

Tumala, Mohammed Musa; Atoi, Ngozi Victor; Karimo, Tari Moses

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EXCHANGE RATE DETERMINATION IN NIGERIA: TESTING THE MONETARY THEORY IN THE PRESENCE OF ASYMMETRIES¹

Tumala, Mohammed Musa; Atoji, Ngozi Victor and Karimo, Tari Moses

Abstract

This study examines the Nigeria Naira to US Dollar (₦/\$) exchange rate determinants within the monetarist framework while accounting for potential asymmetric responses of the exchange rate to changes in money supply, real income, monetary policy rate, and inflation rate in Nigeria relative to the US. The study utilizes monthly data from 2010:M1 to 2019:M12. By applying a nonlinear autoregressive distributed lag (NARDL) model, the study shows that in the long-run, nominal exchange rate adjusts asymmetrically to relative money supply, real income, and inflation. However, the adjustment to relative money supply, is less than proportionate. The incomplete adjustment is attributed to CBN's intervention in the foreign exchange market. The study provides evidence that exchange rate adjustment is asymmetric only to changes in inflation in the short run. However, there is no evidence of asymmetry to the policy rate both in the short and long-run. Furthermore, monetary flexible exchange rate theory is effective in exchange rate determination only in the long run since all the variables are significant. For stronger Naira, the study recommends tight monetary policy stance, and that monetary authority should ensure that the domestic inflation does not go higher than that of her trading partners.

Key Word: Exchange rate, interest rate, monetary theory, NARDL

JEL Classification: F31, F41

1.0 INTRODUCTION

Exchange rate is an important variable in any economy that engages in international trade. When the exchange rate rises (falls), it means the value of domestic currency has depreciated (appreciated) relative to a foreign currency. Speculators observe this rise and fall in the exchange rate closely, to make international investment decisions since movements in the exchange rate can have significant consequence for the future value of a current investment (Teall, 2018; Melvin & Norrbin, 2013). Furthermore, exchange rate movements can have important implications for international capital flows and economic growth (Karimo, 2020). It is, therefore, important to understand the factors that determine exchange rate movement.

This study examines the determinants of the Nigeria Naira to US Dollar (₦/\$) exchange rate movement within the monetarist framework while accounting for asymmetries in the money stock (supply), real income, interest rate and inflation using a nonlinear autoregressive distributed lag (NARDL) model. Accounting for asymmetry is important due to the nonlinearity of economic agents' behavior. The Central Bank's monetary policy stance could be expansionary contractionary, or no change. There is no guarantee that money market operators, given their profit motive, would always follow the direction of the policy stance of the monetary authority except there are some forms of subtle coercion or incentive to do so. This behavior could have divergent effect on the exchange rate than expected.

This study is particularly relevant for an emerging economy like Nigeria that is witnessing exchange rate fluctuation arising from its import dependent nature. Nigeria is a major player in Africa and fluctuations in the country's macroeconomic fundamentals could spillover to the entire continent. In recent years, Nigeria has grappled with exchange rate depreciation in the face of dwindling oil price, depleting foreign reserves, declining real income, and rising inflation. As part of efforts to defend the value of the Naira, the Central Bank of Nigeria (CBN) had maintained high for a marked or noticeable period² as a way of attracting foreign investment (CBN MPC Communique No.132, September 21 and 22, 2020). But with mounting inflationary pressure³, gains from the higher interest rates are yet to manifest as the value of the Naira has continued a downward trend (CBN, 2020). Increase in electricity tariffs and pump price of premium motor spirit (PMS) has also contributed to mounting inflationary pressure in the country, thus, the need for deliberate policy efforts to stabilize the Naira (CBN MPC Communique, No.132, September 21 and 22, 2020). However, stabilizing the Naira requires an understanding of the factors that determine its movement and response to positive and negative changes, respectively. The monetary model provides a framework for understanding exchange rate determination.

² The Monetary Policy Committee (MPC) increased the Monetary Policy Rate (MPR) to 12% in September 2011 from 9.75% in the previous month. The MPR remained at 12% up until October 2014 and was further increased to 13% in November 2014. It again remained at 13% up until October 2015. In July 2016 it was raised to 14% after it had hovered between 11% and 12% between November 2015 and June 2016. The MPR remained at 14% up to February 2019 and was reduced by 50 basis points to 13.5% in March 2019 and remained so until May 2020 when it was further reduced by 100 basis points to 12.5% (see Central Bank of Nigeria Statistics Database available at <http://statistics.cbn.gov.ng/cbn-onlinestats/QueryResultWizard.aspx> retrieved on Tuesday, September 29, 2020).

³ In September 2011, inflation rose to 10.34% from 9.30% the previous month. Inflation hovered between 11.25% and 12.89% between September 2011 and December 2012. In January 2016, inflation increased to 11.40% from the single digit enjoyed between January 2013 and December 2015. Since February 2016, Nigeria has not had single digit inflation. Inflation went as high as 18.72% in January 2017 (see Central Bank of Nigeria Statistics Database available at <http://statistics.cbn.gov.ng/cbn-onlinestats/QueryResultWizard.aspx> retrieved on Tuesday September 29, 2020)

The monetary model of exchange rate determination, which was championed by Mundell (1968), and Johnson (1976) and became popular in the 1970s argued that the exchange rate is a relative price of two currencies and that the expected future exchange rate significantly determines the current exchange rate with emphasis on equilibrium conditions in the money market (Mundell, 1968; Johnson 1976; Frankel, 1976; Dornbusch, 1976; Hoffman & Schlagenhauf, 1983). The exchange rate, being a relative price of two currencies is determined by the forces of demand and supply. If there is a change in macroeconomic condition that cause the demand for the traded currency to rise, its price would rise, and the exchange rate depreciates. On the other hand, if the condition is such that leads to a decline in the demand for the currency, its price will fall, and the exchange rate appreciates. For instance, starting from an equilibrium position in the money markets of two trading partners, a rise in money supply, creates excess demand for interest-paying assets such as bonds in a domestic economy. To reduce liquidity, domestic residents invest in interest-paying assets or lend their excess cash balances. The increased demand for interest-paying assets puts a downward pressure on domestic interest rate. Given that the foreign exchange market is in equilibrium, this leads to a decline in returns of domestic assets and the domestic currency depreciates.

Conversely, a fall in money supply reduces the demand for interest-paying assets and puts an upward pressure on the interest rate and returns on domestic assets thereby causing the domestic currency to appreciate (Krugman, Obsfeld, & Melitz, 2018). There is, however, no guarantee that the magnitude of exchange rate depreciation associated with a rise in money supply would be equal to the magnitude of appreciation associated with a fall in the money supply. When the magnitude of exchange rate adjustment to a positive and negative changes such as a rise and a fall in money supply is different, then there is asymmetry, that is, exchange rate responds differently to positive and negative changes in its determinants. Factors that could cause exchange rate adjustment to be nonlinear include heterogeneous behaviour of economic agents such as economic fundamentalists, technical analysts, activities of speculators, and monetary authorities' intervention in the foreign exchange market (Sarno & Taylor, 2002; Sarno & Taylor, 2003; Kilian & Taylor, 2003; Bauer, De Grauwe & Reitz, 2009; Dick & Menkhoff, 2013; Cifarelli, & Paesani, 2016). In spite the potential asymmetric response of exchange rate to positive and negative changes in monetary variables, most studies did not account for this potential asymmetric relationship (Hoffman & Schlagenhauf, 1983; Ogun, 2012; Kia, 2012; Saeed et al., 2012; Umoru, 2013; Otapo, 2020). Abubakar (2019) and Nwachukwu et al. (2016) who accounted for asymmetry focused on crude oil price and regime shift, respectively. Hence, there is literature gap regarding the asymmetric response of exchange rate to positive and negative changes in monetary variables.

The assumption of symmetric adjustment of exchange rate to changes in monetary variables, means that exchange rate responds in the same fashion to equal magnitude of positive and negative changes in those variables. However, it is important to iterate that rational economic agents are asymmetric in their behavior and so are monetary authorities (Sarno & Taylor, 2002; Bauer, De Grauwe & Reitz, 2009; Dick & Menkhoff, 2013). The asymmetric behavior of economic agents could propagate dissimilar (positive and negative) changes and there is no guarantee that the exchange rate would respond symmetrically to equal magnitude of changes of opposite signs. According to Salim and Shi (2019), an expansionary monetary policy shock would not necessarily have equal impact on the exchange rate as a contractionary monetary policy shock of equal magnitude would. When there is a contractionary monetary policy resulting from increase in the policy rate, the cost of credit would rise leading to decline in money supply. If the domestic money supply falls short of that of trading partners the exchange rate would appreciate (del Castillo, 2002; Kallianiotis, 2013). However, when the monetary authority takes an expansionary stance by reducing the policy rate, the demand for money is expected to rise as income rises, but that is not always the case. If banks are reluctant to reduce their lending rates, the speculative demand for money, at most would remain unchanged as income would not rise since investment would not respond to the expansionary monetary policy.

Thus, the exchange rate would not depreciate as expected. However, if banks are not reluctant to reduce the lending rates, the speculative demand for money would rise and the exchange rate depreciates. Hence, exchange rate adjustment to positive and negative changes could be asymmetric and ignoring the differential response of exchange rate to asymmetric changes could engender misleading results and portray the monetary theory as being ineffective.

In addition, extant studies have used single equation residual based cointegration, autoregressive distributed lag (ARDL) or the family of vector autoregressive (VAR) models (Wasiu, et al., 2019; Saeed, et al., 2012; Oriavwote & Oyovwi, 2012). These methods assume linear changes in monetary variables and symmetric adjustment of the exchange rate to these changes, therefore, did not distinguish between negative and positive changes in monetary variables and how the exchange rate responds to these different changes.

To fill the gap in literature, this study uses a nonlinear ARDL (NARDL) modelling technique. The NARDL approach has the advantage of differentiating between negative and positive changes, and the response of exchange rate to these changes. It also provides a platform for validating (or refuting) the assumption of linearity in economic models. It is, therefore, a more general technique for modelling economic relationships. A few studies have examined the nonlinearity of exchange rate adjustment but focused on either trade balance or oil price (Salim & Shi, 2019; Abubakar, 2019). Asymmetry in monetary variables such as the demand/supply of money, real income, interest rate and inflation remain largely unaccounted for. Ignoring certain behavior of the data such as, the response of exchange rate to positive and negative changes to macroeconomic fundamentals could be misleading for, both policy and investment purposes (Shin, Yu & Green-Nimmo, 2014). Thus this study intends to fill this gap by x-raying the determinants of exchange rate in a nonlinear monetarist framework to account for diverse dynamics inherent in the data.

The rest of the study is structured as follow: following this section is literature review in Section 2, where review of theoretical and empirical literature is provided; followed by the methodology applied in Section 3. In Section 4 results and discussion are presented and in Section 5 we have the conclusion and policy implications.

2.0 LITERATURE REVIEW

2.1 Theoretical Literature

The nexus between exchange rate and monetary variables is entrenched in the literature. The monetarists' viewpoint is that the exchange rate is determined in the money market. The exchange rate adjustment is instantaneous and equilibrates international demand for stock of national assets. The emphasis is on the equilibrium conditions of stock in each country's money market rather than trade flows and capital movement (Kallianiotis, 2013; Frankel, 1992 & 1976; Hoffman & Schlagenhauf, 1983; Dornbusch, 1976).

However, there is a dichotomy among the monetarists in the handling of prices and money supply. Whereas the Monetarist Flexible Price Exchange Rate (MFPER) theory assumes flexible prices in the domestic goods market, the Monetarist Sticky Price Exchange Rate Overshooting (MSPERO) theory assumes short-run sticky prices in the goods market hence changes in nominal and real money supply are equal (Dornbusch, 1976).

Given that the money market in each country is in equilibrium and that prices are flexible, the MFPER theory thought of the spot exchange rate as a function of relative money supply, income and interest rates, respectively. An increase in the supply of domestic currency relative to foreign currency increases the spot rate and hence depreciation in the domestic currency. Increase in domestic real income creates

excess demand for the domestic money stock. To increase real money balances, domestic residents would reduce their expenditure thus leading to decline in prices in the goods market, which would continue until a new money market equilibrium is established. The fall in domestic price relative to foreign price reduces the exchange rate hence the domestic currency appreciates. The third factor is the relative short-term interest rate. The interest rate is future exchange rate expectation. When the short-term interest rate increases, speculators anticipate that the exchange rate would rise which is why the monetary authority increased the interest rate to cover for the anticipated future rise in the exchange rate. Hence the impact of interest rate on exchange rate movement is through the anticipated future exchange rate.

The monetarist sticky price exchange rate dynamics or overshooting theory postulate that the spot exchange rate is a function of short-run fluctuations and long-run equilibrium. They argue that the spot rate depends on the relative money supply, income, money growth and real interest rate. The real interest rate differential defines the long-run path of the spot rate. A monetary tightening that causes real interest rate differential to rise above equilibrium leads to capital inflow and causes domestic currency to appreciate (the spot rate falls) proportionately above equilibrium. If real interest rate equalizes across countries, then the spot rate adjustment to long-run path will be infinite and the assumption of perfect capital mobility (the monetarist theory) does hold. By assuming that the expected long-run inflation differential is zero the monetarist exchange rate overshooting theory postulate that the spot rate is determined by equilibrium in each country's money and goods markets and that exchange rate overshooting occurs when the nominal interest rates equalize if domestic and foreign bonds are not perfect substitutes, interest rate differential will not equal expected rate of currency depreciation for several reasons namely, transaction costs, errors in expectation, and risk premium.

2.2 Empirical Literature

Exchange rate determination is a subject that has generated debate over the years, especially since the exchange rate disconnect puzzle by Meese and Rogoff (1983). The empirical debate, in recent years, borders on the effectiveness of macroeconomic theories in explaining the adjustment of exchange rate in the short run. Some of these empirical studies are examined.

Studies examining exchange rate determination within the monetarist framework have shown monetary policy to be effective around the world, with some caveats. For example, Hoffman and Schlagenhauf (1983), Zakaria and Ahmad (2009), Ogun (2012), Kia (2012), Saeed, et al. (2012), and Salim and Shi (2019), showed that monetary policy is effective in explaining exchange rate movements. Specifically, Hoffman and Schlagenhauf (1983) confirmed the monetary theory and rational expectation hypothesis using Australia's data while Ogun (2012) confirmed the theory in less developed countries operating flexible exchange rate system with the caveat that theory is effective in more advanced developing countries with relatively more effective legal system, less corruption, and smaller sizes of parallel exchange rate market. Zakaria and Ahmad (2009) study on Pakistan rupee against the currencies of 17 major trading partners over the period 1983Q1-2007Q4, supports the monetary model. The study used the GMM technique and showed that the monetarist flexible price model better explains the behaviour of the data compared to the sticky price and real interest rate differential models. Another study supporting the monetarist model is, Saeed et al. (2012) with the caveat that political instability exacerbates the Pakistani rupee depreciation. The study which focused on the Pakistani Rupee/US Dollar exchange rate used an ARDL model with data spanning the period from 1982:M01 to 2010:M04. Kia (2012) developed and tested a theoretical monetary model for Canada. The study results support the monetary theory both in the short and long run. The study spans the period 1972Q1 to 2010Q3 and employed the Johansen's Vector error correction approach. These studies did not account for asymmetry. Chaubal (2020) study for India over the period 1993M1- 2014M1 supports the flexible price monetarist theory but with smooth transition asymmetry. The study tested different forms of nonlinear models and showed that the nonlinear error correction exponential smooth transition autoregressive

(NLECM-ESTAR) model outperformed the others. Salim and Shi (2019) who also showed the effectiveness of monetary theory in explaining movements in exchange rate accounted for asymmetry but not in monetary variables. The study, applying an ARDL and an NARDL models revisited the exchange rate disconnect puzzle with focus on the Indonesian Rupiah exchange rate vis-a-vis Chinese Yuan, Japanese Yen, Euro, and Singapore dollar. The rupiah exchange rate responded asymmetrically to positive and negative changes in trade balances in the long run, showing that not accounting for positive and negative trade balance changes may produce misleading results. In Nigeria, there are few studies that applied the monetary approach. Umoru (2013), who analyzed exchange rate determinants for Nigeria within the monetary framework used three variants of monetary model (Monetary Flexible Price; Sticky Price; and a Hybrid, Flexi- Sticky Price models) and suggest that relative money supply, income and real interest rate differentials provide better forecasts of the Naira-US dollar exchange rate, thus, upholding the monetarist theory. The study concludes that, an economy that grows its money supply faster than that of her trading partner would have the external value of her currency depreciate proportionately to the difference between the two economies money supply. The above studies are however, at variance with Meese & Rose (1991) which considered five OECD countries over the period 1974-1987 and tested five theoretical models of exchange rate determination and found the explanatory power of macroeconomic/monetary variables to be weak and the introduction of nonlinearities did not improve the results.

Some studies within the Traditional Balance of Payment framework have shown mixed results. For example, Abubakar (2019), using monthly data for the period 1986:M01-2018:M06 examined the relationship between oil price and exchange rate in Nigeria by utilizing monthly data spanning the period 1986:M01- 2018:M06 with focus on asymmetries in the relationship and the impact of a shock to oil price on exchange rate. The study used a Threshold Autoregressive (TAR), Momentum Threshold Autoregressive (MTAR) and Structural Vector Autoregressive (SVAR) models and results suggests that there is no asymmetry in the relationship. This is counterintuitive as the N/\$ exchange rate is largely dependent on oil price. Since Nigeria is an oil exporting/dependent economy when oil price rise (fall) the exchange rate falls (rise). Therefore, it is expected that the N/\$ exchange rate should respond asymmetrically to changes in oil price. The study results from an SVAR model suggest appreciation of the Naira in response to positive oil price shock, though, with lags hence provides support for the portfolio balance theory. Fasanya, Oyewole, and Raheem (2021) also examined the relationship between oil price and exchange rate in Nigeria. The study, applying an NARDL model on Nigerian data over the period 1997M1 to 2019M12 suggests that the traditional balance of payment theory explains the exchange rate — oil price relationship. However, unlike Abubakar (2019), Fasanya et al. (2021) suggests that exchange rate responds asymmetrically to oil price changes in the short and long run. Another study which support the portfolio balance theory but with asymmetry is Salisu et al. (2019). The study, using Westerlund and Narayan (2015) estimator on monthly data of five major tradable currency pairs in the world examined the predictability of exchange rate using disaggregated commodity price indices over the period of 1960—2017 and suggests that accounting for asymmetries and structural breaks improves the forecast performance of the model but using lower frequency data diminishes the forecast accuracy. Like Abubakar (2019), Nwachukwu, et al. (2016) also provide support for economic theory when it studied the relationship between the Bureau De Change exchange rate and external reserves in Nigeria and show that external reserve explains exchange rate adjustment to long-run equilibrium. The study identifies two regimes (usual and unusual) characterizing the series, and applies a threshold vector error correction model (TVECM) to analyse daily data spanning January 1, 2014 to July 31, 2015. The study results suggest a non-linear long-run relationship between exchange rate and external reserve. Studies relying on the Portfolio Balance framework have also shown mixed results. Oriavwote and Oyovwi (2012) provided support for the portfolio balance theory in Nigeria. The study investigated the determinants of real exchange rate for the period 1970-2010. Results from Johansen cointegration test suggest a long run relationship among the variables. The Engle-Granger residual-based error correction mechanism (ECM) results reveal that capital flow, price level and nominal effective exchange rate are

the important determinants of the real effective exchange rate in Nigeria. Otapo (2020) study for Nigeria during the period starting from 1982 to 2018 assumed a linear relationship and concludes that exchange rate adjustment does not conform to theory since changes in reserves, domestic credit, foreign inflation, real income, domestic bond and foreign bond are statistically not significant. The study applies the Ordinary Least Squares technique.

There is also the hybrid framework, where a combination of theories is examined. The essence is to show the relative importance of the theories in question. Studies using this approach are also scarce. Within this framework Wasie et al. (2019) applied a hybrid of monetary and Balance of payment theory in Nigeria using quarterly data for the period 1986-2017. The study, using an ARDL model suggests that the key determinants of official exchange rate movement include GDP, inflation, interest rates, non-oil exports, oil exports and reserves, while the determinants of the parallel exchange rate movement include inflation, non-oil exports and GDP. These results partly conform to the monetary and Balance of Payment theories, respectively.

The study by Musa et al (2021) for four leading African economies - Algeria, Egypt, Nigeria and South Africa supported the nominal exchange rate -interest rate differential nexus with asymmetry and structural break in all four countries. The study of Olowe (2009) for Nigeria which showed asymmetry was a univariate study with focus on exchange rate volatility. The study estimated GARCH (1,1), GJR-GARCH(1,1), EGARCH(1,1), APARCH(1,1), IGARCH(1,1) and TS-GARCH(1,1) models using monthly data for the period 1970M1 to 2007M12, and showed asymmetric effect in the Naira/US\$ exchange rate volatility.

The review shows that studies that applied the monetary approach in Nigeria are scanty, though, Umoru, (2013) who applied the monetary framework for Nigeria showed the effectiveness of theory in explaining exchange rate movement. The study however, assumed linearity in the relationship, thus did not account for exchange rate response to positive and negative changes to monetary variables. It is important to note that economic agents are nonsymmetric in their behaviour and monetary aggregates can rise or fall with unequal effect on exchange rate. Therefore, accounting for such asymmetry could shed more light on the relevance of monetary theory in explaining exchange rate movements. This study, therefore, contributes to extant literature by accounting for asymmetry in the monetary model of exchange rate determination.

3.0 DATA AND METHODOLOGY

3.1 Theoretical Framework

The monetarist theory of exchange rate determination makes some important assumptions. First, is the absence of substantial transaction cost, capital control, and other barriers to capital flows, there is perfect capital mobility across the globe (one capital market). These assumptions imply covered interest parity (CIP) as depicted in (1).

$$i_t - i_t^* = fd_t \text{ or } fp_t = f_t - s_t \quad (1)$$

where: i_t and i_t^* are domestic and foreign nominal interest rate, respectively; fd_t is forward discount; fp_t is forward premium; f_t is exchange rate futures and s_t is the spot exchange rate.

Second, is that domestic and foreign bonds are perfect substitutes (single bond in the world), which implies Uncovered Interest Parity (UIP) (Frenkel, 1976; Dornbusch, 1976) as shown in (2).

Second, is that domestic and foreign bonds are perfect substitutes (single bond in the world), which implies Uncovered Interest Parity (UIP) (Frenkel, 1976; Dornbusch, 1976) as shown in (2).

$$i_t - i_t^* = \Delta s_t^e = s_{t+1}^e - s_t \quad (2)$$

Where: Δs_t^e is the expected change in the spot rate; s_{t+1}^e is the expected future spot rate.

In addition, the Monetarist Flexible Price Exchange Rate Theory (MFPERT) assumes domestic and foreign goods are perfect substitute (a single good world) hence Purchasing Power Parity (PPP) holds as presented in (3)

$$P_t = S_t P_t^* \text{ or } s_t = \ln\left(\frac{P_t}{P_t^*}\right) \text{ or } s_t = (p_t - p_t^*) \quad (3)$$

where: P_t and P_t^* are domestic and foreign price level, respectively; \ln is logarithmic operator; and small letter indicates logarithmic transformation. Additionally, they assume that both domestic and foreign prices are consistent with equilibrium conditions in the money market, with the demand for money being a function of income and interest rate. Therefore, the domestic money market equilibrium condition is defined as:

$$\ln\left(\frac{M_t^d}{P_t}\right) = \ln\left(\frac{M_t^s}{P_t}\right) = \ln\left(\frac{M_t}{P_t}\right) = \alpha_0 + \alpha_1 \ln(Y_t) - \alpha_2 i_t \quad (4)$$

and the foreign money market equilibrium condition as:

$$\ln\left(\frac{M_t^{*d}}{P_t^*}\right) = \ln\left(\frac{M_t^{*s}}{P_t^*}\right) = \ln\left(\frac{M_t^*}{P_t^*}\right) = \alpha_0^* + \alpha_1^* \ln(Y_t^*) - \alpha_2^* i_t^* \quad (5)$$

Where: M_t^d and M_t^s are money demand and supply in the domestic economy at time t, respectively; M_t indicates equilibrium in the domestic money market; Y_t is domestic income; the superscript * indicates foreign variables; α_1 and α_1^* are income elasticities of the demand for real money balances in domestic and foreign countries; α_2 and α_2^* are the interest rate semi-elasticity of the demand for real money balances in domestic and foreign countries, respectively. Other variables are as defined previously. Substituting the money market equilibrium conditions into the PPP condition yields the Monetarist Flexible Price Exchange Rate equation as⁴:

$$s_t = \beta_0 \left[\ln\left(\frac{M_t}{P_t}\right) - \ln\left(\frac{M_t^*}{P_t^*}\right) \right] - \beta_1 \ln\left(\frac{Y_t}{Y_t^*}\right) + \beta_2 (i_t - i_t^*) \quad (6)$$

$$\beta_0 = 1, \beta_1 < 0, \beta_2 > 0$$

⁴ Note: the logarithm of domestic price level is determined by equilibrium condition in the domestic money market as $p_t = m - l(y, i)$ and the logarithm of foreign price level is determined by money market equilibrium in the foreign country as $p^* = m^* - l(y^*, i^*)$. Thus $p_t - p^* = m - m^* - l(y, i) - l(y^*, i^*)$ (see Musa, M. (1984). *The theory of exchange rate determination*. In Bilson, J. F. O. and Marston, R. C. (eds.). *Exchange Rate Theory and Practice*. University of Chicago Press: Chicago.

Whereas an increase in the supply of money increases the spot rate, an increase in the demand for money (increase in income and decline in interest rate) reduces the spot rate. Increase in domestic real income creates excess demand for the domestic money stock. As domestic residents try to increase real money balance, they reduce expenditure thus the price level will fall until money market equilibrium is re-established. The exchange rate declines as domestic price fall relative to foreign price hence the domestic currency appreciates. The third factor is the relative short-term interest rate. The interest rate is an expectation of the exchange rate. According to Mussa (1984) when the short-term interest rate increases, speculators anticipate that the currency will depreciate hence the monetary authority increases the interest rate to cover its forward discount to attract foreign capital. Hence the impact is through the anticipated future spot exchange rate. The expectation that the future spot rate would rise results in capital outflow hence the spot rate rises leading to exchange rate depreciation and the prophesy is self-fulfilling.

This study is, however, anchored on the Monetarist Sticky-Price Exchange Rate Theory. The theory ignores the assumption of continuous PPP but assumes that sticky prices in the goods market creates differences between the short- and long-run (Dornbusch, 1976; Frankel, 1979). They argue that PPP may hold in the long-run but not in the short-run since prices in the goods market do not change instantaneously but adjust gradually. Changes in nominal and real money supply are equal as indicated in (7),

$$\frac{\Delta M_t^s}{\bar{P}_t} = \Delta \left(\frac{M_t^s}{P_t} \right) \quad (7)$$

They allow for expectations about the long-run prices in domestic and foreign goods markets, respectively. Thus, expected changes in the future spot rate is expressed as:

$$\Delta s_t^e = -\theta(s_t - \bar{s}_t) + \pi_t^e - \pi_t^{*e} \quad (8)$$

Indicating that the expected rate of exchange rate adjustment depends on the difference between the spot rate at time t and the long-run equilibrium rate, and the expected long-run inflation differential between the two countries. If there are short-run perturbations that causes the exchange rate to deviate from its equilibrium path it will revert at the speed of θ . In the long run when exchange rate is along its equilibrium path it will rise at a rate proportional to the inflation differential. Together with the UIP condition, this yields the following exchange rate overshooting equation:

$$s_t - \bar{s}_t = -\frac{1}{\theta} [(i_t - i_t^*) - (\pi_t^e - \pi_t^{*e})] \quad (9)$$

That is, the difference between the spot rate and its equilibrium value is proportional to the real interest rate differential between the two countries. This means that when there is a rise in nominal interest rate differential above its equilibrium level due to a contractionary monetary stance in the domestic economy, an incipient capital inflow causes the exchange rate to appreciate proportionately from its equilibrium level. This causes the exchange rate to overshoot its long-run equilibrium level proportionately to the real interest rate differential. In the long run $s_t = \bar{s}_t$, therefore, $i_t - i_t^* = \pi_t^e - \pi_t^{*e}$. Substituting for \bar{s}_t in the overshooting equation and assuming that the equilibrium money supplies and incomes are given by their level values in the current period, the monetarist sticky price exchange rate model is defined by (10)

$$s_t = \beta_0 \left[\ln \left(\frac{M_t}{P_t} \right) - \ln \left(\frac{M_t^*}{P_t^*} \right) \right] - \beta_1 \ln \left(\frac{Y_t}{Y_t^*} \right) - \frac{1}{\theta} [(i_t - i_t^*) - (\pi_t^e - \pi_t^{*e})] \quad (10)$$

Or in a more general form as

$$s_t = \beta_0 \left[\ln \left(\frac{M_t}{P_t} \right) - \ln \left(\frac{M_t^*}{P_t^*} \right) \right] - \beta_1 \ln \left(\frac{Y_t}{Y_t^*} \right) - \beta_2 (i_t - i_t^*) + \beta_3 (\pi_t^e - \pi_t^{*e}) \quad (11)$$

where: $\beta_0, \beta_3 > 0$ and $\beta_1, \beta_2 < 0$

The sticky-price assumption means that a contraction in the domestic money supply relative to money demand (without a corresponding fall in prices) will cause the domestic interest rate to rise relative to the foreign rate. The higher rates will spur a capital inflow, causing the domestic currency to appreciate. Thus, this model, unlike the flexible price version, postulates a negative relationship between the exchange rate and the relative nominal interest rate.

3.2 Data

The data for this study are obtained in monthly frequency, which include money supply, real income, policy interest rate and consumer price index, each for Nigeria and the US, and the Naira/US dollar exchange rate. The data spans the period 2010M1 — 2020M5. Data were obtained from the CBN statistics database⁵ for Nigeria and the Federal Reserve System (FRS) data download program⁶ for the US.

3.3 Model Specification

Following the monetarist theory in equation (11), the spot exchange rate function is specified as
Following the monetarist theory, the spot exchange rate function is specified as

$$s_t = s(m_t, y_t, r_t, p_t) \quad (12)$$

where: s_t is the logarithm of nominal exchange rate; m_t is money supply; y_t is real income; r_t is interest rate; and p_t is prices. All the variables are measured for Nigeria relative to corresponding US variables. Assuming symmetry, the basic econometric model is presented as:

$$s_t = \beta_0 + \beta_1 m_t + \beta_2 y_t + \beta_3 r_t + \beta_4 p_t + \xi_t, \quad \xi_t \sim iid(0, \sigma) \quad (13)$$

Where: β_j 's (for $j=1,2,3,4$) are symmetric long-run coefficients; ξ_t is the error term assumed to be normally distributed with zero mean and constant variance. The associated autoregressive distributed lag (ARDL) model with error correction term is specified as

$$\Delta s_t = \alpha + \sum_{j=1}^{p-1} \psi_j \Delta s_{t-j} + \sum_{j=0}^{q-1} (\lambda_j \Delta m_{t-j}) + \sum_{j=0}^{q-1} (\phi_j \Delta y_{t-j}) + \sum_{j=0}^{q-1} (\zeta_j \Delta r_{t-j}) + \sum_{j=0}^{q-1} (\varphi_j \Delta p_{t-j}) + \rho \xi_{t-1} + \varepsilon_t \quad (14)$$

where: ρ is the speed of adjustment to long-run equilibrium.

However, if exchange rate responds asymmetrically to positive and negative shocks to monetary variables, the ARDL model breaks down and the NARDL approach becomes appropriate. According to Shin, Yu and Green-Nimmo (2014), if the true relationship is asymmetric estimating a linear model

⁵Data for Nigeria is available at <http://cenbank.org/cbn-onlinestat/>

⁶Data for the US is available at <https://www.federalreserve.gov/data/download/>

produces profoundly misleading results. Another important property of the NARDL model is it provides the flexibility of also validating or refuting the assumption of linearity.

Now, define positive shock as

$$xPos_t = x_t^+ = \sum_{k=1}^t \Delta x_k^+ = \sum_{k=1}^t \max(x_k, 0) \quad (15)$$

and negative shock as

$$xNeg_t = x_t^- = \sum_{k=1}^t \Delta x_k^- = \sum_{k=1}^t \min(x_k, 0) \quad (16)$$

Where x_t is a representative explanatory variable constituted of positive change, x_t^+ , negative change, x_t^- .

The asymmetric basic regression model is written as

$$s_t = \beta_0 + \beta_1^+ m_t^+ + \beta_1^- m_t^- + \beta_2^+ y_t^+ + \beta_2^- y_t^- + \beta_3^+ r_t^+ + \beta_3^- r_t^- + \beta_4^+ p_t^+ + \beta_4^- p_t^- + \xi_t \quad (17)$$

The (NARDL) model is defined as

$$s_t = \alpha + \sum_{j=1}^p \psi_j s_{t-j} + \sum_{j=0}^q (\lambda_j^+ m_{t-j}^+ + \lambda_j^- m_{t-j}^-) + \sum_{j=0}^q (\phi_j^+ y_{t-j}^+ + \phi_j^- y_{t-j}^-) + \sum_{j=0}^q (\zeta_j^+ r_{t-j}^+ + \zeta_j^- r_{t-j}^-) + \sum_{j=0}^q (\varphi_j^+ p_{t-j}^+ + \varphi_j^- p_{t-j}^-) + \xi_t \quad (18)$$

Equation 18 is an ARDL model since it contains lags of the dependent variable as regressors as well as current and lagged values of the exogenous variables. It is nonlinear (asymmetric) because it distinguishes between the effect of a positive and a negative change of the exogenous variables on the endogenous variable. An error correction form of Equation 18 is required in order to account for the long-run behavior and short-run dynamics of the variables.

Applying the Pesaran *et al.* (2001) technique Shin, Yu and Green-Nimmo (2014) showed that the error correction model associated with Eqn. (19) can be specified as:

$$\Delta s_t = \alpha + \sum_{j=1}^{p-1} \eta_j \Delta s_{t-j} + \sum_{j=0}^{q-1} (\gamma_j^+ \Delta m_{t-j}^+ + \gamma_j^- \Delta m_{t-j}^-) + \sum_{j=0}^{q-1} (\delta_j^+ \Delta y_{t-j}^+ + \delta_j^- \Delta y_{t-j}^-) + \sum_{j=0}^{q-1} (\theta_j^+ \Delta r_{t-j}^+ + \theta_j^- \Delta r_{t-j}^-) + \sum_{j=0}^{q-1} (\varrho_j^+ \Delta p_{t-k}^+ + \varrho_j^- \Delta p_{t-k}^-) + \rho \xi_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma) \quad (19)$$

3.4 Estimation Procedure

Money supply, real income, monetary policy interest rate and consumer price index data were obtained for Nigeria and the United States, including data on the Naira nominal effective exchange rate. Except interest rates, the other variables were transformed to their natural logarithms. Next, relative variables were estimated as the difference between corresponding variables for Nigeria and US. The use of US as the reference country is on the ground that US is the world leading economy and its policy and

macroeconomic fluctuations affects most countries in the world including Nigeria. Also, the US dollar is the reference currency for most national currency exchange rates including the Naira. Unit root tests were conducted using the Philips Perron, and Augmented Dickey Fuller techniques. Then the NARDL model was estimated.

The estimates were tested for asymmetry using the Wald statistic, which follows a chi-square distribution with k degree of freedom. For long-run asymmetry the study tests the joint hypothesis of symmetry that

$$\beta_i^+ = \beta_i^- = \beta_j \text{ versus } \beta_i^+ \neq \beta_i^- \neq \beta_j$$

Rejection of the null indicates the existence of long-run asymmetry and that exchange rate responds differently to positive and negative change in the long-run. For short-run asymmetry the study tests each of the joint hypotheses:

$$\begin{aligned} \gamma_j^+ &= \gamma_j^- = \gamma_j \text{ versus } \gamma_j^+ \neq \gamma_j^- \neq \gamma_j \\ \delta_j^+ &= \delta_j^- = \delta_j \text{ versus } \delta_j^+ \neq \delta_j^- \neq \delta_j \\ \theta_j^+ &= \theta_j^- = \theta_j \text{ versus } \theta_j^+ \neq \theta_j^- \neq \theta_j \\ \varphi_j^+ &= \varphi_j^- = \varphi_j \text{ versus } \varphi_j^+ \neq \varphi_j^- \neq \varphi_j \end{aligned}$$

A rejection of the null hypothesis indicates the presence of short-run asymmetry in the corresponding variable of money supply, real income, interest rate, and inflation, respectively.

To test the existence of long-run relationship, the bounds test is relevant. If $\rho = 0$, Eqn. (19) reduces to regression with first differenced variables only, indicating that there is no long-run relationship among the variables. Thus, this study tests the hypothesis that $\rho = 0$ against the alternative that $\rho < 0$ using the t-statistic proposed by Banerjee et al. (1998).

4. RESULTS AND DISCUSSION

4.1 Preliminary results

As a first step in the estimation, the series were tested for unit root using Augmented Dickey-Fuller (ADF) and the Philips-Perron (PP) techniques and the results are in Table 1. Results from both the ADF and PP tests show that none of the variables is integrated of an order greater than one, thus, satisfying the condition for estimating an ARDL model. In fact, all the variables became stationary after first difference, that is they are integrated of order one I(1).

Table 1: Unit Root Test Results

Variable	Augmented Dickey-Fuller Test			Philips-Perron Test		
	Level	1 st Diff.	Decision	Level	1 st Diff.	Decision
	-1.163	-10.825***	I(1)	-3.373	-119.682***	I(1)
	(-0.6895)	(0.0000)		(0.6630)	(0.0000)	
	-2.803*	-10.423***	I(1)	-3.993*	-132.481***	I(1)
	(0.0578)	(0.0000)		(0.0820)	(0.0000)	
	-2.470	-9.912***	I(1)	-5.444	-116.152***	I(1)
	(0.1228)	(0.0000)		(0.1329)	(0.0000)	
	0.912	-13.899***	I(1)	0.322	-159.951***	I(1)
	(0.9932)	(0.0000)		(0.9952)	(0.0000)	
	-0.453	-9.855***	I(1)	-0.965	-105.410***	I(1)
	(0.9008)	(0.0000)		(0.8861)	(0.0000)	

Note: y is the logged difference of Nigeria and US income; m is the logged difference of money supply in Nigeria and US; r is the difference between Nigeria and US monetary policy rates; p is the logged difference of Nigeria and US consumer price index; s is the nominal real effective exchange rate; and ***(**)* indicate significance at 1%(5%)10% critical level; p -values in ().

The study tests for asymmetric cointegration using the bounds test and the results are presented in Table 2.

Table 2: Test for Asymmetric Cointegration

Critical level	F-statistic=7.2015		t-statistic= -7.2578	
	I(0)	I(1)	I(0)	I(1)
10%	2.68	4.044	-2.499	-3.621
5%	3.297	4.873	-2.878	-4.068
1%	4.826	6.911	-3.663	-4.995
p-value	0.000	0.000	0.000	0.000

Note: Kripfganz and Schneider (2018) critical values and approximate p-value

Source: Author's computation

The computed bounds F-statistic (7.2015) and t-statistic (-7.2578) in absolute terms, are larger than their respective upper bound critical values at 1% critical level indicating the existence of asymmetric long-run relationship between exchange rate and monetary variables. The study also test the individual coefficients for long-run and short-run asymmetries and presents the results in Table 3.

Table 3: Test for long- and short-run asymmetries

Long-run Asymmetry			Short-run Asymmetry		
Variable	Wald F-Statistic	Prob > F	Variable	Wald F-statistic	Prob > F
m	45.440***	0.000	m	1.038	0.314
y	63.290***	0.000	y	0.092	0.764
r	2.487	0.122	r	1.589	0.214
p	4.808**	0.034	p	6.591**	0.014

Note: y is the logged difference of Nigeria and US income; m is the logged difference of money supply in Nigeria and US; r is the difference between Nigeria and US monetary policy rates; p is the logged difference of Nigeria and US consumer price index; s is the nominal real effective exchange rate; and ***(**)* indicate significance at 1%(5%)10% critical level.

The joint Wald F-statistics for long-run asymmetry in money supply (m), real income (y) and price level (p) are statistically significant. Whereas m and y are significant at the 1% critical level, p became significant at the 5% critical level. These results indicate the presence of long run asymmetry in the model. In the short run, except for p , the Wald F-statistic for the other variables are all not statistically significant, indicating short-run asymmetry only in the price level. These results mean that exchange rate responds asymmetrically to positive and negative changes in relative money supply, real income and inflation in the long run, and inflation only in the short run. These findings are unique as previous studies did not test for asymmetric response of exchange rate to positive and negative change in monetary variables. Interest rate did not show asymmetry.

4.2 Main Results

Having established asymmetries in the monetarist exchange rate determination model, the long-run and short-run asymmetric results are discussed. The study long-run results from the NARDL model are presented in Table 4.

Table 4: Long-run Asymmetric Estimates

Long-run	Coefficient	F-statistic	p>F	Long-run	Coefficient	F-statistic	p>F
	α				β		
m^+	0.345***	9.99	0.003	m^-	0.742***	88.53	0.000
y^+	-1.306***	21.38	0.000	y^-	-1.102***	10.75	0.002
r^+	-.024***	30.42	0.000	r^-	0.004	0.108	0.744
p^+	2.226***	11.13	0.002	p^-	0.329	0.047	0.835

Note: y is the logged difference of Nigeria and US income; m is the logged difference of money supply in Nigeria and US; r is the difference between Nigeria and US monetary policy rates; p is the logged difference of Nigeria and US consumer price index; s is the nominal real effective exchange rate; + (-) over a variable indicates a positive (negative) change; ***(**)* indicate significance at 1%(5%)10% critical level.

Once the exchange rate is on its long-run equilibrium path, its rate of growth is explained by the long run coefficients of m , y , r and p . As expected, m^+ has a positive sign indicating that when the domestic money supply grows faster in relative terms, the Naira depreciates, and the rate of depreciation for a 1% rise in relative money supply is about 0.35%. However, being less than proportionate the rate of depreciation falls short of the monetary theory, which predicts that an economy that grows her money supply faster than her trading partner would have her currency depreciated at a rate that is proportionate to the difference in money supply between the countries. This is expected for a currency whose monetary authority intervenes in the foreign exchange market. The intervention ensures that the currency does not adjust fully to differences in money supply, signaling the possibility of the currency being overvalued. The finding that money supply is positive is similar to Umoru (2013), but the finding that exchange rate adjustment to relative money supply is less than proportionate differs from Umoru (2013) who shows proportionate adjustment.

Intuitively plausible, m^- turns out positive, indicating that when foreign money supply, grows relatively faster, the Naira exchange rate declines and the Naira appreciates, it turns out that the rate of appreciation is more than twice the rate of depreciation associated with domestic money supply growing faster. This is expected, since the monetary authority intervenes in the foreign exchange market whenever there are shocks that could cause disturbing depreciation and sustains its policy whenever the shocks are favourable leading to appreciation. This finding differs from Umoru, (2013) who assumes symmetry in the exchange rate adjustment.

For money demand, y^+ is negative as expected and statistically significant, indicating that when real income rises, the exchange rate falls, and the domestic currency appreciates. The rise in real income increases the demand on available money stock leading to excess money demand. Domestic residents would try to increase their real money balances by reducing expenditure causing the price level to fall.

The relative decline in the domestic price level means that domestic goods are cheaper in the international market, hence export demand rises resulting in positive current account balance thus the spot rate declines, and the domestic currency appreciates. For a decline in real income, y^- is negative and statistically significant. The negative sign is intuitively plausible since decline in income increases the exchange rate and causes the domestic currency to depreciate. From the monetary perspective demand for available money stock declines as real income falls, thereby creating excess money supply which leads to exchange rate depreciation. Once again, this result suggests asymmetry in the adjustment of exchange rate thus distinct from Umoru (2013) who assumes symmetry in the exchange rate adjustment to income.

Next, is exchange rate adjustment to changes in nominal interest rate. As expected, r^+ is negative, indicating that, when there is monetary tightening in the domestic economy, representing positive change in interest rate, there would be an incipient capital inflow if the price level does not rise, and the exchange rate appreciates. The coefficient on r^+ and r^- are less than unity, each indicating the absence of exchange rate overshooting.

Positive change in the price level, p^+ has positive sign as expected and statistically significant, reflecting exchange rate adjustment to positive change in relative prices. When domestic inflation rises faster than foreign inflation, the exchange rate depreciates since domestic goods are now more expensive leading to decline in export demand, hence balance of payment deterioration through decline in the current account balance. Further, there is evidence of exchange rate overshooting as the coefficient on positive price change is greater than unity and statistically significant. Also, when the change is negative as the coefficient of p^- indicates the exchange rate appreciates as expected, but statistically not significant. The simple explanation for this behavior is that, except for crude oil, the Nigeria's economy is not export oriented so when the price level declines it is unable to take advantage of the opportunity presented by the competitive advantage to export, hence the exchange rate response to declining price level is weak in the long run. Previous studies did not show asymmetry in exchange rate adjustment to the price level.

Table 5 shows the short-run and error correction mechanism results. Intuitively, the speed of adjustment is negative, less than unity and statistically significant. The estimate (0.93) reflects the speed at which exchange rate reverts to long-run equilibrium after short-run shocks have caused it to drift away. Specifically, when the exchange rate falls (rises) below (above) its long run equilibrium due to a permanent short-run perturbation, it depreciates (appreciates) at the speed of 93% per month, indicating that the errors generated due to short-run shocks is corrected in less than two (2) months.

In the short-run exchange rate responds asymmetrically to changes in the price level, though, the coefficients negate a priori expectation and only becomes statistically significant at 10% critical level. Exchange rate does not respond differently to positive and negative changes in money supply, income, and interest rate in the short-run and only the sign on income, which turns out to be statistically not significant is intuitively plausible. Therefore, the monetary model of stick prices and short-run exchange rate overshooting does not explain the short-run exchange rate behaviour for the Naira/US dollar exchange rate in the presence of asymmetry.

Table 5: Short-run Asymmetry and Error Correction Mechanism results

Variable	Coefficient	Wald F-stat	P-value	Variable	Coefficient	Wald F-stat	Pvalue
Δm_t^+	-1.113*	3.810	0.058	Δm_t^-	-1.173	0.140	0.708
Δy_t^+	-1.351	0.570	0.453	Δy_t^-	-0.713	0.410	0.527
Δr_t^+	0.115***	20.180	0.000	Δr_t^-	0.174***	12.470	0.001
Δp_t^+	-3.271*	3.670	0.062	Δp_t^-	7.867*	3.000	0.090
ECM	-0.927*** (0.128)			Constant	4.203*** (0.590)		

Note: y is the logged difference of Nigeria and US income; m is the logged difference of money supply in Nigeria and US; r is the difference between Nigeria and US monetary policy rates; p is the logged difference of Nigeria and US consumer price index; s is the nominal real effective exchange rate; Δ is difference operator, ***(**)* indicate significance at 1%(5%)10% critical level; standard errors ().

This study, in showing that exchange rate adjusts asymmetrically to positive and negative changes in money supply, real income and inflation in the long-run and inflation in the short-run differs from Salim and Shi (2019) study for Indonesia but similar in showing that exchange rate adjustment conforms to theory. The study results also corroborate Wasii *et al.* (2019), but differs from Otapo (2020) whose study for Nigeria is within the Portfolio Balance framework and assuming symmetry concludes that the Naira exchange rate adjustment does not conform to theory.

The study diagnostic test results are presented in Table 6. All the diagnostic statistics are statistically not different from zero, indicating model adequacy: the Portmanteau test indicates no serial correlation; Breusch/Pagan could not reject the null of homoscedastic error variance distribution; the Ramsey RESET showed the model is correctly specified; and the Jarque-Bera test indicates that the residuals from the regression are normally distributed. The adjusted R-squared indicates that about 95% of exchange rate adjustment is explained by the model, which is a good fit. The model is therefore appropriate for policy prescriptions.

Table 6: Diagnostic test results

R-squared	Adjusted R-squared	F-Statistic (69, 43)	Prob > F
0.9794	0.9464	29.68	0.0000
Diagnostics		Statistic	Prob-Value
Portmanteau Test for serial correlation up to lag 40 (Chi-square)		43.61	0.320
Breusch/Pagan Test for Heteroskedasticity (Chi-square)		0.484	0.487
Ramsey RESET Test (F)		1.650	0.193
Jarque-Bera Residual Normality Test (Chi-square)		1.038	0.595

The results were checked for robustness by introducing oil price as an additional explanatory variable in the model since Nigeria's foreign reserve is largely dependent on foreign exchange earnings from the sales of crude oil. The study, therefore, expects that changes in oil price could have significant impact on the Naira exchange rate adjustment. The results from the robustness check are presented as appendix.

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With the introduction of oil price in the model: the bounds' test turns out to be inconclusive, though, the long-run effect of a positive change in money supply, income, interest rate and consumer prices all show the expected signs and statistically significant; oil price did not show asymmetry and the individual effect was also statistically not significant; money supply and income still showed long-run asymmetry but not consumer prices, indicating money supply and income are robust to the inclusion of oil price in the model; there was no short-run asymmetry observed hence consumer prices is not robust but sensitive to oil price changes. However, the model now showed significant autocorrelation hence not adequate for policy prescription.

5. CONCLUSION AND POLICY IMPLICATIONS

The exchange rate is an important indicator for investors and managers of the economy. When the exchange rate rises it indicates that the domestic economy is importing more than it is exporting and/or capital outflow is more than inflow. From the monetary perspective when domestic money supply rises above foreign money supply the exchange rate depreciates and at a rate that is proportionate to the difference in money supply between the two countries. However, factors that causes the foreign money supply to rise above the domestic money supply results in exchange rate appreciation. This study examines the Naira exchange rate determination within the monetarist framework while accounting for asymmetric response of exchange rate to positive and negative changes in relative money supply, real income, interest rate and inflation.

The study shows that exchange rate adjusts asymmetrically to changes in money supply, real income and inflation in the long-run and only to inflation in the short-run. In the long run, when the exchange rate is in equilibrium and a trading partner's money supply grows faster, the Naira appreciates by less than proportion, though, the rate of appreciation is relatively faster compared to the depreciation associated with a faster growing domestic money supply. Also, an increase in real income results in exchange rate appreciation; but a decrease in real income results in depreciation. The study also showed that Nigeria is not being able to take advantage of the competitive advantage presented to her by lower domestic prices to strengthen the Naira both in the short- and long-run due to her import dependent nature. The study, therefore, concludes that modelling exchange rate movement in Nigeria without accounting for asymmetries could generate unreliable estimates which has implications for policy prescriptions. Also, taking asymmetry into consideration, monetary policy is effective in determining exchange rate adjustment only in the long-run, interest rate did not show asymmetry, though, it was significant in explaining exchange rate movement in the long run. The Naira exchange rate appreciates as the domestic interest rate rises above the foreign rate.

The policy implications of the findings are that: increasing the domestic interest rate is an important policy measure to raise the value of the Naira; factors that increase the income of domestic residents are also important for a stronger Naira; also, to maintain the value of the Naira, the monetary authority should ensure that the domestic inflation does not go higher than that of her trading partners.

REFERENCES

- Abubakar, A. B. (2019). Oil price and exchange rate nexus in Nigeria: Are there asymmetries. *CBN Journal of Applied Statistics*, 10 (1), 1-28.
- Banerjee, A, Dolado, J. & Mestre R. (1998). Error-correction mechanism tests for cointegration in a single-equation framework. *Journal of Time Series Analysis* 19, 267-283.
- Bauer, C., De Grauwe, P., & Reitz, S. (2009). Exchange rate dynamics in a target zone—a heterogeneous expectations approach. *Journal of Economic Dynamics and Control*, 33(2), 329-344.
- Central Bank of Nigeria (2020). Monetary Policy Committee Communique No. 132, September 21 & 22
- Central Bank of Nigeria (2017). Monetary Policy Committee Communique No. 112, March 20 & 21
- Central Bank of Nigeria (2015). Monetary Policy Committee Communique No. 101, May 18 & 19
- Chaubal, A. (2020). Exchange rates in India: Current account monetarism in a nonlinear context. *Studies in Nonlinear Dynamics & Econometrics*, 24(5). <https://doi.org/10.1515/sn-de-2019-0072>
- Cifarelli, G., & Paesani, P. (2016). Speculative pricing in the Liverpool cotton futures market: A nonlinear tale of noise traders and fundamentalists from the 1920s. *Cliometrica*, 10(1), 31-54.
- del Castillo, G. (2002) Determinants of nominal exchange rates: A survey of the literature. In: *Macroeconomic Management Programs and Policies*. Khan, M. S, Nsuoli, S. M & Wong, C. H. (eds), Washington DC.: IMF Institute.
- Dick, C. D., & Menkhoff, L. (2013). Exchange rate expectations of chartists and fundamentalists. *Journal of Economic Dynamics and Control*, 37(f), 1362-1383.
- Dornbusch, R. (1976). Expectations and exchange rate dynamics. *Journal of Political Economy*, 84, 1161-1176
- Fasanya, I. O., Oyewole, O. J., & Raheem, I. D. (2021). Oil prices and exchange rate dynamics: How important is the role of asymmetry and structural breaks? *Journal of African Business*, 1-20.
- Frenkel, J. A. (1976). A monetary approach to the exchange rate: Doctrinal aspects and empirical evidence. *Scandinavian Journal of Economics* 78, 200-224.
- Hoffman, D. L. & Schlagenhauf (1983). Rational expectations and monetary models of exchange rate determination: An empirical examination. *Journal of Monetary Economics* 11, 247-260.
- Johnson, H. G. (1976). The monetary approach to balance-of-payments theory. *Journal of International Economics*, 7(3), 251-268.
- Kallianiotis, J. N. (2013). *Exchange rates and International Financial Economics*. Palgrave Macmillan, New York
- Karimo, T. M. (2020). Impact of exchange rate movement and interest rate differential on Nigeria's international private capital flows. *CBN Journal of Applied Statistics*, 11 (2), 29-63.

- Kia, A. (2013). Determinants of the real exchange rate in a small open economy: Evidence from Canada. *Journal of International Financial Markets, Institutions and Money*, 23, 163-178.
- Kilian, L., & Taylor, M. P. (2003). Why is it so difficult to beat the random walk forecast of exchange rates? *Journal of International Economics*, 60(1), 85-107.
- Krugman, P. R., Obsfeld, M., & Melitz, M. (2018). *International Economics: Theory and Policy*. 11th Edition. Pearson Addison-Wesley
- Lyons, R. K. (2001). *The microstructure approach to exchange rates*. Cambridge, MA: MIT Press.
- Makin, A. J. (1984). Money's role in determining the exchange rate. Unpublished Honours Thesis, University of Queensland.
- Mark, N. C. (1995). Exchange rates and fundamentals: Evidence on long-horizon predictability. *American Economic Review*, 85(1), 201—18.
- Meese, R. A. & Rogoff, K. (1983). Empirical exchange rate models of the Seventies: Do they fit out of sample? *Journal of International Economics*, 14(1—2), 3—24.
- Meese, R. A., & Rose, A. K. (1991). An empirical assessment of non-linearities in models of exchange rate determination. *The Review of Economic Studies*, 58(3), 603-619.
- Melvin, M. & Norrbin, S. C. (2013). Exchange rates, interest rates and interest parity. In *International Money and Finance, Eighth edition*. <http://dx.doi.org/10.1016/B978-0-12-385247-2.00006-8>
- Mpofu, T. R. (2016). The determinants of exchange rate volatility in South Africa. ERS working paper No. 604.
- Mundell, R. A. (1968). *International Economics*. Macmillan: New York.
- Musa, A., Salisu, A. A., Aliyu, V. O., & Mevweroso, C. R. (2021). Analysis of asymmetric response of exchange rate to interest rate differentials: The case of African big 4. *The North American Journal of Economics and Finance*, 55, 101320.
- Nwachukwu, N. E., Ali, A. I., Abdullahi, I. S., Shettima, M. A., Zirra, S. S., Falade, B. S. & Alenyi, M. J. (2016). Exchange rate and external reserves in Nigeria: A threshold cointegration analysis. *CBN Journal of Applied Statistics* 7(1b), 233-254.
- Ogun, O. D. (2012). Exchange Rate determination in developing economies. *Modern Economy*, 3, 518521 <http://dx.doi.org/10.4236/me.2012.35067>
- Olowe, R. A. (2009). Modelling Naira/Dollar exchange rate volatility: Application of GARCH and asymmetric models. *International Review of Business Research Papers*, 5(3) 377- 398
- Oriavwote, V. E. & Oyovwi, D. O. (2012). The determinants of real exchange rate in Nigeria. *International Journal of Economics and Finance*, 4(8), doi:10.5539/ijef.v4n8p150
- Otapo, T. W. (2020). Determinants of Exchange Rates in Nigeria: An empirical evidence using the portfolio balance model. *IOSR Journal of Business and Management*, 22(3. Ser. IV), 1-10. DOI: 10.9790/487X-2203040110.

- Saeed, A, Awan, R. U., Sial, M. H. & Sher, F. (2012). An econometric analysis of determinants of exchange rate in Pakistan. *International Journal of Business and Social Science* 3(6, Special Issue -March), 184-196
- Salim, A & Shi, K (2019). A cointegration of the exchange rate and macroeconomic fundamentals: The case of the Indonesian Rupiah vis-a-vis Currencies of primary trade partners. *Journal of Risk and Financial Management*, 12 (87), doi:10.3390/jrfm12020087
- Salisu, A. A., Adekunle, W., Alimi, W. A., & Emmanuel, Z. (2019). Predicting exchange rate with commodity prices: New evidence from Westerlund and Narayan (2015) estimator with structural breaks and asymmetries. *Resources Policy*, 62, 33-56.
- Sarno, L., & Taylor, M. P. (2003). *The Economics of Exchange Rates*. Cambridge University Press.
- Sarno, L., & Taylor, M. P. (2002). Purchasing power parity and the real exchange rate. *IMF staff papers*, 49(1), 65-105
- Shin, Y., Yu, B. & Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In: Sickles, R., & Horrace, W. (eds) Festschrift in Honor of Peter Schmidt. Springer, New York, NY. https://doi.org/10.1007/978-1-4899-8008-3_2
- Teall, J. L. (2018). Arbitrage and hedging with fixed income instruments and currencies. In *Financial Trading and Investing*. <https://doi.org/10.1016/B978-0-12-811116-1.00007-6>
- Umoru, D. (2013). Monetary models and exchange rate determination: The Nigerian evidence. *International Journal of Development and Management Review*, 8(1), 172-197
- Wasiu, W. A., Oyegoke. E. O., Gylych, J. & Haruna, T. M. (2019). Determinants of exchange rate in Nigeria: A comparison of the official and parallel market rates. *Economics*, 6(2), 178-188.
- Zakaria, M., & Ahmad, E. (2009). Testing the monetary models of exchange rate determination: Some new evidence from modern float. *Southeast Asian Journal of Economics*, 125-145.

APPENDIX A: Additional Results

Table A1: Test for Asymmetric Cointegration

Critical level	F-statistic = 4.6525		t-statistic = -5.7044	
	I(0)	I(1)	I(0)	I(1)
10%	2.68	4.044	-2.499	-3.621
5%	3.297	4.873	-2.878	-4.068
1%	4.826	6.911	-3.663	-4.995

Note: Kripfganz and Schneider (2018) critical values and approximate p-value

Table A2: Test for long- and short-run asymmetries

Variable	Long-run Asymmetry		Variable	Short-run Asymmetry	
	Wald F-Statistic	Prob > F		Wald F-Statistic	Prob > F
m_t	47.21	0.000	m_t	2.045	0.164
y_t	40.44	0.000	y_t	0.071	0.792
r_t	0.149	0.703	r_t	2.351	0.137
p_t	2.422	0.131	p_t	1.254	0.273
$oilp_t$	1.097	0.304	$oilp_t$	0.001	0.979

Table A3: Long-run Asymmetric Estimates

St	Coef.	F-statistic	p>F	St	Coef.	F-statistic	p>F
m_t^+	0.403	11.92	0.002	m_t^-	0.863	79.11	0.000
y_t^+	-0.927	4.67	0.040	y_t^-	-1.293	7.078	0.013
r_t^+	-0.019	11.68	0.002	r_t^-	0.027	2.285	0.142
p_t^+	1.716	3.53	0.071	p_t^-	0.833	0.187	0.669
$oilp_t^+$	-0.071	0.96	0.336	$oilp_t^-$	-0.014	0.368	0.549

Table A4: Short-run Asymmetry and Error Correction Mechanism results

ΔS_t	Coef.	Wald F-	P- value	ΔS_t	Coef.	Wald F-stat	P-value
Δm_t^+	-0.447	3.48	0.073	Δm_t^-	-0.459	0.14	0.714
Δy_t^+	-0.401	0.73	0.409	Δy_t^-	-0.059	0.57	0.456
Δr_t^+	0.074	10.85	0.003	Δr_t^-	0.195	9.29	0.005
Δp_t^+	-0.97	2.66	0.114	Δp_t^-	-0.15	0.28	0.602
$\Delta oilp_t^+$	-0.118	0.19	0.663	$\Delta oilp_t^-$	-0.188	1.31	00.264
ECM	-0.95 (0.167)			constant	4.343 (0.778)		

Note: ***(**)* indicate significance at 1%, 5%, 10% critical level.; standard errors ()

Table A5: Diagnostic test results

R-squared	Adjusted R-squared	F-Statistic (85, 27)	Prob > F
0.988	0.951	26.29	0.000
Diagonistics		Statistic	ProbValue
Portmanteau Test for serial correlation up to lag 40 (Chi-square)		52.09	0.095
Breusch/Pagan Test for Heteroskedasticity (Chi-square)		0.26	0.607
Ramsey RESET Test (F)		1.228	0.321
Jarque-Bera Residual Normality Test (Chi-square)		0.01	0.995

Note: ***(**)* indicate significance at 1%(5%)10% critical level