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A Yen for Change:
The strong yen and the Japanese automobile industry

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A Yen for Change: The strong yen and the Japanese automobile industry

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Abstract

The yen depreciation since 2012 has not revived Japanese exports. To investigate why, this paper examines automobile exports. Panel regression evidence points to price elasticities exceeding unity. However, out-of-sample forecasts and other evidence indicate that offshoring since the Global Financial Crisis has prevented automobile exports from recovering. Further, results from pass-through equations indicate that exporters allowed the recent depreciation to raise yen export prices and profit margins rather than export volumes. Finally, regressing stock returns on exchange rates indicates that automakers were more exposed to the value of the yen in 2016 than at any time over the last 12 years.

***JEL classification*:** F10, F40
***Keywords*:** Japanese automobile industry, Exchange rate elasticities, Exchange rate exposures

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1. Introduction

The Japanese real effective exchange rate depreciated logarithmically by 30 percent between the fourth quarter of 2003 and the second quarter of 2007. The volume of exports increased by 25 percent over this period. The yen then appreciated almost 30 percent over the subsequent 7 quarters as the Global Financial Crisis (GFC) took hold. The volume of exports tumbled. Following the implementation of Prime Minister Shinzo Abe's stimulus packages in the third quarter of 2012, the yen depreciated by more than 30 percent. However, as Fig. 1 shows, the volume of Japanese exports has not increased. Why has the yen depreciation beginning in 2012 not been associated with an increase in exports?

Investigating the effect of exchange rates on Japanese exports is tricky, since more that 25 percent of Japanese exports are parts and components (p&c) and other intermediate goods. A depreciation in a downstream country importing p&c from Japan (equivalently an appreciation of the yen) may increase the downstream country's exports of final goods to the rest of the world and thus its imports of Japanese p&c that are used to produce exports. Therefore, a depreciation in the importing country and an appreciation of the yen may be associated with an increase in Japanese p&c exports (see Kamada and Takagawa, 2005). This effect can cloud estimates of exchange rate elasticities.

One way to circumvent this problem is to investigate exports of final goods. Since Japan is an upstream country in global value chains, much of the value added of Japanese final goods exports comes from Japan. Examining how the yen affects final goods exports should provide a cleaner test of how exchange rates affect Japanese exports than examining how the yen affect total exports.

In every year since before 1990, Japan's leading export category at the International Standard Industrial Classification (ISIC) 4-digit level has been motor vehicles. In 2014, more than 16 percent of the value of Japanese exports were in this category. This paper thus investigates how exchange rates affect the Japanese automobile industry.

Another reason why investigating the automobile sector or other individual sectors can provide better estimates of trade elasticities than investigating aggregate exports has been presented by Orcutt (1950). He showed that aggregate estimates of price elasticities may be biased downwards and that estimating elasticities for individual sectors attenuates this bias.

In previous work Shioji and Uchino (2012) investigated how external shocks affect the Japanese automobile industry. They estimated a monthly vector autoregression (VAR) over the 1980 to 2008 period. Their VAR included oil prices, the Japanese nominal effective exchange rate, measures of demand in the U.S. and the EU, real Japanese automobile exports, Japanese auto production, and industrial production. They assumed a recursive ordering to the variables and employed a Cholesky decomposition. They reported that over time positive shocks to U.S. demand increase Japanese automobile exports and positive exchange rate shocks (yen appreciations) reduce automobile exports. They also found that their model could not explain the huge fall in automobile exports during the GFC. They thus estimated another model using panel data on automobile production, sales, and inventories that are available by company and type of car. They reported a non-linear response, with Japanese automakers cutting production more quickly in response to accumulated inventories when output is falling rapidly than when output is falling slowly or rising.

Sato, Shimizu, Shrestha and Zhang (2013) investigated how Japanese transport equipment exports responded to rest of the world output and to real exchange rates. They measured rest of the world output as a weighted average of trading partners' industrial production indices and exchange rates as industry-specific real effective exchange rates for the transport equipment sector. They employed a monthly VAR over the 2001 to 2013 period and assumed that industrial production in the rest of the world is strictly exogenous and that the exchange rate is not contemporaneously affected by shocks to exports. They reported that a positive shock to world output increases Japanese transport equipment exports in subsequent months and that a positive exchange rate shock (yen appreciation) decreases transport equipment exports. They did not report the exact magnitude of the effect of exchange rate changes on transport equipment exports.

Chinn (2013) reported exchange rate elasticities for Japan's aggregate exports. He used Johansen maximum likelihood techniques and quarterly data on aggregate exports, real effective exchange rates, and rest of the world GDP over the 1990Q1-2013Q3 period. Real effective exchange rates were deflated by both the consumer price index and by unit labor costs. Rest of the world GDP was calculated as a weighted average of trading partners' GDP. He found evidence of a cointegrating relationship between the variables. He reported exchange rate elasticities of between 0.3 and 0.7. Reversion coefficients indicate that the disequilibrium between actual and long run exports closes at a rate of between 42% and 76% per quarter. This implies that there is a tight relationship between exports and the independent variables. Finally, he estimated the aggregate export equation over the 1990Q1-2007Q4 period and then forecasted exports using actual values of the independent variables over the 2008Q1-2012Q4 period. He found that the estimated model predicted exports fairly well during the GFC period and after, although by 2012Q4 actual exports were 6 percent less than predicted.

This paper reports exchange rate elasticities for Japanese automobile exports. It finds elasticities greater than unity in many specifications. To investigate why the yen depreciation beginning in 2012Q3 did not lead to a resurgence of automobile exports the paper employs out-of-sample forecasts using actual values of the exchange rate and other variables. The evidence indicates that exports did not rebound because Japanese automakers after the GFC relocated production out of Japan. In addition, evidence from exchange rate pass-through equations shows that exporters since 2012 have practiced a pricing-to-market (PTM) strategy as the yen has depreciated. This implies that the depreciation increases profit margins but not exports. Although exports since 2012 have not responded to the yen, findings from exchange rate exposure equations indicates that even in 2016 a stronger yen would cause auto industry profitability to tumble.

The next section uses dynamic ordinary least squares techniques to find trade elasticities for Japanese automobile exports. Section 3 employs pass-through equations to investigate the short run pricing behavior of Japanese transport equipment exporters. Section 4 estimates stock market exposure for every year from 2001 to 2016 to shed light on the changing effects of exchange rates on the profitability of the Japanese auto and auto parts industries. Section 5 concludes.

2. Estimating export elasticities using panel data

2.1 Data and methodology

In theory export demand should depend on the real exchange rate and real GDP in the importing countries. To investigate the relationship between these variables, this section employs Japan's automobile exports to 30 countries over the 1992-2015 period. The importing countries are: Australia, Austria, Brazil, Canada, China, Denmark, Finland, France, Germany, India, Indonesia, Ireland, Italy, Malaysia, Mexico, the Netherlands, Norway, the Philippines, Poland, Saudi Arabia, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, the United Kingdom, and the United States. Including many countries over a long period of time provides cross sectional and time series variation in the independent variables. This should lead to more precise estimates of the effects of the real exchange rates and real GDP on automobile exports.

To measure exports, annual data on Japan's motor vehicle exports (ISIC category 3410) are employed. These data are obtained from the CEPII-CHELEM database. Since these data are measured in U.S. dollars and since Japan's exports are imports in places like the U.S., exports are deflated using the U.S. Bureau of Labor Statistics import price deflator for motor vehicles.[1]

Data on bilateral real exchange rates between Japan and each of the importing countries and real GDP in the importing countries are obtained from the CEPII-CHELEM database. An increase in the exchange rate variable represents an appreciation of the yen.

Panel unit root tests indicate that the variables are integrated of order 1 (I(1)). Kao (1999) residual cointegration tests permit rejection of the null hypothesis of no cointegration at the 1 percent level. Dynamic ordinary least squares, a technique for estimating cointegrating relations, is thus employed.

The Mark and Sul (2003) weighted dynamic ordinary least squares (DOLS) estimator is used. The model takes the form:

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

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

[1] These data are obtained from www.bls.gov.

where $ex_{i,j,t}$ represents real exports from Japan to country *j*, $rer_{i,j,t}$ represents the bilateral real exchange rate between Japan and importing country *j*, and $y_{j,t}^{*}$ represents real GDP in country *j*. Cross-section specific lags and leads of the first differenced regressors are included to asymptotically remove endogeneity and serial correlation. A sandwich estimator is employed to allow for heterogeneity in the long-run residual variances. Individual specific fixed effects are included and individual specific time trends are included in one specification.

2.2 Results

Table 1 present the findings. Columns (1) through (4) present results with a heterogeneous time trend included and column (5) through (8) present results without a trend term. The sample period in all eight specifications begins in 1992. In columns (1) and (5) the sample period ends in 2012; in columns (2) and (6) it ends in 2013; in columns (3) and (6) it ends in 2014; and in columns (4) and (8) it ends in 2015.

The trade elasticities in every specification are of the expected signs and significant at the 1 percent level. The specifications including the heterogeneous trend term in columns (1) through (4) provide a better fit according to the standard error of the regression. Including this term thus captures important country-specific trends across the 30 markets.

The results including the time trend in columns (1) through (4) indicate that the yen exchange rate exerts important effects, with elasticities exceeding unity. GDP elasticities are also large, ranging from 1.8 to 2.4.

As the end of the sample expands from 2012 to 2015, the exchange rate elasticities in columns (1) through (4) become smaller. The GDP elasticities on the other hand become larger.

The Japanese real effective exchange rate depreciated by more than 35 percent following the implementation of Prime Minister Shinzo Abe's stimulus packages in the third quarter of 2012. The results in Table 1 imply that this should increase auto exports by about 35 percent. However, as Fig. 2 shows, the volume of automobile exports has not increased.

To investigate why, the specifications over the 1992-2013 period (columns (2) and (6) in Table 1) and actual out-of-sample observations of the independent variables in 2014 and 2015 are used to forecast exports in 2014 and 2015. When converted into value terms, the specification with a trend indicates that Japan's auto exports to the 30 countries in 2015 should equal \$90.6 billion. Japan's actuals exports were \$72.0 billion, implying a shortfall of \$18.6 billion. The specification without a trend indicates that Japan's auto exports in 2015 should equal \$101.1 billion, implying a shortfall of \$29.1 billion. For 2014, the specification with a trend indicates that Japan's auto exports to the 30 countries in 2014 should equal \$87.9 billion. Japan's actuals exports were \$72.6 billion, implying a shortfall of \$15.3 billion. The specification without a trend indicates that Japan's auto exports in 2014 should equal \$96.5 billion, implying a shortfall of \$23.9 billion. Thus the yen depreciation has not stimulated exports in the way that the model predicts.

For the specification with a trend, 74 percent of the shortfall in 2015 came from exports to the NAFTA countries (Canada, Mexico, and the U.S.). For the specification without a trend, 68 percent of the shortfall in 2015 came from exports to North America. In 2014, for the trend specification 71 percent of the shortfall was from exports to NAFTA and for the specification without a trend 68 percent of the shortfall was from exports to the U.S., Canada, and Mexico.

To shed light on what was happening in NAFTA countries, Fig. 3a shows the number of Japanese automobiles either produced in North America or exported from Japan to North

America before, during, and after the 2008-2009 global crisis. It also shows the share of Japanese cars produced in North America relative to the sum of Japanese cars produced in the NAFTA countries and exported from Japan to North America. The figure shows that, while the number of Japanese cars destined for the NAFTA countries plummeted during the crisis, it has since surpassed its pre-crisis values. The figure also shows that the share of Japanese cars produced in the NAFTA region rose 12 percentage points from 62 percent to 74 percent between 2006 and 2014. Japanese producers thus responded to the crisis and the strong yen by moving production to North America. This helps explain why exports from Japan have not recovered in the wake of the yen depreciation that began in 2012Q3.

Fig. 3b shows the number of Japanese automobiles either produced in the rest of the world (ROW) or exported from Japan to the rest of the world. It also shows the share of Japanese cars produced in the ROW relative to the sum of those produced in the ROW and those exported from Japan to the ROW. The figure shows that the share produced outside of Japan is even higher for the whole world than the share for North America in Fig. 3a. This makes sense since the cars exported from Japan tend to be higher-end products then the cars that Japan produces abroad, and North America being wealthier demands more high-end automobiles on average than other countries demand.[2]

The tendency for higher end cars to be produced in Japan as the industry offshores more production also explains why the price elasticities in Table 1 decline as the end of the sample expands from 2012 to 2015 and why the GDP elasticities increase. As the average quality of

[2] Shimizu and Sato (2015) reported that Japanese transport equipment and general machinery firms responded to the yen appreciation associated with the Global Financial Crisis by shifting lower-value added production overseas and producing differentiated and higher value-added goods in Japan.

exports from Japan increases, automobile exports compete less on price and tend to be purchased by consumers with higher incomes.

3. Investigating the short run pricing behavior of exporters

3.1 Data and methodology

For those cars exported from Japan, how have export prices varied as the yen has fluctuated? At one extreme, exporters could practice a pricing-to-market strategy. This implies that an appreciation of the yen would cause a one-for-one drop in yen export prices and squeeze firms' profit margins. At the other extreme, exporters could pass through the entire appreciation into foreign currency export prices. This would maintain profit margins but reduce export volumes.

Researchers have typically investigated the degree of pass through using a single equation model (see, e.g., Campa and Goldberg, 2005). In this framework, export prices should depend on firms' marginal costs (MC) and on their markups over MC.

Ceglowski (2010) used this framework to investigate the pricing behavior of Japanese exporters. She estimated the first difference of export prices as a function of current and lagged values of the first difference of the exchange rate, foreign prices, domestic costs, and economic activity in the destination market:

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

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

The Japanese yen price of exports for the transport equipment industry (p_j^x) is available from the Bank of Japan (BoJ).[3] The nominal exchange rate (e_j) is measured in three ways. First, the nominal effective exchange rate from the BoJ is used. Second, the nominal yen/dollar exchange rate is used. Third, the ratio of Japanese yen export prices for the transport equipment industry to export prices measured in the invoice currencies are used. The foreign price measure (p^f) is calculated by multiplying the BoJ real effective exchange rate series by the product of the nominal effective exchange rate and the Japanese corporate goods price index. Costs (c_j) are represented by the producer price index in the transport equipment industry. Economic activity in export markets (y^f) is measured by a geometrically weighted average of industrial production (IP) in nine key countries importing transport equipment from Japan. The time-varying weights used to calculate y^f are determined by the share of Japanese transport equipment going to each of the countries. Data on industrial production are obtained from the CEIC database.

These data are available starting in January 2000. The sample period extends from January 2000 to August 2016. The estimation begins with six lags of e_j , p^f , and c_j and y^f . To avoid overfitting, the lag length is then progressively reduced by one down to a minimum of two lags and the Schwarz Information Criterion is used to choose between the models.

[3] Unless otherwise stated, the data mentioned in this paragraph come from the Bank of Japan.

3.2 Results

Table 2 reports the sum of the coefficients on the contemporaneous and lagged first differences of the three exchange rate measures.[4] For the yen/dollar measure and the ratio of Japanese yen export prices to contract currency export prices, a positive coefficient implies that an appreciation would lower Japanese yen export prices. For the BoJ nominal effective exchange rate, a negative coefficient implies that an appreciation would lower Japanese yen export prices.

The signs of the coefficients in all three cases indicate that an appreciation of the yen would lower Japanese yen export prices. All three coefficients are significant at the one percent level. The results imply that a 10 percent appreciation of the yen would lower yen export prices for transport equipment by between 5.9 and 9.4 percent. These findings imply that Japanese transport equipment exporters only pass through a small share of exchange rate appreciations into foreign currency prices.

The effect is largest when the exchange rate is measured as the ratio of Japanese yen export prices to contract currency export prices. Shimizu and Sato (2015) noted that this is a good measure to include in pass-through equations. If this is true, then the results in Table 2 imply that yen appreciations cause large declines in export prices for transport equipment. This pricing-to market behavior implies severe pressure on exporters' margins in the face of large appreciations.

Fig. 4 sheds light on this issue. It shows Japanese yen export prices for transport equipment compared to the domestic producer price index for transport equipment. The

[4] Results for the other variables are available on request.

domestic producer price index proxies for producers' costs.[5] The figure shows that there was a huge drop in yen prices relative to yen costs. The figure also shows that the export price index moves very closely with the exchange rate. This implies that yen appreciations erode profit margins for transport equipment exporters.

Fig. 5 indicates that the yen depreciation beginning in the third quarter of 2012 has had the opposite effect. The figure shows the exchange rate coefficient from rolling regressions of equation (2) over 44-month periods beginning with the April 2000 to November 2003 subsample and extending month by month until the September 2012 to April 2016 subsample. The figure indicates that the exchange rate coefficients were less precisely estimated during the Global Financial Crisis period and more precisely estimated during the period of yen depreciation beginning in 2012. This is not surprising, since the GFC period included huge inventory changes and other temporary shocks that affected pricing behavior. During the yen depreciation period beginning in 2012, the point estimates are close to unity, implying that auto exporters followed a pricing-to-market strategy at this time. As Shimizu and Sato (2015) have noted, by choosing not to lower prices in destination countries after 2012, Japanese exporters attenuated the impact of the yen depreciation on exports. They responded instead to the yen depreciation by allowing yen export prices and thus profit margins to increase. To further investigate the effect of exchange rates on profitability, the next section investigates how exchange rates affect stock returns.

4. The Exchange rate exposure of automobile stock returns

4.1 Data and methodology

[5] To the extent that the producer price index is calculated using hedonic methods, it will be an imperfect measure of actual costs.

Another way to examine how exchange rates affect industry profitability is to investigate how exchange rate changes affect industry stock returns (see, for example, Dominguez and Tesar, 2006, or Jayasinghe and Tsui, 2008). This is useful because theory teaches that stock prices should equal the expected present value of future net cash flows. Investigating how changes in the yen affect automobile stock returns can thus indicate how exchange rates affect profitability in the auto industry.

Exchange rate exposures can be estimated by regressing industry stock returns ($\Delta R_{i,t}$) on exchange rate changes (Δe_t) and on changes in aggregate stock market returns ($\Delta R_{M,t}$):

$$\Delta R_{i,t} = \alpha_i + \beta_{i,e}\,\Delta e_t + \beta_{i,M}\,\Delta R_{M,t} + \varepsilon_{i,t}\ . \qquad (3)$$

This model is estimated for the automobile and automobile parts industries.

Stock return data for these sectors are obtained from the Datastream database. Industry stock returns are calculated as the daily change in the natural log of the industry stock index. Following Chamberlain, Howe, and Popper (1997), the yen/dollar rate is used to estimate exposures. The daily change in the natural log of the yen/dollar exchange rate is employed. The market index is measured as the daily change in the natural log of the Tokyo Stock Price Index (TOPIX). The TOPIX is a capitalization-weighted index that include 1,700 of the most important Japanese companies.

The sample period extends from 26 September 2001 to 23 September 2016. There are 3913 observations.

4.2 Results

Table 3 presents the results. Column (2) presents the exchange rate exposures and column (3) presents the market exposure. Positive values of the exchange rate exposure in column (2) imply that a weaker yen raises stock returns.

Both of the coefficients on the exchange rate indicate that a yen depreciation raises returns and both are significant at the 1 percent level. For automobile stocks, the results indicate that a 1% appreciation of the yen would reduce stock returns by 0.39 percent. For auto parts stocks, the results indicate that a 1% appreciation would reduce returns by 0.30 percent. The yen appreciated logarithmically by 47 percent between the end of June 2007 and the end of September 2011. The result in Table 3 indicate that this appreciation caused auto stocks to fall by 18.5 percent. Thus, the automobile sector is significantly exposed to an appreciation of the yen.

The results in Section 2 imply that exports have become less important for the Japanese automobile industry as more production is relocated abroad. Has the exposure of Japanese automobile stocks to the yen also declined? To investigate this, exposures are estimated using rolling regressions, where the first coefficient represents the value from a regression over the 9/26/2001 to 9/11/2002 period, the second value represent the coefficient from a regression over the 9/27/2001 to 9/12/2002 period, and so on. The results are presented in Fig. 6.

Values from 2016 are the highest since 2004. They indicate that a 1 percent yen appreciation in 2016 would reduce stock returns by 0.62 percent. The yen thus continues to exert important effect on automotive stock returns.

Japanese manufacturers responded to the yen appreciation following the Plaza Accord by shifting labor-intensive assembly operations to lower-wage locations and then sending parts and components from Japan to these lower wage countries. Thus as final production was relocated abroad, parts produced in Japan continued to be in demand. Does a similar phenomenon explain why auto parts stocks in Table 3 are less exposed to a yen appreciation than automobile stocks?

Fig. 7 sheds light on this question. The figure plots coefficients on the yen/dollar exchange rate from estimating equation (3) using either automobile stocks or auto parts stock as the dependent variable. The value for 2002 represents the coefficient from a regression over the 9/26/2001 to 9/23/2002 period, the value for 2003 represents the coefficient from a regression over the 9/26/2002 to 9/23/2003 period, and so on. The figure shows that, in the early 2000s, automobile stocks were much more exposed to a yen appreciation than automobile parts stocks. Thus, if the strong yen caused exporters in the early 2000s to offshore assembly, the effect on parts producers was not as strong. Since the Global Financial Crisis of 2008-2009, however, auto stocks and auto parts stocks have responded very similarly to changes in the yen.

One reason for this is that Japanese automakers producing overseas may have become less dependent on parts produced in Japan. For instance, cars.com reported in 2016 that the top 5 models sold in America ranked by variables such as domestic parts content are the Toyota Camry, the Honda Accord, the Toyota Sienna, the Honda Odyssey, and the Honda Pilot. The cars.com ranking includes all American and foreign brands sold in America.[6] Thus, for many models produced in America, Japanese automakers are procuring more parts locally and fewer parts from Japan.

A second reason why Japanese auto parts producers are more exposed to the yen now is that parts producers have begun selling more to foreign auto producers in recent years.[7] To the

[6] Their website is https://www.cars.com/.

[7] For instance, the largest Japanese automobile parts maker, Denso, is increasingly selling to foreign automakers (see, e.g., Greimel, 2014).

extent that these sales are invoiced in foreign currencies, an appreciation of the yen will reduce profit margins for auto parts makers and lower stock prices.

5. Conclusion

The volume of Japanese exports tumbled during the Global Financial Crisis. Despite the 30 percent depreciation of the yen that began in the third quarter of 2012, exports have not recovered.

To investigate why, this paper focuses on the automobile industry. There are several advantages to investigating this sector. Automobiles are Japan's most important export category year after year. By focusing on an individual sector, it is also possible to attenuate the downward bias that arises when estimating price elasticities using aggregate data. By investigating a final goods export, one can finesse the difficulties of examining how exchange rates affect parts and components exports that are sent to downstream countries that produce final goods for re-export to third markets.

Panel DOLS results indicate that Japanese motor vehicle exports are very sensitive to exchange rates. Estimated exchange rate elasticities in many specifications exceed unity. Nevertheless, the yen depreciation starting in 2012 has not revived exports partly because Japanese automobile producers relocated production overseas. In addition, regression evidence indicates that auto exporters during the depreciation period followed a pricing-to-market strategy rather than lowering foreign currency export prices. This raises profit margins but not the volume of exports.

The paper also reports that exchange rate appreciations cause large declines in automobile stock prices. The response in 2016 was stronger than at any point since 2004.

Why does an appreciation of the yen cause such large drops in Japanese auto stock returns even in 2016? One reason could be that, as the yen appreciates, the yen value of profits repatriated from abroad falls. A second reason could be that a yen appreciation decreases the yen value of Japanese automakers' plant and equipment that are located outside of Japan. A third reason could be that pricing-to-market strategies cause profitability to be closely related to exchange rates. A fourth reason could be that a strong yen reduces exports. Future research should investigate why Japanese automobile stock returns are more exposed to the value of the at present than at any time over the last 12 years.

Table 1
Panel DOLS estimates of Japan's auto exports to 30 countries.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bilateral Real Exchange Rate	-1.20***	-1.21***	-1.13***	-1.06***	-0.93***	-0.90***	-0.72***	-0.60***
	(0.08)	(0.07)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(010)
Real GDP (ULC-deflated)	1.77***	1.84***	2.14***	2.43***	0.62***	0.61***	0.67***	0.60***
	(0.29)	(0.28)	(0.26)	(0.26)	(0.11)	(0.11)	(0.11)	(0.11)
Adjusted R-squared	0.954	0.950	0.948	0.945	0.901	0.894	0.885	0.880
S.E. of regression	0.31	0.32	0.33	0.33	0.45	0.46	0.48	0.49
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Heterogeneous Linear Trend	Yes	Yes	Yes	Yes	No	No	No	No
Sample Period	1992-2012	1992-2013	1992-2014	1992-2015	1992-2012	1992-2013	1992-2014	1992-2015
No. of Observations	630	660	690	720	630	660	690	720

Notes: The number of leads and lags of the first differences of the independent variables is determined by the Schwarz Information Criterion. An increase of the bilateral real exchange rate implies an appreciation of the Japanese yen. The predicted sign of the coefficient is negative.
*** denotes significance at the 1% level.

Table 2

The effect of exchange rate changes on Japanese yen export prices for transport equipment.

(1)	(2)	(3)
Exchange Rate Measure	Sum of Coefficients	Standard Error
Yen/dollar Nominal Exchange Rate	0.59***	0.05
Bank of Japan Nominal Effective Exchange Rate	-0.68***	0.04
Yen Export Prices ÷ Export Prices in Invoice Currencies	0.94***	0.06

Notes: The values in the second column are the sum of the coefficients on the contemporaneous first difference of the exchange rate and lagged first differences of the exchange rate. The number of lags is determined by the Schwarz Information Criterion. For the Bank of Japan exchange rate, an increase represents a yen appreciation and for the other two exchange rate measures, an increase represents a depreciation. The sample period for the estimation extends from April 2000 to April 2016. Heteroskedasticity-consistent standard errors are in parentheses. *** denotes significance at the 1% level.

Table 3
Exchange rate exposure by sector.

(1)	(2)	(3)
Industry	Yen/dollar rate	TOPIX Index
Automobile	0.39***	1.03***
	(0.03)	(0.02)
Auto Parts	0.30***	1.08***
	(0.03)	(0.02)

Notes: The coefficients come from a regression of daily stock returns on the daily yen/dollar nominal exchange rate and the daily return on the Tokyo Stock Price Index (TOPIX) Market Index. The data come from Datastream. The sample period extends from 9/26/2001 to 9/23/2016. There are 3913 observations. Heteroroskedasticity-consistent standard errors are in parentheses.
*** (**) [*] denotes significance at the 1% (5%) [10%] level.

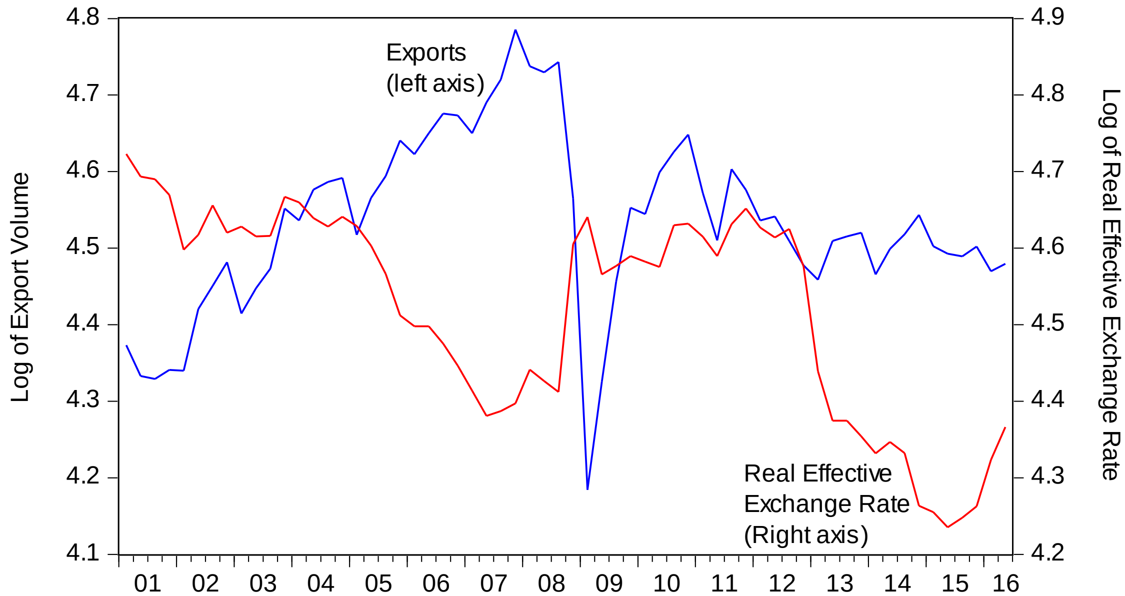

Fig. 1. Volume of Japanese exports to the world and IMF CPI-deflated real effective exchange rate.

Source: CEIC database.

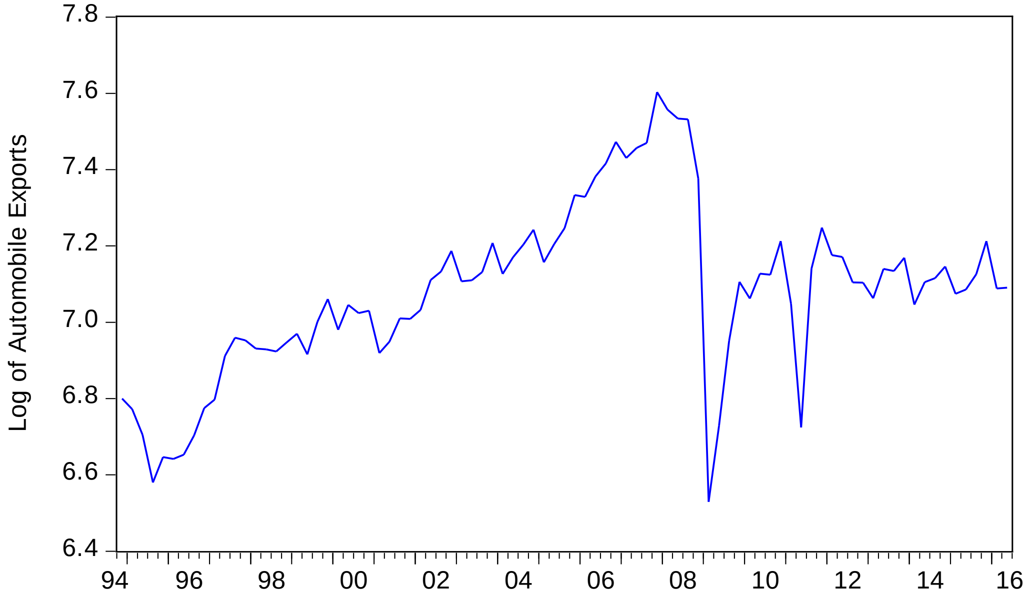

Fig. 2. Volume of Japanese automobile exports to the world. Source: CEIC database.

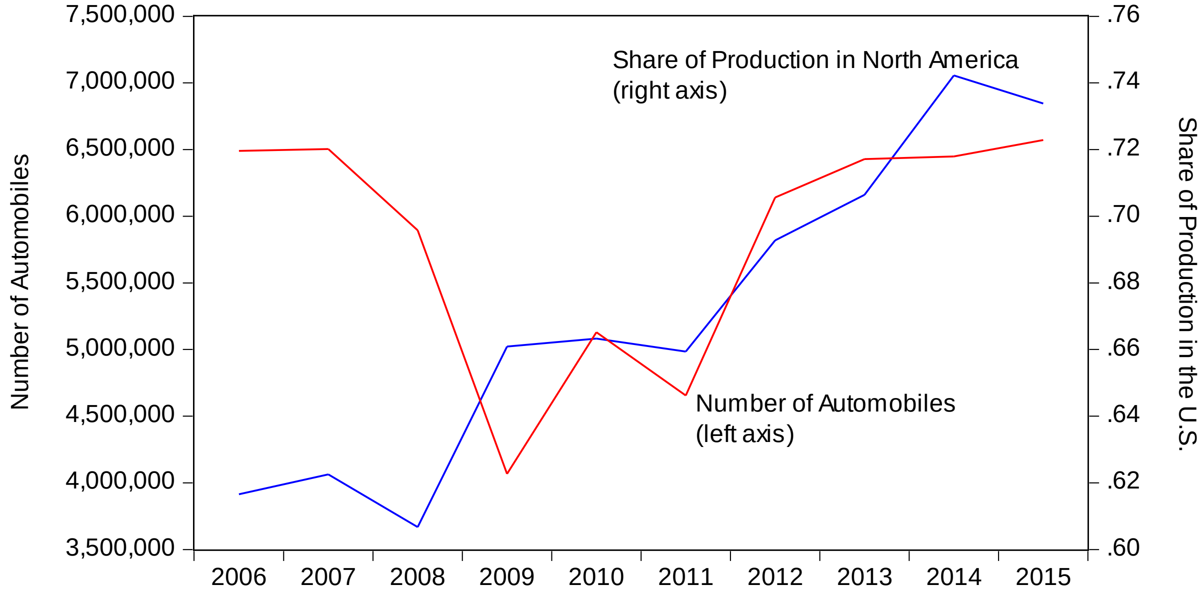

Fig. 3a. Japanese automobiles produced in North America or exported from Japan to North America and share of Japanese automobiles produced in North America.

Source: Japanese Automobile Manufacturers Association.
Notes: Share of production in North America represents North American production by Japanese automobile manufacturers divided by the sum of North American production by Japanese manufacturers and automobile exports from Japan to North America. North America includes Canada, Mexico, and the U.S.

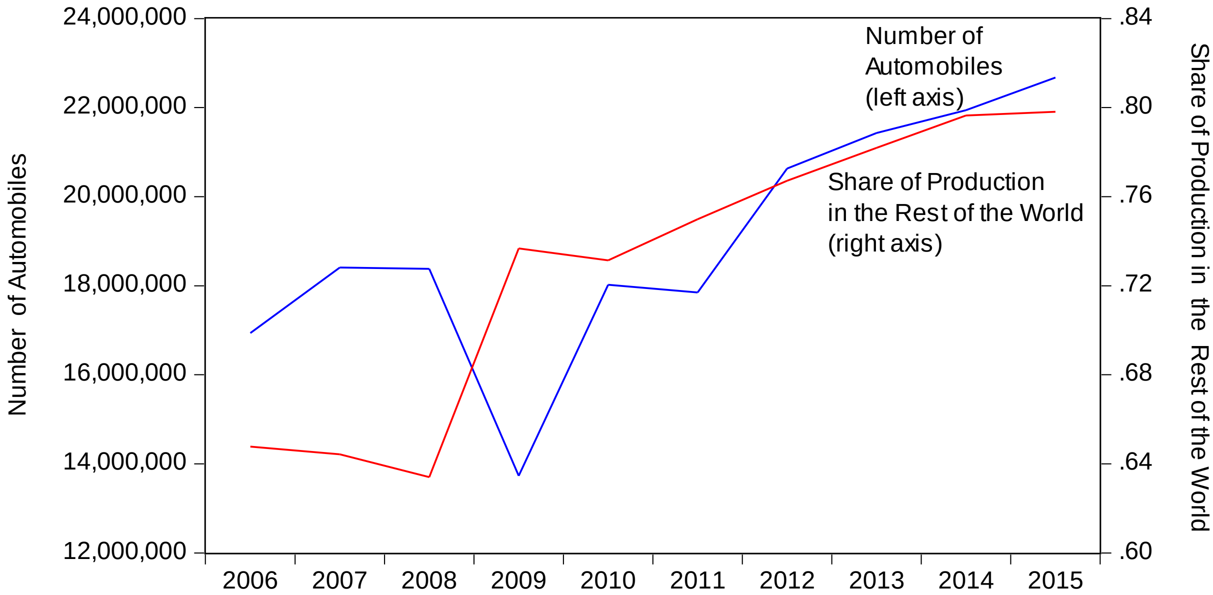

Fig. 3b. Japanese automobiles produced in the rest of the world or exported from Japan to the rest of the world and share of Japanese automobiles produced in the rest of the world.

Source: Japanese Automobile Manufacturers Association.
Notes: Share of production in the rest of the world represents production by Japanese automobile manufacturers outside of Japan divided by the sum of foreign production by Japanese manufacturers and automobile exports from Japan to the rest of the world.

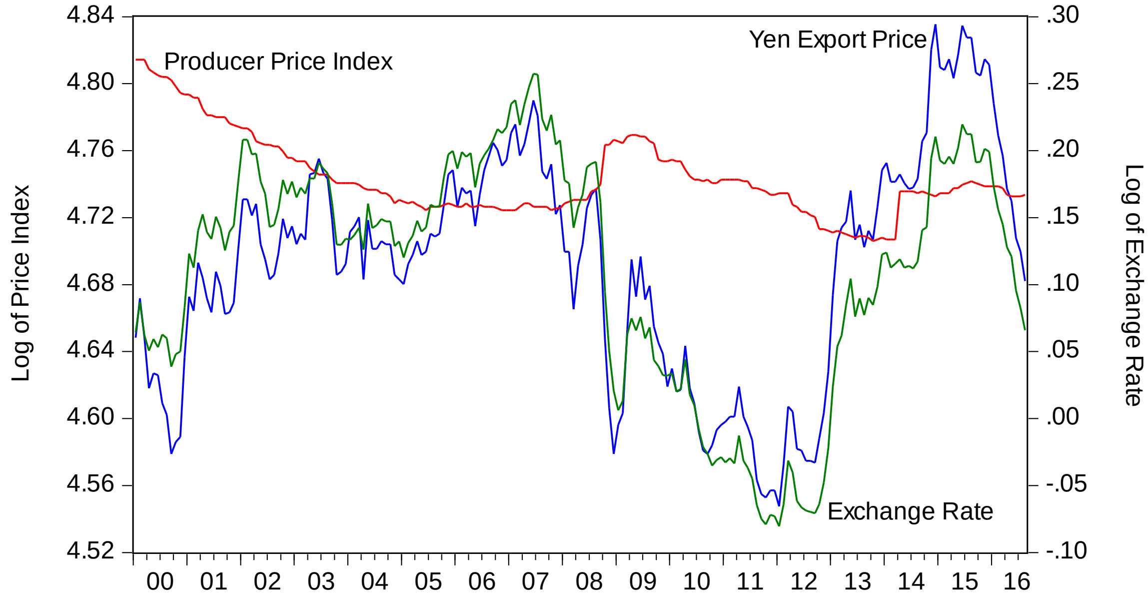

Fig. 4. Japanese yen export prices, Japanese yen producer price index, and nominal effective exchange rate for the transport equipment.

Source: Bank of Japan and author's calculations.
Notes: The nominal effective exchange rate for transport equipment exports is calculated as the ratio of Japanese yen export prices for the transport equipment industry to export prices measured in the invoice currencies.

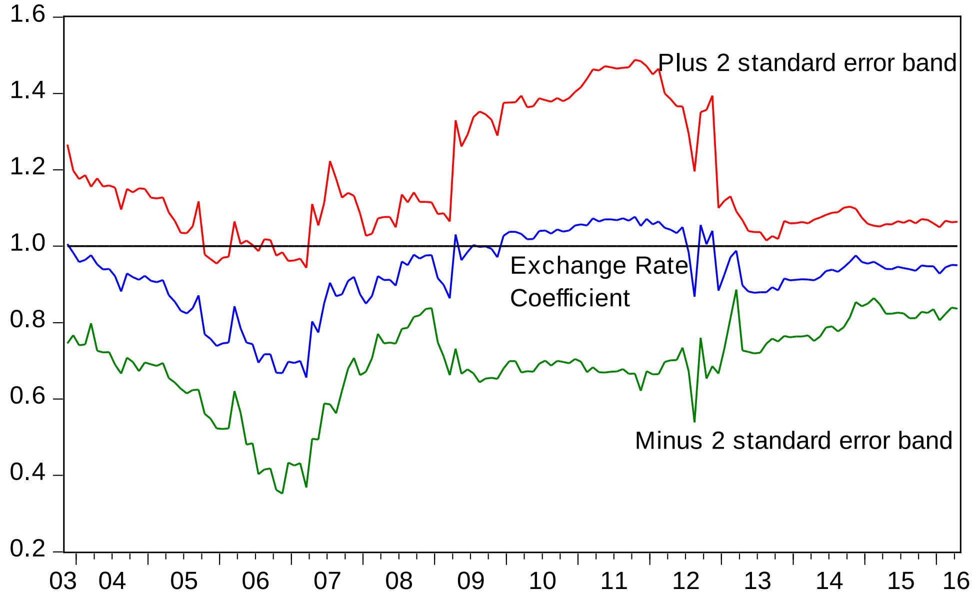

Fig. 5. The effect of exchange rate changes on Japanese yen export prices for transport equipment.

Source: Datastream database, Bank of Japan, and author's calculations.
Notes: The exchange rate coefficient represents the sum of the coefficients on the contemporaneous first difference of the exchange rate and lagged first differences of the exchange rate in a regression of the first difference of Japanese yen export prices for transport equipment on contemporaneous and lagged first differences of exchange rates, foreign prices, producer prices for Japanese transport equipment, and industrial production in importing countries. The exchange rate is measured as the ratio of the Japanese yen export prices for the transport equipment industry to export prices measured in the invoice currencies. The exchange rate coefficients are calculated using rolling regressions over 44 month periods. The standard error bands are calculated using heteroskedasticity-consistent standard errors.

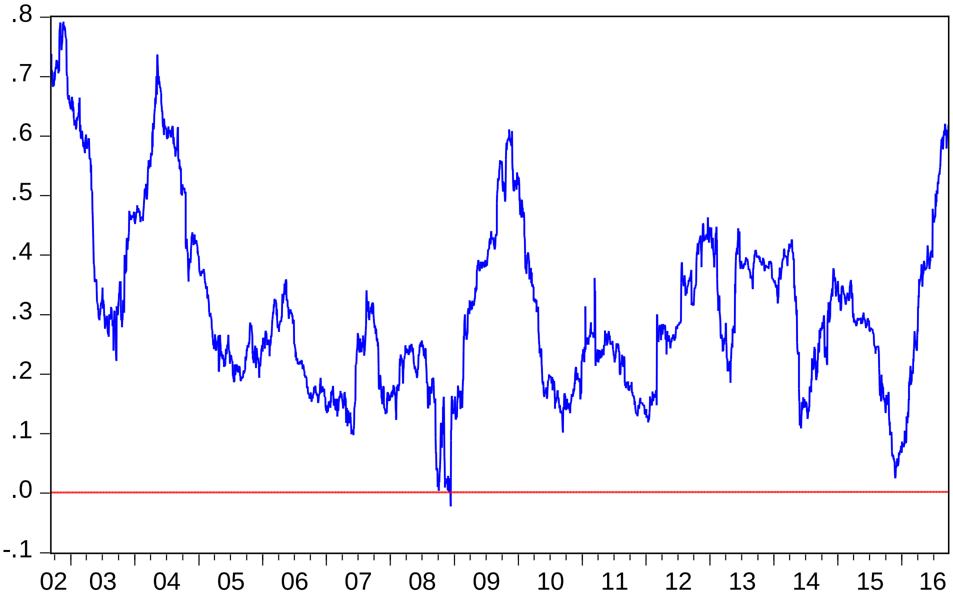

Fig. 6. Exposures of Japanese automobile stocks to the yen/dollar nominal exchange rate.

Source: Datastream database, Bank of Japan, and author's calculations.
Notes: The figure reports rolling regression coefficients on the yen/ dollar exchange rate from a regression of either automobile stock returns on the yen/dollar nominal exchange rate and the Tokyo Stock Price Index (TOPIX) Market Index. The first value represents the coefficient from a regression over the 9/26/2001 to 9/11/2002 period, the second value represent the coefficient from a regression over the 9/27/2001 to 9/12/2002 period, and so on.

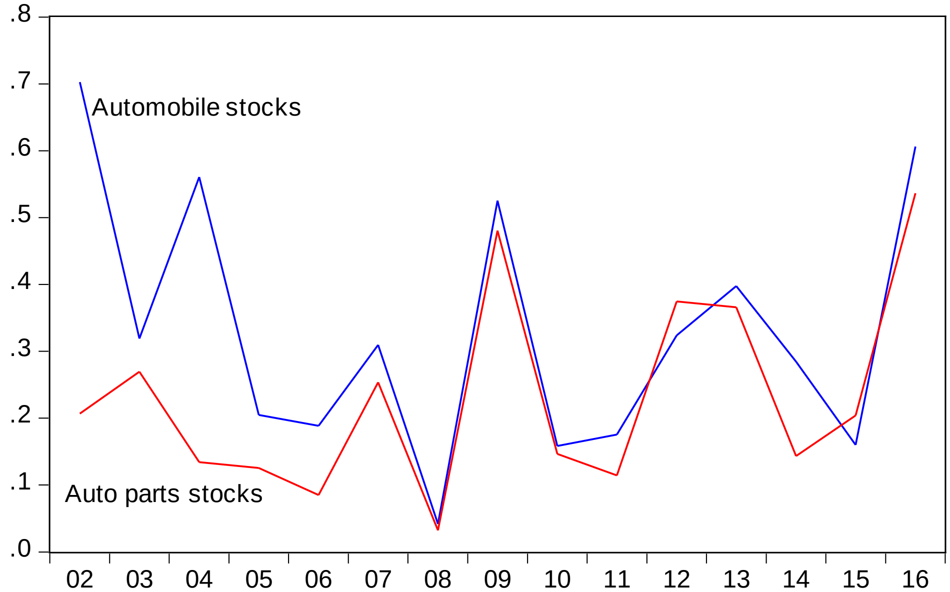

Fig. 7. Exposures of Japanese automobile stocks and Japanese auto parts stocks to the yen/dollar nominal exchange rate.

Source: Datastream database, Bank of Japan, and author's calculations.
Notes: The figure reports regression coefficients on the yen/ dollar exchange rate from a regression of either automobile stock returns or auto parts stock returns on the yen/dollar nominal exchange rate and the Tokyo Stock Price Index (TOPIX) Market Index. The value for 2002 represents the coefficient from a regression over the 9/26/2001 to 9/23/2002 period, the value for 2003 represents the coefficient from a regression over the 9/26/2002 to 9/23/2003 period, and so on.

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