated with an increase in services imports. Thus, contrary to what Chinn (2013) reported for the 1990-2012 period, the Marshall-Lerner condition no longer holds over the 1998-2012 and *a fortiori* over the 1998 - 2018 period. Thus a yen depreciation will not improve Japan's trade balance.

Looking at individual sectors, those related to the transportation equipment industry exported much less than predicted over the 2013-2018 period. Their exports also became much less sensitive or insensitive to exchange rates. In contrast, their stocks gained more than any other sector investigated when the yen depreciated. Thus exchange rates still matter for this industry, even though they do not matter for exports.

The Japanese aggregate stock market also benefited almost twice as much from yen depreciations after 2013 than before. This finding indicates that firms' new pricing and export strategy benefited corporate Japan. However several sectors such as pharmaceuticals and biotechnology that rely on imported inputs were harmed by depreciations after 2012. Oil imports are not affected by exchange rates, indicating that yen depreciations increase Japan's import bill in yen terms. In addition, the large drop in exports compared to what would be expected suggests that the weaker yen had a diminished effect on Japanese manufacturing output and employment. Future research should investigate in depth the distributional and differential effects of changes in the yen on the Japanese economy.

Table 1. Japan's Exports, Imports, Trade Balance, and Comparative Advantage in 2019

		Exports		Imports		Exports minus Imports		Baldwin and Okubo Comparative Advantage Measure
(1)	Sector	Billions of USD	Percent of GDP	Billions of USD	Percent of GDP	Billions of USD	Percent of GDP	
(2)	Chemicals ex. Pharmaceuticals	93.9	1.9	52.2	1	41.7	0.8	0.285
(3)	Pharmaceuticals	8.1	0.2	20.1	0.4	-12	-0.2	-0.426
(4)	Vehicles	167	3.3	29.6	0.6	137.4	2.7	0.699
(5)	Machinery	188	3.7	96.8	1.9	91.2	1.8	0.32
(6)	Electronics	111	2.2	79.9	1.6	31.1	0.6	0.163
(7)	Iron & Steel	26	0.5	7.3	0.1	18.7	0.4	0.562
(8)	Metals ex. Iron & Steel	28	0.6	25.6	0.5	2.4	0	0.045
(9)	Crude Oil	0.1	0	55.5	1.1	-55.4	-1.1	-0.996
(10)	Refined Oil	10.4	0.2	12.2	0.2	-1.8	0	-0.08
(11)	Minerals ex. Crude & Refined Oil	4.5	0.1	74.3	1.5	-69.8	-1.4	-0.886
(12)	Textiles	10	0.2	48.8	1	-38.8	-0.8	-0.66
(13)	Agriculture	13	0.3	83.3	1.6	-70.3	-1.4	-0.73
(14)	Stone	20	0.4	15.2	0.3	4.8	0.1	0.136
(15)	Travel & Tourism Services	46.0	0.9	21.2	0.42	24.7	0.5	0.369
(16)	ICT Services	66.4	1.3	50.2	1.0	16.2	0.3	0.139
(17)	Other Services	96.6	1.9	147.5	2.9	-50.9	-1.00	-0.209
(18)	Total (Goods Only)	718	14.1	624	12.3	94	1.9	
(19)	Total (Goods & Services)	927	18.2	843	16.6	84	1.7	

Note: The table presents export, import, and comparative advantage date. Comparative advantage (CA) is calculated according to the method of Baldwin and Okubo (2019). They calculated CA as $(X_{cik} - M_{cik})/(X_{cik} + M_{cik})$, where X represents exports, M represents imports, *c* represents country, *i* represents sector, and *k* represents product type. This table does not distinguish between parts and final goods.
Source: https://atlas.cid.harvard.edu/and calculations by the author.

Table 2. Export Elasticities for Japanese Sectors.

	1998-2012 Sample Period				1998-2018 Sample Period				2013-2018
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Export Category	Exchange Rate Coefficient	S.E.	GDP Coefficient	S.E.	Exchange Rate Coefficient	S.E.	GDP Coefficient	S.E.	Actual – Forecasted Exports (%)
Total Goods Exports	-0.46***	0.15	2.27**	1.02	0.02	0.14	5.18***	1.08	-0.12
Total Services Exports	-0.72***	0.22	1.05	1.42	-0.70***	0.19	0.71	1.35	0.03
Rubber Tires and Tubes	-0.67***	0.21	0.35	1.40	0.31	0.29	6.89***	2.11	-0.35
Passenger Motor Car	-1.68***	0.26	0.55	1.73	-0.59**	0.28	6.82***	2.09	-0.32
Agricultural Machinery	-1.17***	0.44	3.58	2.92	-0.30	0.33	9.19***	2.44	-0.32
Motor Vehicles	-1.63***	0.25	0.67	1.69	-0.59**	0.27	6.71***	2.00	-0.31
Transport Equipment	-1.21***	0.20	1.31	1.37	-0.27	0.24	6.86***	1.78	-0.28
Manufactured Rubber	-0.56***	0.21	1.36	1.4	0.25	0.24	6.73***	1.76	-0.26
Medical Products	-0.78**	0.34	-2.10	2.27	0.02	0.27	2.94	1.95	-0.24
Buses, Trucks	-1.20***	0.33	1.67	2.20	-0.62**	0.27	5.62***	2.00	-0.23
Pump & Centrifuges	-0.43**	0.16	1.40	1.10	0.21	0.18	5.42***	1.36	-0.21
Paper & Paper Manufacturing	-0.98***	0.32	-3.06	2.15	-0.07	0.29	2.03	2.11	-0.19
Plastic Materials	-0.33**	0.15	1.09	0.98	0.30	0.19	5.32***	1.39	-0.17
Parts of Motor Vehicles	-0.38**	0.17	0.15	1.16	0.32	0.2	4.61***	1.49	-0.17
Electric Power Machinery	-0.29	0.18	5.05***	1.22	-0.27**	0.14	4.87***	1.04	-0.15
Chemicals	-0.41***	0.13	0.40	0.91	0.09	0.15	3.64***	1.1	-0.12
Iron & Steel & Products	-0.26	0.20	-3.37***	1.31	0.15	0.19	-0.36	1.4	-0.12
Power Generating Machinery	-0.10	0.15	3.47***	1.01	0.29**	0.14	6.05***	1.03	-0.12
Machinery & Equipment	-0.46***	0.17	2.83**	1.16	0.04	0.16	5.78***	1.16	-0.11
Manufactured Goods	-0.44***	0.16	2.37**	1.04	0.04	0.15	5.29***	1.09	-0.11
Metal Products	-0.40**	0.19	1.83	1.25	0	0.16	4.56***	1.18	-0.11
Bearings	0.12	0.24	3.40**	1.61	0.38**	0.19	5.64***	1.43	-0.10
Electrical Machinery	-0.16	0.22	3.18**	1.49	0.27	0.17	5.78***	1.27	-0.08
Hand Tools, Machinery Tools	-0.32	0.31	2.13	2.06	-0.20	0.20	3.44**	1.46	-0.08
Heating or Cooling Equipment	0.92***	0.3	6.37***	1.98	1.12***	0.26	8.33***	1.94	-0.06
Food-stuff	-0.77**	0.34	0.08	2.27	-0.66***	0.23	0.43	1.68	-0.05
Motorcycles	-1.91***	0.48	5.93***	3.14	-1.58***	0.4	6.13***	2.91	-0.05
Machinery Other Than Electrical	-0.29	0.26	3.51**	1.71	0.01	0.17	5.28***	1.3	-0.05
Photographic Supplies	-0.42***	0.10	-0.25	0.66	-0.95***	0.15	0.44	1.11	-0.05

Internal Combustion Engines	-0.10	0.18	2.92**	1.21	0.21	0.13	5.00***	1.00	-0.04
Transistors and Diodes	0.73***	0.25	4.63***	1.64	0.88***	0.20	6.31***	1.48	0
Electrical Apparatus	-0.11	0.15	4.38***	1.02	0.18	0.12	6.07***	0.85	0
Textiles	-0.24	0.15	1.36	1.04	-0.24**	0.10	1.30	0.78	0.01
Metal Working Machines	0.29	0.51	9.04***	3.37	0.02	0.33	8.55***	2.44	0.03
Textile Materials	0.09	0.22	0.09	1.47	-0.31	0.27	-0.88	2.01	0.06
Office Machines	-0.60	0.38	-1.86	2.52	-0.61**	0.27	-2.29	2.01	0.09
Synthetic Fabrics	-0.05	0.19	3.12**	1.3	-0.29	0.17	1.11	1.26	0.1
Textile & Yarns	0.18	0.18	3.01**	1.23	-0.1	0.14	1.05	1.02	0.18
Textile Machines	-0.50	0.58	0.06	3.8	-0.30	0.36	0.71	2.67	0.22
Clothing	-0.33	0.31	0.36	2.06	-0.75**	0.31	-3.2	2.31	0.23

Note: The table presents exchange rate and GDP elasticities from dynamic ordinary least squares (DOLS) estimates of export equations. The left-hand-side variable is Japanese real exports and the right-hand-side variables are the IMF CPI-deflated real effective exchange rate, real GDP in the G-20 countries, one lag and one lead of the first difference of the real effective exchange rate and real GDP, and a time trend. S.E. are heteroskedasticity and autocorrelation consistent standard errors. Columns (2) through (5) report results employing the 1998Q1-2012Q4 sample period. Columns (6) through (9) report results employing the 1998Q1-2018Q2 sample period. Column 10 reports the difference between actual exports over the 2013Q1-2018Q2 period and those forecasted employing the results in columns (2) through (5) and actual out-of-sample values of the right-hand-side variables over the 2013Q1-2018Q2 period.

Source: CEIC database, OECD database, and calculations by the author.

*** (**) [*] denotes significance at the 1% (5%) [10%] level.

Table 3. Import Elasticities for Japanese Sectors.

	1998-2012 Sample Period				1998-2018 Sample Period				2013-2018
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Import Category	ER Coeff.	S.E.	GDP Coeff.	S.E.	ER Coeff.	S.E.	GDP Coeff.	S.E.	Actual – Forecasted Imports (%)
Total Goods Imports	0.31***	0.09	3.60***	0.36	0.33**	0.14	3.15***	0.63	-0.09
Total Services Imports	0.06	0.15	1.20**	0.59	-0.42*	0.22	0.40	1.04	0.22
Precision Instruments	-0.10	0.31	6.08***	1.24	0.33	0.38	6.39***	1.78	-0.34
Machinery Excluding Electric	0.41	0.37	7.13***	1.50	0.74*	0.42	6.63***	1.96	-0.33
Electrical Machinery	0.48**	0.19	5.06***	0.78	0.69**	0.30	4.71***	1.39	-0.24
Inorganic Chemicals	0.44	0.28	6.55***	1.13	0.84***	0.27	7.20***	1.28	-0.23
Furniture	0.17	0.41	4.12***	1.69	0.50	0.33	4.39***	1.56	-0.22
Paper & Manufactures	0.85**	0.41	3.04	1.68	0.86**	0.38	2.15	1.78	-0.19
Manufactured Goods	0.37**	0.14	4.94***	0.56	0.50**	0.22	4.55***	1.05	-0.18
Footwear	0.21	0.12	1.89***	0.50	0.31	0.21	1.48	1.00	-0.17
Semiconductor	0.73*	0.45	4.62**	1.81	0.86**	0.39	4.08**	1.84	-0.16
Electrical Power Machinery	0.29	0.21	5.33***	0.85	0.38	0.22	4.96***	1.02	-0.15
Articles of Apparel	0.52*	0.28	3.80***	1.14	0.53**	0.22	3.57***	1.01	-0.12
Non Ferrous Metals	0.65***	0.20	6.50***	0.81	0.69***	0.20	6.04***	0.92	-0.11
Parts for Motor Vehicles	-0.27	0.32	5.42***	1.33	-0.18	0.23	5.16***	1.06	-0.10
Textile Yarn & Fabrics	0.26	0.19	2.87***	0.78	0.33**	0.15	2.83***	0.72	-0.09
Clothing	0.13	0.19	2.35***	0.77	0.13	0.15	2.11***	0.69	-0.08
Crude Oil	-0.07	0.10	1.51***	0.40	0.01	0.10	1.38***	0.47	-0.07
Chemicals	0.36***	0.13	2.92***	0.54	0.31***	0.11	2.49***	0.50	-0.03
Foodstuffs	0.36***	0.10	1.46***	0.40	0.21**	0.09	1.36***	0.43	0.08
Fruits and Vegetables	0.68***	0.12	2.78***	0.51	0.46***	0.10	2.23***	0.45	0.08
Iron and Steel	1.47***	0.34	9.24***	1.37	0.74**	0.31	6.49***	1.43	0.09
Medicinal & Pharmaceutical	0.83***	0.24	0.41	0.98	-0.09	0.28	-2.22	1.32	0.27
Telephony, Telegraphy	0.61	0.84	0.18	3.41	-0.32	0.55	-2.55	2.57	0.29
Textile Materials	0.57**	0.26	3.97***	1.05	-0.35	0.40	2.14	1.86	0.42
Passenger Motor Cars	1.46**	0.63	9.70***	2.57	0.04	0.55	6.24***	2.59	0.46

Note: The table presents exchange rate and GDP elasticities from dynamic ordinary least squares (DOLS) estimates of import equations. The left-hand-side variable is Japanese real imports and the right-hand-side variables are the IMF CPI-deflated real effective exchange rate, Japanese real GDP, one lag and one lead of the first difference of the real effective exchange rate and real GDP, and a time trend. S.E. are heteroskedasticity and autocorrelation consistent standard errors. Columns (2) through (5) report results employing the 1998Q1-2012Q4 sample period. Columns (6) through (9) report results employing the 1998Q1-2018Q2 sample period. Column 10 reports the difference between actual imports over the 2013Q1-2018Q2 period and those forecasted employing the results in columns (2) through (5) and actual out-of-sample values of the right-hand-side variables over the 2013Q1-2018Q2 period.

Source: CEIC database, Federal Reserve Bank of St. Louis FRED database, and calculations by the author.

*** (**) [*] denotes significance at the 1% (5%) [10%] level.

Table 4. Exchange Rate Exposures for Japanese Sectors.

	22 January 2001 – 31 December 2012		1 January 2013 – 30 June 2018	
(1)	(2)	(3)	(4)	(5)
Sector	Coefficient	Standard Error	Coefficient	Standard Error
Japanese Aggregate Stock Market	0.631***	0.068	1.117***	0.062
Automobiles	0.422***	0.040	0.430***	0.050
Auto Parts	0.291***	0.038	0.370***	0.043
Biotechnology	-0.148	0.110	-0.598***	0.189
Chemicals	0.035	0.026	0.067	0.043
Consumer Electronics	0.254***	0.042	0.087	0.064
Cosmetics	-0.022	0.038	-0.159**	0.075
Electrical & Electronic Equipment	0.141***	0.026	0.082*	0.043
Electronic Equipment: Controls	0.055	0.063	-0.171**	0.085
Electronic Equipment: Other	0.083	0.062	0.264***	0.094
Electronic Components	0.125***	0.031	0.174***	0.055
Food Retail, Wholesale	-0.301***	0.043	-0.126**	0.053
General Industrials	-0.025	0.034	0.165***	0.059
Household Furnishing	-0.076**	0.037	-0.267**	0.074
Home Improvement Retail	-0.267***	0.055	-0.426***	0.071
Industrial Engineering	0.129***	0.026	0.104**	0.043
Industrial Suppliers	-0.067	0.045	-0.079	0.056
Industrial Support Services	-0.060	0.024	-0.121***	0.033
Iron & Steel	0.049	0.042	0.152**	0.075
Machinery: Agricultural	0.147**	0.064	0.280***	0.099
Machinery: Construction	0.108**	0.054	0.144*	0.082
Machinery: Industrial	0.151***	0.030	0.061	0.042
Machinery: Specialty	0.092**	0.045	0.047	0.060
Marine Transport	0.173***	0.053	0.199***	0.074
Medical Equipment	0.153***	0.042	0.034	0.052
Medical Services	-0.032	0.066	-0.163	0.110
Oil Equipment & Services	-0.006	0.111	-0.138	0.143
Pharmaceuticals	0.002	0.034	-0.224***	0.058
Semiconductors	0.142***	0.046	0.242***	0.070
Software	-0.133***	0.044	-0.175***	0.050
Telecommunications Equipment	-0.203***	0.052	-0.108***	0.058
Telecommunications Services	-0.252***	0.056	-0.202**	0.082
Textile Products	0.017	0.039	0.016	0.062
Travel & Tourism	-0.157***	0.032	-0.191***	0.053

Note: The table presents results from regressions of stock market returns for the Japanese sectors listed in column (1) on the change in the log of the Japanese yen/U.S. dollar nominal exchange rate (columns (2) and (4)), the return on the Japanese aggregate stock market, the return on the world stock market, and the change in the log of the spot price for Dubai crude oil. An increase in the yen/dollar exchange rate represents a depreciations of the yen. The sample period in columns (2) and (3) extends from 22 January 2001 to 31 December 2012. There are 3,116 observations. The sample period in columns (4) and (5) extend from 1 January 2013 to 30 June 2018. There are 1,434 observations. When return data are not available on 22 January 2001, the sample begins on the first date when return data become available. Standard Error in columns (3) and (5) are heteroscedasticity and autocorrelation consistent standard errors.

Source: Datastream database and calculations by the author.

*** (**) [*]denotes significance at the 1% (5%) [10%] level.

Figure 1. The Nominal Japanese Yen/U.S. Dollar Exchange Rate.
Source: Datastream database.

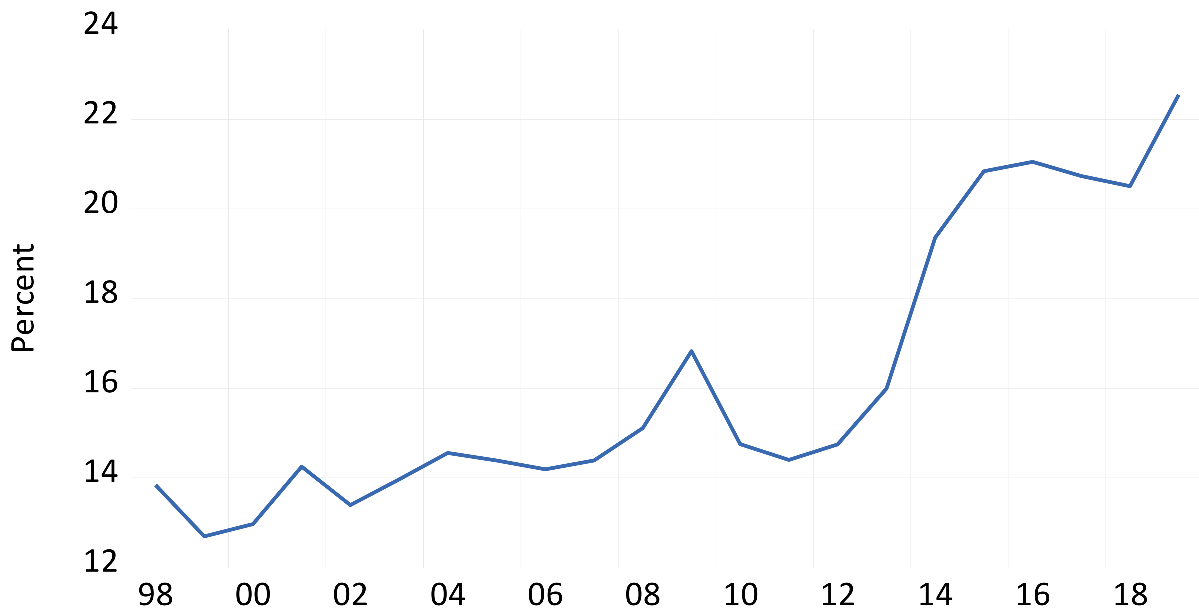

Figure 2. The Share of Services Exports in Japan's Total Exports.
Source: https://atlas.cid.harvard.edu/and calculations by the author.

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