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Asymmetric Analysis of Exchange rate Volatility and Stability in Money Demand in the USA: An ARDL Approach

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ABSTRACT

The main focus of this study is the asymmetric relationship between volatility in the exchange rate and demand for money in United State. Data was used from 1990 Q1 to 2020 Q1 to conduct this research. The study uses a nonlinear Autoregressive Distributed Lag technique to derive empirical estimates from selected sample data. Although the rate of exchange is regarded as a fundamental predictor of demand for money in the literature, there is insufficient empirical data to support this claim. We split the exchange rate into two strands in this analysis, positive (appreciation) and negative (depreciation) values, and we find that changes in the rate of exchange (EXR) affected asymmetrically the demand for money in United State. Furthermore, our findings show that when the US dollar appreciates, US citizens expect the dollar to appreciate even more, so they hold more US dollars. When the US dollar depreciates, the negative coefficients of exchange rate depreciation indicate that they continue to demand more US dollars. Rather than expecting additional deterioration, the impact of the wealth effect, and when the value of far-off assets held by US citizens' increases in the US dollar, US citizens now want more US dollars to finance their rising consumption.

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Introduction

The main objective of the monetary policy is to obtain higher employment, stability in price and interest rate. Quantifying the rate of exchange (EXR) impact on the US economy is critical from numerous angles. The US economy has been more vulnerable to external shocks since the Bretton Woods era. The volume of US exports and imports increased to 13.6%, and 17.3% respectively compared to 5% in 2011. Foreign direct investment which is a combination of assets and liabilities increased to 40% and 36% respectively compared to 7.5 percent and 2.5 percent of gross domestic product (GDP) of US in 1970 and currently, the US citizen's total assets touched the highest number $ 25trillion which means it is 140% of the US GDP. Second, the euro, Japanese yen, and Chinese yuan have all emerged in recent years, requiring modifications to the existing international monetary system. Because the velocity of money includes all relevant variables of money demand function, the efficacy of money policy may be assessed by examining the stability of velocity of money and ultimately money demand. The parameters of the demand function for money are not explicitly stated when testing for stability in money demand.

The demand for money has always been determined by the interest rate and income. However, in 1963, Nobel Laureate Robert Mundell hypothesized that, along with interest rate and income, money demand could be influenced by exchange rate also. Due to break down of the Breton wood system in 1970 encouraged countries to shift from fixed exchange rate regimes to floating and similarly increasing globalization and interdependence of countries in financial markets caused the exchange rate fluctuations uncertain. Today the foreign exchange market is the largest financial market compared to other markets in which on daily basis around 15$B dollars are exchanged and the larger proportion 88% is US dollars used in this.

So, the instability in the foreign exchange rate (FER) causes fluctuations in the real exchange rate (REXR) which ultimately distort the prices, production, consumption, and financial market. Although he did not demonstrate an empirical relationship between money demand and exchange rate, it does present an opportunity for scholars to investigate whether or not there is an empirical correlation between exchange rate and money demand stability. Several studies have been undertaken in this area, with the rate of exchange (EXR) being included in definition of money demand function.

Arango and Ishag (1981) for the UK, Germany, and the US, Bahmani-oskooee and Poueheydarian (1990) for some developing nations. For Sudan, Domowitz and Elbadwi (1987), Bahmani Oskooe and Malaxei for 13 developing countries, Bahmani Oskooe and Malaxei (1987) for Venezuela, Macnown and Wallace 1992 (US), Karfakis 1991 (Greek), Harb 2004 (Six Oil producing nations), Cycir 2003 (Turkey), Bahmani-Oskooee 1996 (Iran), Mohsin Bahmani-oskooee 2016 (China). Although, in the field of monetary economics, a massive quantity of research has been created about the stability in money demand. However, because our research is focused on the United States of America (USA) and it is important it present a brief overview of literature on US money demand stability. In this sense, we've divided our research into two sections. The first section contains research that excluded exchange rate in their specifications, while the 2nd section contains studies included exchange rate.

Benati (2019) explained the volatility in demand function for money against short-term interest rates for the USA, UK, New Zealand, and Canada. In testing volatility in demand for money, he discovered that when selecting wealth allocation for no-interest bearing assets M1 and interest bearing assets. Economic agents almost exclusively respond to persistent shocks of opportunity cost which ignore transient shocks. The fact is, that no existing money demand (MD) model exhibits this trait suggests that future research should focus on developing a framework that allows for both transient and permanent shocks to alternate opportunity cost of money.

Bitrus, Yamden, and Pandok (2011) looked at numerous drivers of volatility in money demand functions in developed and industrialized countries, including the United States. The researchers used a comparative analysis to look at the pattern of volatility in the demand for money function. According to their findings, various factors influence money demand in both developing and developed nations. People’s willingness to cash demand in hand is influenced by various factors i-e interest rate, income, price level, deposit rate, wealth, personal choice, habits and risk. As a result, the current study more literature in several ways.

The present study is organised so that the literature is in section 2, introduces the models and estimating methods in section 3, display of results in section 4 and conclusion in last section 5.

Literature Review

Further *et al.*, (2013) used dynamic least square method to evaluate the money demand model for Eurozone, USA and UK. Their research exposes the existence of effect of wealth on demand for money in Eurozone and UK. Money demand's interest rate versatility is very small and negative, implying that quantity theory of money demand (QTM) is a reasonable representation of how true money behaves. Khan (1974), this technique is also used by Brown and J. Durbin to examine the United State structural stability of money demand from 1901 to 1965. The presence of a steady relationship between real balance demand and some variables are overwhelming for United State.

In addition, Knell and Stix (2005) investigated plausible explanations for the wide range of disparities in empirical finding of income elasticity of money demand in the United States using meta-analytic approaches. Their findings imply that the size of total monetary assets including wealth and all financial innovations that effect the money demand function projected income elasticity. The income elasticity (Ey) of narrow money is smaller than broad money, according to theoretical predictions. For many parameters and all types of country groups, this impact is consistently and reliably produced. However, by employing multivariate meta-reg, we were able to produce beyond this broad statement and to torsion quantify the gap. They discovered that the magnitude difference in between 0.3 and 0.5. Aside from the monetary aggregate, wealth inclusion appears to have a systematic impact on money demand calculations.

Wang (2011) looks for co-integration relationships in order to pinpoint the location of long term changes in demand for money in United State. During the second regime (1932–1952), the interest in semi-elasticity skyrockets. This could be owing to the effect of low level rate of interest and liquidity trap. The data also show that after 1952, the income elasticity of money demand falls sharply. The estimated interest elasticity and income elasticity of money demand for period of 1953 to 1997 are closely related to Ball's estimates (1946-1994). Key contribution of this study is that it will officially evaluate the long run structural stability in money demand of USA and discovering co-integration vector changes and structural changes consistently. The following research includes or illuminates the role of volatility in rate of exchange and money demand stability.

Arango and Ishaq Nadiri (1981) demonstrated that real cash balance demand determined from an underlying portfolio market is influenced by domestic variables as well as foreign monetary developments. For the postwar period, the model is calculated for the US, UK, Canada, and Germany. It was discovered that fluctuations in international EXR (exchange rate) and foreign rate of interest have impact on demand for money with additional domestic variables i-e permanent income, domestic rate of interest, and price expectation. The analysis, however, ignores the effects of international interest rates and foreign exchange rates, resulting in misspecification of money demand.

According to McNown and Wallace (1992), in United State the long run stationarity in money demand necessitates the inclusion of an effective exchange rate. They claim that by including the rate of exchange in money demand, the function became more stable in the long run. If rate of exchange is part of M 2 money supply and demand relationship, it is classified as a level. The addition of rate of exchange significantly strengthens the conclusions for M2. The test statistic rejects the no existence of co integration (null hypothesis) at 0.01 level.

The test statistic also rejected the null hypothesis of zero co-integrating vectors at level 0.01 when six lag are included in the initial error correction model. The results for the four lag criteria are a little weaker, with the proposition, test rejects the co-integrating vectors at 0.05 level and the eigen value (maximum) test narrowly missing at level 0.01a (A value of 24.9 17 is required for significance at 0.10). Currency rate changes and international interest rate (short run) differential also appear to be stationary, implying that they cannot be included in a co-integrated system with non-stationary variable.

Wang and lee (2013) carried out research on foreign penetration and undesirable competition and their findings show that in the case of the oligopolistic market more entry into the market is undesirable and bring more volatility to financial markets. Sun and De (2019) applied vector auto regressive model (factor augmented) to examine the impact of exchange rate depreciation on United State economy during 1973-2017 by using single step Baysian Likelihood Method (BLM) and Gibs sample approach method that exchange rate depreciation stem to be inflationary because consumer price, export and import prices all rise with response to depreciation shocks. One fundamental flaw in the model was that it was symmetric and linear, meaning it treated appreciation and depreciation shocks of exchange rate identically. As a result, no conclusions could be drawn regarding how exchange rate volatility affects US money demand and the entire economy asymmetrically.

Similarly, Bahmani-Oskooee & Pourheydarian (1990) tried to empirically establish Mundell conjuncture and assessed a money demand work comprehensive of real effective EXR for the US and observed that without a doubt truly compelling rate of exchange applies a critical effect on real balance money demand. The long-run impacts of an adjustment of REEXR are normally inferred as the amount of the slack coefficient. Since the total is positive in the instances of US and Canada, Therefore, it is presumed that Mundell's unique guess gets support on account of these two nations.

Most of the research on money demand in US did not incorporate the rate of exchange in their definition of the function of money demand when test for stability of demand function for money, as shown by the studies shown above. Those studies which are in favor of inclusion of rate of exchange in determining the money demand have supported that exchange rate effect are asymmetric such as when currency depreciate it lead to increase in domestic currency demand and when currency appreciate it lead to decrease in domestic currency demand in same proportion. Is this hypothesis correct? Could exchange rates have asymmetric impacts as a result of the public's mixed reactions to EXR volatility? The major goal of this study is to provide answers to these concerns by examining the real money demand M2 in United State.

Models and Methods

We started with a typical money demand function and followed Bahmani-Oskoee and Shabigh criteria (1996). The adopted equation (1) is given below.

$$LnM_t = a + b\, ln\, Y_t + c\, ln\, r_t + d\, ln\, EX + \epsilon_t \qquad (1)$$

Where *M* stands for real money M2, real income is denoted by Y_t, and r_t denotes rate of interest (defined as government bonds yield). Likewise, it is supposed that b's estimate is positive and c's estimate is negative. EX also stands for the nominal exchange rate, which is used to compensate substitution of currency. A drop in EX indicates a drop in the value of the United State dollar or increase in value of foreign currency. If the dollar is depreciating, then the home currency worth of foreign assets rises and it is seen as expansion in wealth by US people, then consumption will rise and consequently, internal domestic money demand will rise, as a result of negative forecast of d. While the estimate of d will be positive in the case of currency appreciation, while d will be negative in case of depreciation.

A long-run model is defined as Equation (1). As a result, estimating equation (1) produces long-term estimates. All literature has incorporated short-run dynamics when testing for estimate stability by transforming (1) into an auto-error correlation specification with short-run estimates. However, we used Pesaran *et al.*, (2001) uses bounds testing strategy to convert equation 1 into an auto-error correction methods model, which produces both short run and long run coefficient estimates. The following is the auto-error correction model (AECM) that was used:

$$\Delta LnM_t = \alpha + \sum_{i=1}^{n_1} \beta_i \Delta\, ln\, M_{t-1} + \sum_{i=0}^{n_2} \delta \Delta\, ln\, Y_{t-1} + \sum_{i=0}^{n_3} \phi_i \Delta\, ln\, R_{t-1} + \Sigma_{i=5}^{n_4}\, \Delta\, ln\, Ex_{t-1} + \rho_0\, ln\, M_{t-1} + \rho_1 LnY_{t-1} + \rho_2\, ln\, r_{t-1} + \rho_3 LnEx_{t-1} + \varepsilon_t \qquad (2)$$

Coefficient estimates of the short and long run are obtained through first differences variables and *ρ1- ρ3* normalized on *ρ0*.3, respectively in equation (2). However, to confirm that in long run estimates are not trivial, The F test was proposed by Pesaran *et al.*, (2001) to determine the combined importance of lagged variables as co-integration parameters. New critical value of F test have been tabulated in order to notice integrating properties of variables. When I(0) and I are used together, the upper bound critical value is used (1). This method outperforms Engle-Granger and Johnson's method, and it require all variables in model to used.

Model (2) is based on the assumption that the impact of exogenous variables i-e rate of exchange are symmetric. Exchange rate volatility, one depicting depreciation and the other depicting appreciations. LnEXt is the cause of exchange rate volatility. Then we used the partial sum concept to create our two measures, which are as follows:

$$ln\,Ex_t^+ = \sum_{j=1}^{t} \Delta lnEx_j^+ = \sum_{j=1}^{t} max\left(\Delta LnEx_j, 0\right) \tag{3}$$

$$ln\,Ex_t^- = \sum_{j=1}^{t} \Delta\, ln\,Ex_t^- = \sum_{j=1}^{t} min\left(\Delta LnEx_j, 0\right) \tag{4}$$

where $ln\,Ex_t^+$ and $ln\,Ex_t^-$ represent the positive and negative changes of the partial sum method in *Ln EX*. *Ln* EX_t variables in (2) are replaced by our two newly generated variables as proposed by Shin *et al.*, (2014).

$$\Delta LnM_t = a + \sum_{i=1}^{n_1} b_i \Delta \ln M_{t-i} + parent + \sum_{i=0}^{n3} d_i \Delta Lnr_{t-i} + \sum_{i0}^{n_5} f_i\, \Delta LnEx_{t-i}^- + \theta_0\, ln\,M_{t-1} +$$

$$\theta_1\, ln\,Y_{t-1} + \theta_2\, ln\,r_{t-1} + \theta_3\, LnEx_{t-1}^+ + \theta_4\, LnEx_{t-1}^- + \epsilon_t \tag{5}$$

It is established that all tests and interpretations mentioned above concerning estimating equation (2) can be extended to the specification (5). Model (2) is characterized as linear ARDL while modeling (5) as non-linear ARDL on the account of generating two new variables. Short-run asymmetry and long-run asymmetry can be observed by comparing estimates of *ei* and *fi* and normalized estimates of θ_3 to θ_4. Different sizes and signs of estimates manifest asymmetric effects otherwise symmetric effects.

Results

The linearity and non-linearity of Autoregressive Distributed Lag models (ARDL), described by eq 2 and 5, are estimated using quarterly data for the United States from 1990: Q1 to 2020: Q1. Then, using AIC (Akaike's Information Criterion), optimum models for each first-differenced variable are chosen after imposing one lag for explanatory variables and three lags for explained variable. Tables 1 and 2 show the findings of the linear and non-linear models' optimum models, respectively. There are three panels a, b, and c in each table, each reporting short and long-run estimations as well as diagnostic statistics. First, we'll look at the findings of the linear model in Table 1. All independent variables, including interest rate (r) income (Y) and rate of exchange (EXR), have insignificant coefficients in panel A, indicating that independent variables have no effect on short run money demand. Similarly, the coefficients of all independent factors are insignificant in panel B, demonstrating that independent variables have no effect on long run money demand. As a result, none of the independent variables have any short- or long-term impact on money demand in US. To see how useful long-run estimates are, we go to panel C and look for cointegration. Our F statistics are unimportant because their computed value is smaller than the upper value of 3.77, implying that co-integration does not exist. To see if cointegration is supported or not, we employ a variety of methods. To construct the error term, long run normalized coefficient estimate and long run model (1) have been used, which we call Error Correction Model. When ECMt-1 is substituted for the lagged level variable in (2) and the same optimum lags are used as in panel A, the coefficient estimates of ECMt-1 measure the adjustment speed, suggesting that almost 2.29 percent of adjustment occurs.

Table 1: *Linear Auto regressive distributive lages (ARDL) estimates of equation (2)*

Panel (a): Coefficient estimates of the short run					
	Lag order				
	0	**1**	**2**	**3**	**4**
ΔlnM					
ΔlnY	0.164070				
	(0.974438)				
Δlnr	-0.020915				
	(-0.321729)				
ΔlnEX	-0.089424				
	(-0.686903)				
Panel (b): Coefficient estimates of the long run					
Constant	**ln*Y***	**Ln*r***	**ln*EX***		
-40.287643	7.156328	-0.910984	-3.894981		
(-0.656590	(0.890673)	(-0.350562)	(-0.585153)		
Panel (c): Diagnostic tests					
F	***ECM*t-1**	***LM***	***RESET***	***CUS*(*CUS*2)**	***Adj. R*2**
	-0.022959				
0.598059	(-0.874143)	0.7376	0.201514	STABLE	0.986374

Note:

a. The t-ratios of the absolute values are represented by the number inside the parentheses.

b. F is the bounds test, which has the upper value of 3.77 for k=3 at 10% significance level.

c. ECM is the error correction model, which tells us the adjustment speed in long run.

d. LM for checking serial correlation.

e. RESET test with one-degree-of-freedom X^2 distribution.

f. The residual testing of the stability of all coefficients is shown using the CUSUM and CUSUMSQ tests.

g. Adjusted R^2 is applied to the model to check the goodness of fit.

In the long run, within a quarter. It's also worth mentioning the other diagnostic tests mentioned in Panel C. The first order autocorrelation is tested using the Lagrange Multiplier (LM) test, which uses an X2 distribution with one degree of freedom.

Table 2: *Linear Auto regressive distributive lages (ARDL) estimates of equation (5)*

Panel A: Coefficient estimates of the short run analysis					
	Lag Order				
	0	**1**	**2**	**3**	**4**
ΔlnY	-0.977062 (-2.309282)				
Δlnr	0.116836 (1.485625)				
ΔlnEX^{+}	0.622292 (2.269444)				
ΔlnEX-	-0.657543 (-2.838138)				
Panel B: Coefficient estimates of the long run analysis					
Constant	**ln*Y***	**Ln*r***	**ln*EX*+**	**ln*EX*-**	***DUM***
65.913957 (3.380955)	-6.840943 (-3.160746)	0.818031 (1.557843)	4.357006 (3.251083)	-4.603815 (-4.147001)	
Panel C: Diagnostic tests					
F	***ECM*t-1**	***LM***	***RESET***	***CUS*(*CUS*2)**	***Adj. R2***
1.960558	-0.142826 (-2.959628)	0.9417	3.047607	STABLE	0.987220

Note:

a. The t-ratios of the absolute values are represented by the number inside the parentheses.

b. F is the bounds test, which has the upper value of 3.77 for k=3 at 10% significance level.

c. ECM is the error correction model, which tells us the adjustment speed in long run.

d. For serial correlation, the Lagrange multiplier (LM) test is used.

e. Ramsey's RESET test with one-degree-of-freedom X2 distribution.

f. The residual testing of the stability of all coefficients is shown using the CUSUM and CUSUMSQ tests.

g. To check the model's quality of fit, an adjusted R2 is used.

In the absence of autocorrelation residuals, the LM statistics are meaningless. Ramsey's RESET test to check out misspecification, and it is likewise stated to be insignificant, indicating that the optimum model is accurately defined. While estimating the demand function, we run into a difficulty with the estimated model's stability. We applied the famous CUSUM (indicated by CUS) and CUSUMSQ (indicated by CUS2) tests to the residuals of the predicted optimum ECM to address this concern. In panel c, all of the estimated coefficients are stable, and the value of the adjusted R2 indicates that the model is well-fit.

The major inadequacy while employing the linear ARDL model (2) is that all results reported are insignificant. Would this be due to because of the presumption that impacts of exchange rate are symmetric? To address this question, we employed a non-linear ARDL model (5) and analyzed its estimates as reported in Table 2. As shown in Panel A, the coefficients of short-run estimates of all explanatory variables i-e income (Yt), interest rate (rt), exchange rate appreciation (lnEX+), and depreciation of exchange rate (InEX-), have a considerable impact on money demand. In the same way, the coefficients of long-run estimates of all explanatory variables have a major impact on money demand in the United States. Both the positive and negative values of the partial Sum of EXR changes are extremely significant coefficient values. They differ in signals but not in magnitude, demonstrating that exchange rate volatility has asymmetric effects on money demand in the United States. That is, as the US dollar strengthens, people in the US expect the US dollar to appreciate much more, so they keep more US dollars, bolstering the predicted effects of exchange rate fluctuations on money demand. On the other hand, as the US dollar depreciates because to the negative factors, America's demand for US dollars rises. We tested for cointegration and used several diagnostic tests illustrated in Panel C to establish the validity of long-run estimations once more. When F-statistic (Calculated) is compared with the upper limit critical values, the calculated F-statistic is less than tabulated F values of 3.52, implying that co-integration does not exist. ECMt-1 is extremely significant and has a negative coefficient, indicating that in the long run, 14.28 percent of the adjustment occurs within one quarter. The LM test confirms that the residuals have no auto correlation and are auto-correlated free, and the RESET test confirms that the model is correctly described and according to CUSUM and CUSUMQ test all coefficient estimate are stable. Finally, the non-linear ARDL model's results are more appealing and ideal than the linear ARDL model's since it allows cointegration and so aids us in concluding that exchange rate volatility has an asymmetric influence on money demand in the United States.

Conclusion

In United State, the currency depreciation tend to boost the current account balance and ultimately can boost both export and imports and as a result US economy will grows. However monetary policy alone cannot be sufficient to stabilize the effect of exchange rate on US economy. Due to assumption that the effect of exchange rate is symmetric, we think about demand for money in US and it is determined that negligible influence of exchange rate volatility on money demand in current study. There was no evidence of cointegration among variables when utilizing the linear ARDL technique to estimate money demand. Finding reveals that volatility in exchange rate has an asymmetric influence on US money demand after decomposing the exchange rate into a partial sum of negative variations and a partial sum of positive variations and then applying a non-linear ARDL model. The method is based on the non-linear ARDL approach to cointegration, and Error-Correction modeling proposed by Shin et al. (2014). According to our findings, when the US dollar appreciates, the people of the US expect the dollar to increase, even more, thus they hold more US dollars. Because of the negative coefficients of exchange rate depreciation, as the US currency depreciates, there is still a demand for US dollars. Rather than expecting additional deterioration, the wealth effect impacts, and as the value of foreign assets held by US citizen rises, US citizens now want more US dollars to pay for their rising consumption.

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Conflict of Interest

Authors have no conflict of interest.

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