The Japanese trade balance and asymmetric effects of yen fluctuations: Evidence using nonlinear methods

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\textbf{A B S T R A C T}

Over the last four decades, numerous studies have employed the newest empirical methods to examine the role of exchange-rate depreciations and appreciations on international trade flows. In recent years, innovations in cointegration analysis have allowed for the estimation of nonlinear effects, particularly whether appreciations and depreciations have differing impacts on a country's trade balance. This study examines these effects for Japanese bilateral trade with 12 partners. Applying the linear Autoregressive Distributed Lag (ARDL) of Pesaran et al. (2001) as well as nonlinear ARDL method of Shin et al. (2014) to quarterly time-series data, we find that the nonlinear method registers more effects. While the linear approach shows that Japan's trade balance improves in the long run following a yen depreciation for three countries, seven countries respond when the nonlinear method is applied. This effect is asymmetric in most cases—meaning that trade responds differently to currency appreciations as compared to depreciations.

\textbf{1. Introduction}

Since the era of floating exchange rates ended nearly 45 years ago, economists around the world have sought to understand the impact of exchange-rate fluctuations on international trade flows. While standard theory predicts that currency depreciations or devaluations will make exports cheaper and imports more expensive—thereby improving a country's trade balance—certain rigidities keep this process from occurring immediately. Because of fixed contracts, for example, the dollar value of exports declines while quantities remain the same. This temporary reduction prior to an increase in the trade balance has been labeled the "J-Curve" effect.

The J-curve effect was pioneered by Magee (1973), with Bahmani-Oskooee (1985) laying the foundation for a novel empirical test. The current definition of the J-curve, where the short-run and long-run coefficients of the exchange rate in a model of the trade balance are opposite in sign, was introduced by Rose and Yellen (1989). The amount of empirical research on this topic is staggering, as is described in reviews by Bahmani-Oskooee and Ratha (2004) and Bahmani-Oskooee and Hegerty (2010). In recent years, cointegration analysis has been performed, for various trade partners and individual products, but currency movements often have mixed effects on countries' trade balances. Many results are insignificant. Bahmani-Oskooee and Goswami (2003) find that out of nine major trading partners, Japan exhibits a "J-Curve" pattern with only two. Bahmani-Oskooee and Hegerty (2009), for example, find this to be the case for Japanese-U.S. trade in a number of individual industries. Given the introduction of nonlinear

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cointegration methods, perhaps further relationships between exchange rates and trade can be uncovered using these recent techniques.

This study examines Japan’s bilateral trade with 12 major partners, applying the nonlinear Autoregressive Distributed Lag (ARDL) method of Shin, Yu, and Greenwood-Nimmo (2014), which extends the linear approach of Pesaran, Shin, and Smith (2001) to include asymmetric effects. Using this technique, we can see whether yen appreciations affect trade differently than do yen depreciations. Our results show that, even accounting for nonlinearities, the impact is still limited. Only seven countries register an effect, and this effect is asymmetric for five of them.

Our paper proceeds as follows. Section 2 describes the empirical methodology, and Section 3 describes the results. Section 4 concludes, and data are described in the Appendix.

2. Methodology

Using quarterly data over the period from 1973 to 2014, we model Japan’s trade balance \((TB^i = M^i/X^i)\) with trading partner \(i\) as a function of Japanese income \((Y^i_{Japan})\), a partner’s income \((Y^i)\), and the real exchange rate with partner \(i\), \(REX^i\). We expect domestic income growth to increase Japanese imports, reducing the trade balance, while partner’s growth will improve it. As the Appendix reveals, the real exchange rate is depicted in such a way that a yen depreciation is reflected in a decline in the bilateral rate. Hence we expect a positive long-run relation between our definition of the trade balance and the real bilateral exchange rate.

Applying the Autoregressive Distributed Lag (ARDL) approach to cointegration and error-correction introduced by Pesaran et al. (2001), we estimate our trade balance model as follows:

\[
\Delta \ln TB^i_t = \alpha + \sum_{j=1}^{4} \beta_j \Delta \ln TB^i_{t-j} + \sum_{j=0}^{4} \gamma_j \Delta \ln Y^i_{Japan} + \sum_{j=0}^{4} \delta_j \Delta \ln Y^i_{t-j} + \sum_{j=0}^{4} \eta_j \Delta \ln REX^i_{t-j} + \theta_1 \ln TB^i_{t-1} + \theta_2 \ln Y^i_{t-1} + \theta_3 \ln REX^i_{t-1} + \epsilon_t.
\]  

(1)

Here, short-run and long-run variables are combined in a single equation; this allows us to look for any sort of “J-Curve” effect. We expect that Japanese income will increase \(TB\), while foreign income will reduce it. Since an appreciating yen will increase Japanese imports and reduce exports, the coefficient on \(REX\) should be positive in the long run.

Long lengths \(n\) are chosen by minimizing the Akaike Information Criterion. Short-run effects are calculated using the coefficients on the difference terms, while long-run effects are derived from the lagged level variables and normalized by \(\theta_j\). These level terms are also used for a cointegration test; if they are jointly significant in an OLS estimation of Eq. (1), we can say there is a long-run relationship among the variables. If the F-statistic on the joint test falls above the “upper bound” critical value (calculated using Monte Carlo methods), then the variables can be said to be cointegrated.

Next, we apply our nonlinear model that allows for asymmetries in the impact of exchange-rate movements. Following Bahmani-Oskooee and Fariditavana (2015, 2016) and Shin et al. (2014), we first generate changes in \(\ln REX\) as \(\Delta \ln REX\) which includes positive changes reflecting yen appreciation and negative changes reflecting yen depreciation. From these changes we now construct two new time-series variables as partial sums of positive and negative changes as follows:

\[
POS_t = \sum_{j=1}^{n} \Delta \ln REX^+_j = \sum_{j=1}^{n} \max(\Delta \ln REX^+_j, 0)
\]  

(2)

\[
NEG_t = \sum_{j=1}^{n} \Delta \ln REX^-_j = \sum_{j=1}^{n} \min(\Delta \ln REX^-_j, 0)
\]  

(3)

We then replace \(\ln REX\) in Eq. (1) with the \(POS\) and \(NEG\) components, resulting in the following specification:

\[
\Delta \ln TB^i_t = \alpha + \sum_{j=1}^{4} \beta_j \Delta \ln TB^i_{t-j} + \sum_{j=0}^{4} \gamma_j \Delta \ln Y^i_{Japan} + \sum_{j=0}^{4} \delta_j \Delta \ln Y^i_{t-j} + \sum_{j=0}^{4} \eta_j \Delta POS_{t-j} + \sum_{j=0}^{4} \kappa_j \Delta NEG_{t-j} + \theta_1 \ln TB^i_{t-1} + \theta_2 \ln Y^i_{t-1} + \theta_3 \ln REX^i_{t-1} + \theta_4 POS_{t-1} + \theta_5 NEG_{t-1} + \epsilon_t
\]  

(4)

This nonlinear ARDL model where nonlinearity is introduced by way of constructing \(POS\) and \(NEG\) variables can be estimated in the same way as Eq. (1), with the “bounds test” (F-test) for cointegration still appropriate. We can then test for asymmetries, defined here as cases in which the \(POS\) and \(NEG\) coefficients are different in size and in sign, in the short run and long run. Overall, we find that the nonlinear approach uncovers more—and often asymmetric—effects than does the linear model.\(^1\)\(^2\)\(^3\)\(^4\)

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\(^1\) Following the literature, specifically Bahmani-Oskooee (1991), we measure the trade balance as a ratio so that we can specify the model in log form. It has been argued that the log specification better fits macro and trade data and yields elasticity estimates. The ratio is also unit-free. After all, Himarios (1989) has shown that the results could be sensitive to units of measurement of the trade balance.

\(^2\) In Eq. (1), it is assumed that \(TB\) depends upon Japan’s income \((Y^i_{Japan})\), the trading partner’s income \((Y^i)\), and the real bilateral exchange rate \((REX^i)\). As stated in the Appendix, since \(TB\) is defined as Japanese imports from partner \(i\) over its exports to the same partner, and a decline in \(REX\) signifies yen depreciation, the expected sign of the normalized long-run coefficients are as follows: \(\hat{\beta}_1 > 0; \hat{\beta}_2 < 0; \hat{\beta}_3 > 0; \hat{\beta}_4 > 0\).

\(^3\) Since the critical values do account for integrating properties of variables, there is no need for pre-unit root testing, and variables could be combination of \(I(0)\) and \(I(1)\). Indeed, an application of the ADF test revealed that there is no \(I(2)\) variable in any of our models. For other applications of this approach, see Halicioglu (2007), Payne (2008), Dell’Anna and Halicioglu (2010), and Hajjies and Al-Nasser (2014).

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