

Global Financial Crisis of 2008, Asymmetric Effects of Exchange Rate Changes, and Stability of the Demand for Money in Japan

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Abstract: We wonder if Global Financial Crisis of 2008 affected stability of the demand for money in Japan. In testing this hypothesis we deviate from previous studies which either excluded the exchange rate from money demand function in Japan or have not been able to find any significant relation between the exchange rate and the demand for money. While we address stability of the demand for money, we show that failure to find a cointegrating relation or significant effects could be due to assuming a linear model in which exchange rate changes have symmetric effects. Once we consider a nonlinear ARDL approach of Shin *et al.*'s (2014), we show that not only variables in the money demand are cointegrated but exchange rate changes have asymmetric effects. In the long run, while appreciation of yen has significantly positive effect on the demand for money in Japan, depreciation does not. We also find a stable money demand which was not affected by 2008 financial crisis.

Keywords: Nonlinear ARDL Approach, Symmetry versus Asymmetry, Money Demand, Japan.

I. INTRODUCTION

Monetary policy is said to be effective if it results in changes in prices and output in theoretically expected direction. Such effectiveness requires that the velocity of money to be stable. Since velocity represents the linear combination of all the variables in the money demand function, establishing stability of velocity amounts to testing for stability of the demand for money. In testing for stability of the demand for money, whenever researchers have come short, they have tried to include some missing variables in their specification. For example, McNown and Wallace (1992) who investigated the stability of M1 and M2 demand for money in the U.S. concluded that "long-run stationarity of the demand function for M2 (but not M1) requires inclusion of the effective exchange rate". Of course, we must recognize that Mundell (1963, p. 484) was the first who argued that the demand for money could depend upon the exchange rate in addition to interest rate and income, though without any empirical support. Many other studies have followed this path and included the exchange rate in their specification of money demand function. The list includes Arango and Nadiri (1981) for Canada, Germany, UK., the US., Domowitz and Elbadawi (1987) for Sudan, Marquez (1987) for Venezuela, Bahmani-Oskooee and Malixi (1991) for 13 developing countries, Karfakis (1991) for

Greece, Bahmani-Oskooee (1996) for Iran, Civcir (2003) for Turkey, Harb (2004) for six oil producing countries, and Bahmani-Oskooee *et al.* (2012) for China.

The literature on the demand for money is so vast that each country has its own literature. Since this paper is about money demand in Japan, a brief review is in order so that we can highlight contribution of this paper. We classify Japan-related studies into two groups. The first group includes studies that did not include the exchange rate in their specification and the second group includes those that did include the exchange rate. Fair (1987) estimated a money demand function in which only income and interest rate were included as determinants. Japan was one of 27 countries in the sample. While income carried an insignificant coefficient, interest rate carried a significantly negative but very small (-0.005) coefficient. Since Fair (1987) did not test for integrating properties of variables nor did he test for cointegration among the variables, his findings could be considered spurious.¹ To remedy the situation, Hoffman *et al.* (1995) employ Johansen's cointegration approach and estimate the M1 demand for money in five industrial countries that included Japan. After imposing a unitary income elasticity, they estimate the interest rate elasticity to be about -0.5. They not only establish cointegration among variables, but also show that estimates are

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¹There was no indication whether Fair (1987) used M1 or M2 definition of the money supply.

stable. Note that Hoffman *et al.* (1995) estimated the money demand recursively by shifting observations. If their trace statistic was adjusted by the factor proposed by Cheung *et al.* (1993), cointegration would have disappeared in several cases for Japan. As for M2 demand for money in Japan, Miyao (1996) used three alternative cointegration methods to show that real M2 monetary aggregate in Japan is not cointegrated with real output and nominal interest rate. Similar results (lack of cointegration) between real M2, real income, and interest rate was also found by Bahmani-Oskooee (2001) who used Pesaran *et al.*'s (2001) Autoregressive Distributed Lag (ARDL) approach.

Can we support cointegration between real M2, income and interest rate in Japan if we include the exchange rate in our specification, an approach similar to that of McNown and Wallace (1992) for the U.S.? That is exactly what Bahmani-Oskooee and Shabsigh (1996) did by using Johansen's cointegration method. Without including nominal effective exchange rate in their specification, they find no cointegration among real M2, real income and interest rate in Japan. However, when nominal effective exchange rate is added, cointegration is supported. They then reported an income elasticity of 1.02, an interest rate elasticity of -0.42 and an exchange rate elasticity of 0.33. However, since they failed to report results from Johansen's exclusion test, it is not clear which determinant of the demand for money was significant or which variables were responsible for cointegration. After all, cointegration could be due to strong relation between some of the variables and not all of the variables.²

Some of the above studies that included the exchange rate in their specifications have assumed that the effects of exchange rate changes are symmetric, i.e., if currency depreciation results in an increase in demand for domestic currency, appreciation should result in a decrease and by the same proportion. How valid is this assumption? Could exchange rate changes have asymmetric effects due to different response by public to exchange rate changes? It is the main purpose of this paper to answer these questions by considering the demand for real M2 in Japan one more time. Since answering symmetry effects versus asymmetry effects will require using

nonlinear dynamic adjustment process, this study could be considered the first to apply such nonlinear method to demand for money in Japan. To that end, in Section II we introduce the models and estimation method. We report the results in Section III and summarize the paper in Section IV. Finally, we cite the source of the data and definition of the variables in an Appendix.

II. THE MODELS AND METHODS

As mentioned above Bahmani-Oskooee and Shabsigh (1996) estimated the demand for real M2 in Japan by including real income (Y), nominal interest rate (r), and nominal effective exchange rate (EX) as long-run determinants. Therefore, here we adopt their specification outlined by equation (1):

$$\ln M_t = a + b \ln Y_t + c \ln r_t + d \ln EX_t + \varepsilon_t \quad (1)$$

where M is a measure of real M2. Real income (Y) is included to account for transaction demand for money and interest rate (r) is included to account for opportunity cost of holding money. We expect an estimate of b to be positive and that of c to be negative. Finally, the nominal effective exchange rate (EX) is included to account for currency substitution. By way of construction, a decline in EX signifies depreciation of Japanese yen or appreciation of foreign currencies. As foreign currencies appreciate or yen depreciates, domestic currency value of foreign assets rise and if this is perceived as an increase in wealth by Japanese, their consumption and thus, their demand for domestic money will increase, resulting in a negative estimate for d . On the other hand, as foreign currencies appreciate, if there are expectation of further appreciation, Japanese may hold more of foreign currency and less of domestic currency, hence a positive estimate for d .

Equation (1) is said to be a long-run model. In order for the estimates to be stable, almost all studies try to incorporate short-run dynamics by turning (1) into an error-correction specification. While estimate of equation (1) yields long-run estimates, estimate of an error-correction model yields short-run estimates. Therefore, one has to take two steps in applying cointegration and error-correction methods of Engle and Granger (1987) and Johansen (1988). However, in turning (1) into an error-correction model we follow Pesaran *et al.*'s (2001) bounds testing approach where estimating their specification yields both short-run and long-run coefficient estimates. As such, the following error-correction model is adopted:

²Note that similar results for Japan was also reported by Bahmani-Oskooee and Chomsisengphet (2002) who, again, applied Johansen's technique to M2 money demand in 11 industrial countries including Japan.

$$\begin{aligned} \Delta \ln M_t = & \alpha + \sum_{i=1}^{n1} \beta_i \Delta \ln M_{t-i} + \sum_{i=0}^{n2} \delta_i \Delta \ln Y_{t-i} + \sum_{i=0}^{n3} \phi_i \Delta \ln r_{t-i} \\ & + \sum_{i=0}^{n4} \eta_i \Delta \ln EX_{t-i} + \rho_0 \ln M_{t-1} + \rho_1 \ln Y_{t-1} + \rho_2 \ln r_{t-1} \quad (2) \\ & + \rho_3 \ln EX_{t-1} + \varepsilon_t \end{aligned}$$

Once (2) is estimated, short-run estimates are those coefficients that are attached to first-differenced variables. The long-run effects are obtained by estimates of ρ_1 - ρ_3 normalized on ρ_0 .³ However, for the long-run estimates not to be spurious, Pesaran *et al.* (2001) recommend applying the familiar *F* test to establish joint significance of lagged level variables as a sign of cointegration. They tabulate new critical values for the *F* test which accounts for integrating properties of variables. They also demonstrate that their upper bound critical value could be used when we have combination of *I*(0) and *I*(1) variables.⁴ This is another advantage of this approach over Engle-Granger and Johansen's methods which require all variables in a given model to be *I*(1).⁵

Models such as (2) assume that the effects of exogenous variables such as the exchange rate are symmetric. We test symmetry versus asymmetry effects of exchange rate changes by basically constructing two time series variables, where one represents depreciation and the other one represents appreciation. To that end, we first generate exchange rate changes by $\Delta \ln EX_t$. Next, we use the concept of partial sum and construct our two measures as:

$$\ln EX_t^+ = \sum_{j=1}^t \Delta \ln EX_j^+ = \sum_{j=1}^t \max(\Delta \ln EX_j, 0), \quad (3)$$

$$\ln EX_t^- = \sum_{j=1}^t \Delta \ln EX_j^- = \sum_{j=1}^t \min(\Delta \ln EX_j, 0). \quad (4)$$

where $\ln EX_t^+$ and $\ln EX_t^-$ are the partial sum process of positive and negative changes in $\ln EX$. Shin *et al.* (2014) then propose replacing $\ln EX_t$ variable in equation (2) by our two newly constructed variables as follows:

$$\begin{aligned} \Delta \ln M_t = & a + \sum_{i=1}^{n1} b_i \Delta \ln M_{t-i} + \sum_{i=0}^{n2} c_i \Delta \ln Y_{t-i} + \sum_{i=0}^{n3} d_i \Delta \ln r_{t-i} \\ & + \sum_{i=0}^{n4} e_i \Delta \ln EX_{t-i}^+ + \sum_{i=0}^{n5} f_i \Delta \ln EX_{t-i}^- \quad (5) \\ & + \theta_0 \ln M_{t-1} + \theta_1 \ln Y_{t-1} + \theta_2 \ln r_{t-1} + \theta_3 \ln EX_{t-1}^+ \\ & + \theta_4 \ln EX_{t-1}^- + \xi_t \end{aligned}$$

They then demonstrate that all tests and interpretation that were discussed above with regards to estimating equation (2) are equally applicable to specification (5). Whereas model (2) is labeled linear ARDL model, they label model (5) a nonlinear ARDL model due to method of constructing the two new variables. Once (5) is estimated, short-run asymmetry is judged by comparing estimates of e_i to those of f_i . Long-run asymmetry is inferred by comparing normalized estimate of θ_3 to θ_4 . If estimates carry the same sign and size, the effects are said to be symmetric. Otherwise, they are asymmetric.⁶

III. THE RESULTS

In this section, we estimate the linear ARDL model outlined by equations (2) first and the nonlinear ARDL model outlined by (5) next using quarterly data over the period 1973:Q1-2014:Q3 for Japan. Akaike's Information Criterion (AIC) is used to select the optimum models after imposing a maximum of four lags on each first-differenced variable. In order to account for Global Financial Crisis of 2008, we include a dummy variable which takes a value of zero prior to 2008 and one thereafter. The results from each optimum model are reported in Tables 1 for the linear model and Table 2 for the nonlinear model. Note that there are three panels in each table. While Panel A reports the short-run coefficient estimates, Panel B reports the long-run estimates. Diagnostic statistics for each model are reported in Panel C.

Let us consider Table 1 and the results from linear model first. From the short-run results in Panel A, we gather that both income and interest rate carry at least one significant coefficient, indicating that both variables have short-run effects on the demand for money in Japan. However, from Panel B, it is clear that only the effects of income lasts into the long run, since it carries a highly significant and positive coefficient. The exchange rate is insignificant in the short run as well as

³For details of normalization procedure see Bahmani-Oskooee and Tanku (2008).

⁴Indeed, we had to make sure that there is no *I*(2) variable.

⁵For applications in other areas see Halicioglu, F., (2007), Narayan *et al.* (2007), Tang (2007), Mohammadi *et al.* (2008), Wong and Tang (2008), De Vita and Kyaw (2008), Payne (2008), Chen and Chen (2012), and Hajillee and Al-Nasser (2014).

⁶For some other applications of this approach, see Apergis and Miller (2006), Delatte and Lopez-Villavicencio (2012), Verheyen (2013), and Bahmani-Oskooee and Bahmani (2015).

Table 1: Full Information Estimate of Linear ARDL Equation (2)

Panel A: Short-Run Coefficient Estimates					
	Lag Order				
	0	1	2	3	4
$\Delta \ln M$		0.031 (1.332)			
$\Delta \ln Y$	0.948 (41.860)**				
$\Delta \ln r$	0.011 (1.621)*	0.008 (1.122)	-0.011 (1.620)*		
$\Delta \ln EX$	0.012 (0.623)				
DUM	0.001 (0.154)				
Panel B: Long-Run Coefficient Estimates					
Constant	$\ln Y$	$\ln r$	$\ln EX$	DUM	
29.896 (49.125)**	0.596 (3.018)**	-0.004 (0.077)	0.199 (1.594)	0.141 (0.131)	
Panel C: Diagnostic Statistics					
F	ECM_{t-1}	LM	$RESET$	$CUS(CUS^2)$	$Adj. R^2$
2.36	-0.058 (2.127)	0.280	3.085	Stable	0.918

Notes:

a. Numbers inside the parentheses are absolute values of the t -ratios.

b. The upper critical bound value of the F -statistic at the 10% significance level is 3.77. This comes from Pesaran *et al.* (2001), Table CI-Case III.

c. The critical value of the t -test for significance of ECM_{t-1} is -3.47 at the 10% significance level. This comes from Banerjee *et al.* (1998, Table 1).

d. LM and RESET are the Lagrange multiplier test of serial correlation and Ramsey's test or functional form, respectively. These tests are based a χ^2 distribution with one degree of freedom. The critical value at the 5% significance level is 3.84.

e. ** and * denote significance at the 5% and 10% levels, respectively.

in the long run and so is the dummy, implying that Global Financial Crisis of 2008 had neither short-run nor long-run effects on the demand for money in Japan.

Is the long run link between quantity of money demanded and income in Japan meaningful? To answer this question, we turn to Panel C and the results of the F test for cointegration. Clearly, our calculated F statistic is much less than its critical value of 3.77 at the 10% significance level, rejecting the existence of cointegration.⁷ Is cointegration supported if we use an alternative test? Following Pesaran *et al.* (2001) and Bahmani-Oskooee and Tanku (2008), we

use long-run normalized coefficient estimates and long-run model (1) to generate the error term, labeled ECM . After replacing the linear combination of lagged level variables in (2) by ECM_{t-1} and after imposing the same optimum lags from Panel A, we estimate this new specification one more time. A significantly negative coefficient obtained for ECM_{t-1} will not only support convergence toward long-run, but also cointegration. However, as demonstrated by Banerjee *et al.* (1998), the t -ratio that is used to judge the significance of this coefficient has new critical values that they tabulate. Given the critical value of -3.47 at the 10% significance level, clearly the estimated coefficient of -0.07 is insignificant, again rejecting cointegration.⁸

⁷The critical value comes from Pesaran *et al.* (Table CI(iii) Case III, p. 300), where number of exogenous variables is three.

⁸Note that this critical value of -3.47 is for 100 observations and three

Table 2: Full Information Estimate of Nonlinear ARDL Equation (5)

Panel A: Short-Run Coefficient Estimates					
	Lag Order				
	0	1	2	3	4
$\Delta \ln Y$	0.88 (27.071)**	-0.007 (2.227)**	-0.046 (1.542)	-0.075 (2.551)**	
$\Delta \ln r$	0.011 (1.369)	0.012 (1.809)*			
$\Delta \ln EX^+$	0.006 (0.204)				
$\Delta \ln EX^-$	0.035 (0.876)				
DUM	0.006 (0.754)				
Panel B: Long-Run Coefficient Estimates					
Constant	$\ln Y$	$\ln r$	$\ln EX^+$	$\ln EX^-$	DUM
32.257 (10.099)**	0.318 (0.452)	-0.203 (0.612)	0.552 (1.875)*	0.446 (0.546)	0.483 (0.877)
Panel C: Diagnostic Statistics					
F	ECM_{t-1}	LM	$RESET$	$CUS(CUS^2)$	$Adj. R^2$
9.26**	-0.028 (-6.952)**	0.475	2.799	Stable	0.898

Notes:

a. Numbers inside the parentheses are absolute values of the t -ratios.

b. The upper critical bound value of the F -statistic at the 10% significance level is 3.52. This comes from Pesaran *et al.* (2001), Table CI-Case III.

c. The critical value of the t -test for significance of ECM_{t-1} is -3.67 the 10% significance level and -3.82 at the 5% level. They come from Banerjee *et al.* (1998, Table 1).

d. LM and RESET are the Lagrange multiplier test of serial correlation and Ramsey's test or functional form, respectively. These tests are based a χ^2 distribution with one degree of freedom. The critical value at the 5% significance level is 3.84.

e. ** and * denote significance at the 5% and 10% levels, respectively.

A few other diagnostic statistics are also reported in Panel C. To test for first-order autocorrelation, we rely upon the Lagrange Multiplier (LM) test which has a χ^2 distribution with one degree of freedom. Given its critical value of 3.84, the LM statistic is insignificant, supporting autocorrelation-free residuals. We have also reported Ramsey's RESET statistic to test for misspecification. It also has a χ^2 distribution with one degree of freedom. Clearly, the RESET statistic is also insignificant, implying that the optimum model is correctly specified. One issue of concern in estimating any money demand function is its stability. How stable are the short-run and long-run coefficient estimates? To answer this question, following the literature, we

apply the well-known CUSUM (indicated by CUS) and CUSUMSQ (indicated by CUS^2) tests to the residuals of estimated optimum error-correction model. As we have indicated in Panel C, all estimated coefficients are stable, again supporting the fact that the demand for money in Japan was not affected by Global Financial Crisis of 2008. Finally, the model enjoys a good fit reflected by the size of adjusted R^2 .

The two main shortcomings of the results from the linear ARDL model (2) are lack of cointegration among the variables and insignificance of the nominal effective exchange rate in the short-run as well as in the long-run. Can decomposing the exchange rate changes to partial sums of negative and positive changes improve the results? To answer this question, we shift to Table 2 and full-information estimates of nonlinear ARDL model (5). From Panel A and short-run coefficient

estimates, we gather that only income and interest rate carry significant coefficients in the short run. None of the partial sum variables not the dummy is significant. However, the story is somewhat different in the long run. Based on the results reported in Panel B, clearly, the positive partial sum ($LnEX^+$) carries a positive and significant coefficient but the negative partial sum ($LnEX^-$) does not, supporting long-run asymmetric effects of exchange rate changes on the demand for money in Japan. The positive coefficient of 0.552 implies that, as yen appreciate, Japanese expect further appreciation of the yen. Thus, they hold less of foreign currency and more yen which supports expectation effect rather than the wealth effect of exchange rate on the demand for money.⁹ Like before, the income also carries its expected positive and significant coefficient in the long-run. However, the dummy variable is again insignificant.

Once again, in order for the long-run estimates to be valid, we need to establish cointegration. Clearly, cointegration is supported by both the F and ECM_{t-1} tests.¹⁰ The fact that the variables were not cointegrated in the linear model but they are cointegrated in the nonlinear model supports nonlinear adjustment of the exchange rate and the nonlinear specification that is not still affected by Global Financial Crisis of 2008. Once again, the LM test supports autocorrelation free residuals and the RESET test supports correct specification of the nonlinear model. Again, short-run and long-run estimates are stable and the nonlinear model enjoys a good fit. Clearly, the results from nonlinear ARDL model are preferred to those from the linear model in that cointegration is supported by nonlinear model and not by linear model. Furthermore, nonlinear ARDL model helps us conclude that the exchange rate changes have asymmetric effect on the demand for money in Japan.

IV. SUMMARY AND CONCLUSION

A few studies have estimated the demand for money in Japan by using Johansen cointegration technique and have interpreted cointegration as a sign

of long-run relation between income, interest rate, and the exchange rate without testing for significance of each variable in the money demand function. Therefore, it is not easy to judge whether cointegration is due to strong relation between money and income or between money and all variables. Furthermore, an implicit assumption by all previous studies is that all variables have symmetric effects on the demand for money in Japan.

In this paper, we consider the demand for money in Japan one more time and try to determine if it was affected by the Global Financial Crisis of 2008. Our approach differs from previous research in a few ways. First, we use Pesaran *et al.*'s (2001) bounds testing or linear ARDL approach to model the money demand in Japan under which variables could be integrated of order zero or one or combination of the two, ruling out pre-unit root testing. When this method was applied to estimate the money demand in Japan, although income carried a long-run significant positive coefficient, we were unable to support cointegration among the variables. Next, we separated appreciation of the yen from depreciation by means of partial sum approach. We then applied nonlinear ARDL approach of Shin *et al.* (2014) to a specification that included income, interest rate, and two measures of yen appreciation and yen depreciation. Once this nonlinear ARDL model was estimated, we were able to support cointegration among the variables of nonlinear model. Long-run estimates revealed that cointegration is due to significant income effect and significant yen appreciation. The short-run and long-run results also supported the asymmetric effects of exchange rate changes on the demand for money in Japan. Moreover, the partial sum representing yen appreciation carried a significantly positive coefficient, implying that, as yen appreciates, Japanese expect further appreciation; hence they hold less foreign currency and more yen. All short run and long run estimates in both models were found to be stable and not affected by Global Financial Crisis of 2008.

APPENDIX

Data Definition and Sources

Quarterly data over the period 1973:Q1-2014:Q3 are used to conduct the empirical analysis. The data sources are as follows:

- a. International Financial Statistics of the IMF (www.imfstatistics.org).

⁹Comparing 0.552 estimate for positive partial sum to 0.446 for the negative partial sum, one wonders if they are significantly different. Application of the Wald test resulted in an insignificant Wald statistic of 0.152. The Wald test is distributed as $\chi^2_{(1)}$.

¹⁰Note that due to dependency between the two partial sum variables, Shin *et al.* (2014, p. 291) recommend treating them as one variable when it comes to test for cointegration. This implies using the same critical values that are used in the linear model. However, this is not the case for ECM test. Since there are four exogenous variables in the nonlinear ARDL model, the 10% critical value of the t-ratio from Banerjee *et al.* (1998, Table 1) is -3.67. The comparable value at the 5% significance level is -3.82.

b. Bank for International Settlements (www.bis.org).

Variables:

M = Real money supply measured by M2. Nominal M2 is deflated by GDP deflator (source a).

Y = Real GDP (source a).

r = Interest rate defined as government bonds yield (source a).

EX = Nominal effective exchange rate (the narrow index, source b). A decline reflects a depreciation of Japanese yen.

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