

MONETARY MODELS AND EXCHANGE RATE DETERMINATION: THE NIGERIAN EVIDENCE

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Abstract

This paper estimates three different monetary models of exchange rate determination for the Nigerian economy using time series data. These include the Monetary Flex-Price Model, Sticky Price Model and the Hybrid [Flex-Sticky Price] models. Our estimates reveal that the Monetary Flex-Price Model dominates other models in the determination of exchange rate in Nigeria. The model shows that relative money supplies, income levels and real interest rate differentials provide better forecasts of the naira-US dollar exchange rate. The empirical validity of our MFPM estimates is buttressed by the fact that the coefficient of the difference between the domestic and foreign money supply is close to unity. Thus, a one percent increase in the amount of currency supplied in the country stimulates 1.242 percent increase in the nominal exchange rate (depreciation). The empirics of the results are straight forward; a domestic economy that inflates her money supply at a faster rate than does her trading partner can expect to suffer depreciation in the external value of her currency. Consequently, any change in the money supply has as a proportionate effect on the exchange rate and hence on the price level. Thus, the money supply process should be stable; otherwise, the exchange rate system in the country will be unstable. The policy significance in this regard is that monetary policy should be positively predicted.

Keyword: Flex-Price Model, Sticky-Price Model, Hybrid Model, Monetary Models, Exchange Rate,

Background and Problem Statement

Monetary models to exchange rate determination are basically stock models that derived from the IS/LM/Phillip Curve model. So, monetary approach maintains that exchange rate is determined predominantly by shifts in the demand for and supply of money. Essentially, the models are based on finding the exchange rate which the available amount of currency supply is equal to the demand to hold the

currency [Macdonald and Taylor (1992), Adjaoute (1995), Reifscheider, Stockton and Wilcox (1997) and Hoontrakul (1999)]. For an inflationary economy, the models explain why a foreign exchange rate market may be characterized by a self-fulfilling prediction [Edwards and Losada (1994)]. While flow theories like the Purchasing Power Parity [PPP] based on the law of one price asserts that the change in the exchange rate between any two currencies is determined by the change in the relative price levels of the countries involved, the monetary theory of exchange rate determination is entrenched on three building blocks, namely, a stable money demand function in the domestic and foreign countries, the money supply processes in both countries and the equilibrium condition in the money market [Frenkel (1978, 1999), Frenkel and Froot (1989), Vries (1994), Backetti et al. (1995)].

In monetary text, a number of researchers have argued the theory of rational speculative flexible price otherwise known as the rational speculative bubble as a useful means of explaining the volatility in the exchange rates [Meese (1986), Evans (1986) and Macdonald and Taylor (1993)]. This is because speculative bubbles prominently characterize the floating exchange rate regime in the world over. Accordingly, the stochastic nature of money supply induces rational expectations into the dynamic analysis of exchange rate knowing that individuals possess perfect information. In effect, if individuals can distinguish between shocks to levels of money supply and shocks to monetary growth targets, then the changes in the exchange rate would be a one-time response. However, if the market information is imperfect, then the exchange rate feedback movements will reflect a superlative effect each time the market is unable to positively exclude the possibility of a deliberate change of monetary policy by the authorities [Sergeant and Wallace (1975), Cumby and Obstfeld (1981, 1984), Fama (1984) and Hoontrakul, (1999)].

Exchange rate is a price variable that is very germane in every economy as it performs the dual role of maintaining international competitiveness and serving as nominal anchor for domestic prices in the economy [Sercu, Raman and Hulle (1995)]. Indeed, exchange rate is a very sensitive variable, the variation of which determines the pace of economic activities. Apart from being a potent instrument of international exchange, its stability dictates the growth in investment and output of every economy. The determination of the naira-US dollar exchange rate is therefore an issue to be methodically explored. This is the motivation that drives the paper.

The paper therefore estimates econometrically three monetary models of exchange rate determination namely, flex-price model, sticky price model and hybrid, that is, flex-sticky model in order to find the model that is more feasible for exchange rate determination in Nigeria. The significance of the study lies on the fact that it affords the opportunity to do a comparative check of the different monetary models of exchange rates determination in Nigeria.

The motivation of the present research is as well justified given that its empirical measurement covers beyond the age of structural policy break that co-existed in the country as at 1986 with the implementation of the floating or flexible exchange rate through the Second tier Foreign Exchange Market [SFEM]. Also, some

researchers have explored the relevance of the flex model within the Nigerian context without an empirical consideration of other forms of monetary models of exchange rate determination. Above all, in spite of the known fact that some researchers have explored the applicability of the flex model, their coverage is limited since their data points are not elongated to 2011. These facts put together are capable of generating a lacuna between theory and evidence as regards the subject matter and most of all in rapid contrast to the present motivation and research objective which is explored in recent times to wrap both the pre and post deregulation years. The rest of the paper is organized into six sections. Section two gives the trends in money supply and exchange rate management in Nigeria. Section three provides an explicit review of the monetary models of exchange rate determination as well as the prior empirical evidence on the monetary models in the determination of exchange rates. In section four, we focused largely on the derivation of the flexible and sticky price models required for econometric estimation of the monetary approach to exchange rate determination. The econometric methodology, data measurement and sources are also espoused in section four. Section five analyzes the regression results. Model stability test and robustness checks are contained in section six. Lastly, section seven concludes the paper.

2. Trends in Money Supply and Exchange Rate Management in Nigeria

Monetary Developments in Nigeria

Recently, the Central Bank of Nigeria [CBN] predicted a 24.64 percent growth in broad money supply for 2012 [CBN (2012)]. The CBN, in a report on Monetary, Credit, Foreign Trade and Exchange Policy Guidelines for fiscal years 2012/2013, added that the money supply would also grow by 18.38 percent in 2013. In 2011, broad money [M_2] grew by 8.55 percent in the eight months [CBN (2011)], which annualized to a growth rate of 12.82 percent. When the CBN changes the level of money supply, it does so through the control of the base¹ money. When money supply exceeds the level the economy can efficiently absorb, it dislodges the stability of the price system, leading to inflation or higher prices of goods. Once it is perceived by the CBN that there is too much money in circulation and prices are rising or there is potential pressure for prices to rise, it may reduce money supply by reducing the base money. To reduce the base money, the central bank sells financial securities to commercial banks and the non-bank public so as to reduce the ability of deposit money banks to create new money.

Besides, the CBN can reduce the money supply by raising the cash reserve deposits that banks are required to hold with the central bank. The larger the deposit balances on bank balance sheets, the higher their ability to create more money. The

¹ Base money is made up of currency and coins outside the banking system plus the deposits of banks with the central bank. There is excess money supply when the amount of money in circulation is higher than the level of total output of the economy.

CBN's monetary policy, therefore, targets the growth in those deposit balances so as to control the expansion in money supply which could precipitate price distortions. A reduction in money supply affects the ability of commercial banks to create new money through giving loans to their customers. In effect, the CBN could be said to be implementing a contractionary monetary policy. When investors cannot get new loans to expand their investments, it reduces the level of aggregate output in the economy.

Exchange Rate Management in Nigeria

Exchange rate management is a core macroeconomic policy function of the central monetary authority, for example the CBN. The CBN has over the years experimented with the fixed and the market based exchange rate regimes. The overriding policy objective is to achieve a realistic² and stable exchange rate consistent with internal and external balance. In fact, the significance of foreign exchange in international economic transactions has made it vitally evident that the management of scarce foreign exchange is a considerable component of national economic management. During the 1970-1985 period of economic management, Nigeria operated a controlled exchange rate regime where exchange rate of the naira was pegged to the dollar. The second phase of exchange rate management in Nigeria began in 1986. This followed the oil glut of early 80s, where it became evident that the Nigerian economy which depends exclusively on oil revenues was not able to sustain the fixed exchange regime in the sense that the country's foreign reserves got exhausted in addition to enormous foreign debt stock. As an essential element of the Structural Adjustment Programme [SAP] introduced in 1986, the country adopted a flexible exchange rate through the Second tier Foreign Exchange Market [SFEM]. A decisive assessment of the exchange rate regimes from 1986 highlights a propensity towards incessant exchange rate depreciation or put differently, exchange rate volatility which is unfavorable to monetary stability. Despite the adjustment from one regime to another, a consensus on the determination of naira-dollar exchange rates is yet to be reached.

Literature Review

Theoretical Review of Monetary Models of Exchange Rate Determination

There are copious models of the monetary approach to the determination of exchange rate. These include the Monetarist Flex-Price Model [MFPM], Sticky Price Model [SPM] and Mundell-Fleming Model [MFM]. The thrust of the monetarist flex-price model is that the exchange rate level is perfectly correlated with the level of the relative money supply in long run. In the flexible price monetarist view, the asset market equilibrium lies at the center of analysis and the asset in question is money. The demand for money function is stable and the supply is determined by the

²A realistic exchange rate ensures efficient allocation of foreign exchange resources and paves way for a non-inflationary growth.

monetary authorities. The model is indeed, an extension of the PPP theory as it essentially appends a theory of price level determination to a PPP equation in order to explain the rate of exchange [Fischer (1984), Ghosh et al. (1995)]. The analysis of the model is that changes in money supply under the floating exchange rate system determines changes in exchange rate depreciation. The extent of the depreciation depends on how domestic money supply exceeds foreign money supply. Theoretically, when money supply rises, the domestic price level rises as well for a given foreign price level and the exchange rate will have to rise based on the PPP hypothesis [Pippenger (1993)].

Due to Dornbusch (1976), the sticky price model provides an explanation why the exchange rate under the floating system is volatile, overshooting above the long-run equilibrium. This is a spill off from the monetarist model in which employment is full and goods prices become sticky rather than flexible. That is to say the price of 'non-traded' goods changes to their new equilibrium after a disturbance, while 'traded' goods prices increase in proportion to the money supply [Dornbusch (1995, 1988), Dornbusch, Fischer and Samuelson (1977)]. Hence, the overall price level increases less than the money supply, leaving the demand for money lower than the supply. In these circumstances, the exchange would go beyond its new equilibrium before returning to it. Eventually, the excess supply of money is eliminated via rising non-traded goods prices. The basic tenet of the sticky price model is that when currency is devalued and the price of goods remains fixed for short-run, the currency value may 'overshoot'.

The overshooting in the exchange rate refers to a temporary overreaction of the nominal exchange rate before moving back toward the equilibrium value in the long run. According to Frenkel (1976), the exchange rate may temporarily overshoot its long run equilibrium value for at least three reasons. First, the exchange rate overshoots due to imperfect information on the shock of money supply levels. The currency may overshoot after it has been floated as a result of the 'sticky price' effect of the goods markets combined with instantaneous adjustment in asset market.

Third, the lack of credibility, sustainability and confidence in government after periods of high inflation causes the political support to inevitably fall off. Thus, the currency chaos can be resulted in self-fulfilling perpetual currency depreciation belief resulting in hyperinflation period. Nevertheless, Dornbusch (1995) posits that currency speculation attack by itself is not the cause of the currency crisis. It is the economic fundamental underlining the currency that causes the currency to depreciate or appreciate. Speculation is just an accelerator to the currency realignment at the faster rate to reach its fundamental equilibrium value. The problem is thus, that of vulnerability. This leads to full scale financial crisis and forced 'de facto' devaluation by changing currency regime from fixed to float. One lesson from this episode is to avoid vulnerability in the first place. This can only be done by having good macroeconomics management including financial deregulation and supervision, avoiding overvalue real exchange rate to achieve disinflation, lengthening the foreign capital maturity and plenty of transparency.

Mundell (1963) and Fleming (1962) opine that goods prices are sticky; asset markets including the foreign exchange markets are persistently in equilibrium with long-run money neutrality. The model provides predictions regarding the international transmission of domestic shocks and co-movements of macroeconomic variables at home and abroad. Unlike Keynes who overlooks linkage between assets and money markets [Keynes (1923, 1930)], the monetarist considers all three markets: money, assets and goods markets. And all three markets must be clearly in equilibrium under perfect price flexibility in long run. The monetarist exchange rate model contemplates flexible prices which keep the goods markets in permanent equilibrium since employment is not fully utilized. Furthermore, the model assumes zero exchange risk premium, UCIRP holds, PPP holds and there is perfect mobility of capital in a risk neutral world. Still the money has no substitutability. The theory underlying the Mundell-Fleming model is that devaluation could further exacerbate devaluation due to fiscal irresponsibility or indiscipline, excessive inflation and balance of payments deficits [Kouri (1976), Krugman (1979)].

Empirical Evidence on Monetary Models of Exchange Rate Determination

The empirical evidence on the monetary models, namely, MFPM, SPM and MFM to exchange rate determination is vast. However, researchers have focused mainly on the MFPM and the SPM. MacDonald and Taylor (1991c) demonstrated that the null hypothesis of non-co-integration between the variables in the monetary models of exchange rate determination can be rejected for the bilateral US dollar rates of the UK pounds, German mark and the Japanese yen over the sample period (1976-1990). As a matter of empirical finding, MacDonald and Taylor (1991c) econometrically explored that the restrictions of the MFPM cannot be rejected for the mark-dollar exchange rate. Such strong empirical long-run finding motivated MacDonald and Taylor (1993)'s modelling of the short-run exchange rates dynamics of the US dollar-deutschmark exchange rates. These authors demonstrated that the effectiveness of the monetary models to surpass the simple random-walk model of exchange rate determination in an out-of-sample forecasting framework. This surpassing tendency of the monetary models over the random-walk has furthermore been substantiated by the time-varying parameter models of Wolff (1987) and Schinasi and Swamy (1987).

Several researchers including Hoffman and Schlagenhauf (1983), Woo (1985), Kearney and MacDonald (1990), Nessen (1994), Sercu, Raman and VanHulle (1995) and Deverux and Engel (1998) have all modeled and estimated the complete future path of expected inflation. The results of their empirical estimation show that the rational expectation hypothesis underlying the augmented MFPM is valid. In addition, Huang (1981) found empirical evidence that is supportive of the existence of speculative bubbles. Having employed the MFPM as his exchange rate model of economic fundamentals, Huang (1981), in particular, finds evidence of excess volatility of the current exchange rate for the US dollar-mark, US dollar-UK pound and UK pound-mark exchange rates relative to its perfect foresight value. Using the

SPM as a model of economic fundamentals, Wadhvani (1984) also reported empirical evidence of excess volatility for the dollar-sterling rate.

Hodrick (1978), Bilson (1978) and Putnam and Woodbury (1980) have all estimated the MFPM for the deutschmark-US dollar and the UK pound-US dollar respectively using the floating exchange rate data. Hodrick (1978) found the coefficients on the German and US money stock to be significantly equal to unity as predicted by the model. The estimates obtained by Bilson (1978) and Putnam and Woodbury (1980) were poor. The empirical evidence on the SPM is sparse. However, in his empirical investigation of the exchange rate dynamics, Driskell (1981) regression estimates of the SPM for the US economy could not also stand the test of time. Smith and Wicks (1990) have used the SPM to assess the extent of monetary shocks and exchange rate variation for the UK. The econometric fit of UK data to SPM was poor as the coefficient estimates failed to conform to the model predictions. Boughton (1988), Macdonald (1988b) and MacDonald and Taylor (1989e, 1992) have all offered a variety of rationalizations for the poor performance of the MFPM and SPM. Further, Kempa (2005) had recently observed that the SPM is characterized with the problem that it does not allow for a distinction to be drawn between the short-run and long-run changes in the determinants of the real exchange rate. Others have recognized its static nature and hence may perhaps not be well suited for explaining the short-run behaviour of exchange rates.

Frankel (1979a) however, adopted a reduced form sticky price exchange rate model and obtains estimates of exchange rate overshooting for the German economy. The sticky-price model effect according to Frankel (1979a) is simply an estimate of how much the mark-dollar exchange rate would have to depreciate for a once-and-for-all increase in the US money supply of one percentage point (Hallwood and MacDonald, 1996). In particular, the calculated decline in the real interest rate differential gives a current exchange rate overshoot of about 1.23%. Frankel (1979a) further estimates that if the expected inflation rate is raised by one percentage point annually, this will induce a short-run exchange rate overshoot of exactly 1.58%. According to Hallwood and MacDonald (1996), if the monetary expansion signals to investors a new higher target for monetary growth, the initial overshooting will be greater. The general consensus which has been developed on the basis of the hybrid monetary model (Frankel, 1979a) in the empirical literature is that in the long-run, the nominal exchange rate is determined by the MFPM but that in the short-run, the exchange rate deviates by an amount determined by the real interest rate differential between the home and foreign countries.

The Monetary Models of Exchange Rate Determination

There are many versions of monetary models of exchange rate determination [Rosenberg (1996)]. These include the flex-price model [Frenkel (1976) and Bilson (1978)], sticky-price model [Dornbusch (1976)], real interest rate-differential model or the hybrid monetary model [Frankel (1979)] and equilibrium real exchange-rate model [Hooper-Morton (1982)]. For the sake of this paper, focus is given to the

flexible, sticky price and hybrid models in the econometric modeling and estimation of the monetary approach to exchange rate determination. This is the approach that researchers like Hodrick (1978) and Frankel (1979a) have in the past adopted.

Monetarist Flex-Price Model [MFPM]

The basic building blocks of the model are the goods, money and asset markets. Given that the asset in question is money, the money market is made up of stable money demand and supply functions in the domestic and foreign countries:

$$\begin{aligned} M_t - P_t &= \beta_1 Y_t - \beta_2 R_t \\ M_t^f - P_t^f &= \beta_1^f Y_t^f - \beta_2^f R_t^f \end{aligned} \quad [4.1]$$

Where M_t, M_t^f are the domestic and foreign money supplies, P_t, P_t^f are the domestic and foreign price levels, Y_t, Y_t^f are the domestic and foreign national output [income] levels, R_t, R_t^f are the domestic and foreign interest rates and f 's indicate variables pertaining to the foreign economy. Solving for the relative price levels in the home and foreign countries, we have that:

$$\begin{aligned} P_t &= M_t - \beta_1 Y_t + \beta_2 R_t \\ P_t^f &= M_t^f - \beta_1^f Y_t^f + \beta_2^f R_t^f \end{aligned} \quad [4.2]$$

Price level and exchange rate are related through the purchasing power parity [PPP] identity such that:

$$E_t^n = P_t - P_t^f \quad [4.3]$$

Where e_t^n is the nominal exchange rate. On the assumption that capital is perfectly mobile and as such asset-holders can adjust their portfolios instantly when there is a disturbance, uncovered interest rate parity should of course then hold:

$$\Delta E_{t+1}^{nE} = (R - R^f)_t \quad [4.4]$$

Where Δe_{t+1}^{nE} denotes the logarithmic value of the expected change in the nominal exchange rate, one-period ahead. By substituting [4.2] into [4.3], the reduced-form equation for the MFPM is thus derived:

$$E_t^n = (M_t - M_t^f) - \beta_1 Y_t + \beta_1^f Y_t^f + \beta_2 R_t - \beta_2^f R_t^f \quad [4.5]$$

Equation [4.5] can be written as in equation [4.7] based on the Fisher parity relationship that:

$$R = i_t + \pi_{t+1}^e \equiv R^f = i_t^f + \pi_{t+1}^{ef}$$

Where i_t, i_t^f are the real interest rates for the domestic and foreign countries and $\pi_{t+1}^e, \pi_{t+1}^{ef}$ are the expected inflation rates, home and abroad. Assuming the law of one-price in the asset (money) market such that the domestic real rate of interest is tied to the foreign rate, that is, real interest rates are equalized across the world as reflected in the equation:

$$i_t = i_t^f$$

[4.6]

The econometrically estimable MFPM of exchange rate determination is obtained by adding a disturbance term to equation [4.5]:

$$E_t^n = \beta_0 + \beta_1[M_t - M_t^f] - \beta_2[Y - Y^f]_t + \beta_3[\pi^e - \pi^{ef}]_{t+1} + u_t$$

[4.7]

The theoretical expectations for the MFPM are $\beta_1 = 1, \beta_2 < 0, \beta_3 > 0$. According to Laider (1992), for reliable estimates of the MFPM, β_2 and β_3 should take on values close, in absolute terms, to the estimated income elasticity and interest semi-elasticity from an estimated money demand model in the range of 0.5 to 1 depending on the definition of the money stock.

Sticky Price Model [SPM]

Price stickiness indicates that the goods market do not clear in the short-run but does in the long-run. Hence, the PPP hypothesis does not hold in the short-run. Given that price level is sticky, equation [4.3] then holds as a long-run trend such that:

$$\bar{E}^n = \bar{P} - \bar{P}^f$$

[4.8]

The expected change in the exchange rate is thus governed by a regressive expectations component:

$$\Delta E_{t+1}^{nE} = \phi(\bar{E}^n - E^n), \quad [0 < \phi < 1]$$

[4.9]

For the fact that the PPP holds in the long-run, there is therefore an evolution of the price level from the short to the long-run equilibrium. By assumption therefore, the price level adjusts in proportion to excess aggregate demand:

$$\Delta P_{t+1} = \delta(Y^d - \bar{Y})$$

[4.10]

Where Δp_{t+1} is the change in the price level, one-period ahead, δ is the speed of adjustment, Y^d, \bar{Y} are the aggregate demand and the full employment equilibrium

national output respectively. Thus, the aggregate demand function takes the Mundell-Fleming form:

$$Y^d = \beta_5 g - \beta_1 R + \beta_2 (E_t^n - P_t) + \beta_3 \bar{Y} \quad [4.11]$$

Where β_5 is the shift parameter which captures government spending effect, β_1 captures the interest rate effect on domestic absorption, β_2 is the real exchange rate effect and β_3 is the income effect on expenditure growth. Putting [4.11] into [4.10], the change in price level is obtained as:

$$\Delta P_{t+1} = \delta [\beta_0 g + \beta_2 (E_t^n - P_t) + (\beta_3 - 1) \bar{Y} - \beta_1 R] \quad [4.12]$$

Following same procedures as outlined under the MFPM, the econometrically estimable SPM is derived as:

$$E_t^n = \beta_0 + \beta_1 [M_t - M^f]_t - \beta_2 [Y - Y^f]_t + \beta_3 [(R_t - \pi_{t+1}^e) - (R_t^f - \pi_{t+1}^{ef})] + \mu_t, \quad [\beta_3 = 1/\phi] \quad [4.13]$$

Theoretical expectations for the sticky price Dornbusch model are $\beta_1 = 1, \beta_2 < 0, \beta_3 < 0$, β_3 is the measure of exchange rate overshoot and μ is the stochastic disturbance.

Flex-Sticky Price Monetary Model: The Hybrid Model [HM]

As in the MFPM and SPM, the expected change in the exchange rate is governed by a regressive expectations component and the expected inflation differential:

$$\Delta E_{t+1}^{nE} = \phi (\bar{E}^n - E^n)_t + (\pi^e - \pi^{ef})_{t+1}, \quad [0 < \phi < 1] \quad [4.14]$$

In the long-run, $e_t^n = \bar{e}_t^n$. Thus, the exchange rate is expected to change by an amount that is equal to the long-run inflation differential. So, substituting equation [4.14] into equation [4.4] yields:

$$E_t^n = \bar{E}_t^n \frac{1}{\phi} [(R_t - \pi_{t+1}^e) - (R_t^f - \pi_{t+1}^{ef})] \quad [4.15]$$

Equating [4.15] to [4.7] and solving for the equilibrium nominal rate of exchange using the assumption that equilibrium values are given by their current actual values, the estimable hybrid monetary exchange rate model is derived:

$$E_t^n = \beta_1[M_t - M^f]_t - \beta_2[Y - Y^f]_t + \beta_3[\pi_t^e - \pi_t^{ef}]_{t+1} + \beta_4[(r_t - \pi_{t+1}^e) - (r_t^f - \pi_{t+1}^{ef})] + \varphi_t, (\beta_4 = 1/\phi)$$

[4.16]

Theoretical expectations for the hybrid model are $\beta_1 = 1, \beta_2 < 0, \beta_3 > 0, \beta_4 < 0$. The logarithmic representation of the error correction versions of our MFPM, SPM and HM models are specified as follows:

$$\Delta \ln E_t^n = \beta_0 + \sum_{i=1}^k \beta_{1i} \Delta \ln [M_t - M_t^f] - \sum_{i=1}^k \beta_{2i} \Delta \ln [Y - Y^f]_t + \sum_{i=1}^k \beta_{3i} \Delta \ln [\pi^e - \pi^{ef}]_{t+1} + \delta ECM_{t+1} + \nu_t$$

$$\Delta \ln E_t^n = \beta_0 + \sum_{i=1}^k \beta_{1i} \Delta \ln [M_t - M^f]_t - \sum_{i=1}^k \beta_{2i} \Delta \ln [Y - Y^f]_t +$$

$$\sum_{i=1}^k \beta_{3i} \Delta [(R_t - \pi_{t+1}^e) - (R_t^f - \pi_{t+1}^{ef})] + \sigma ECM_{t+1} + \mu_t$$

$$\Delta \ln E_t^n = \beta_0 + \sum_{i=1}^k \beta_{1i} \Delta \ln [M_t - M^f]_t - \sum_{i=1}^k \beta_{2i} \Delta \ln [Y - Y^f]_t +$$

$$\sum_{i=1}^k \beta_{3i} \Delta \ln [\pi_t^e - \pi_t^{ef}]_{t+1} + \sum_{i=1}^k \beta_{4i} \Delta [(R_t - \pi_{t+1}^e) - (R_t^f - \pi_{t+1}^{ef})] + \gamma ECM_{t+1} + \varphi_t$$

Methodological Framework and Data Measurement with Sources

The study utilized the Johansen and Juselius (1990, 1992) co-integration methodology and the dynamic general-to-specific econometric modeling [Hendry (2005)]. By way of contribution, we went beyond the single equation co-integration procedures of Engle and Granger (1987). This is unlike Boothe and Glassman (1987), Meese (1986) and Kearney and MacDonald (1990) who have in the past adopted the said Engle and Granger (1987) Two-Step co-integration procedure to estimate the MFPM. The econometric advantage of our methodology in comparison to the single co-integration procedures is the fact that the multivariate long-run relationship between the variables in our respective models is established simultaneously. We resolved to time series estimations in order to measure the short-run dynamic

relationship between exchange rate and monetary variables under the Monetary Flex-Price, Sticky Price and Hybrid [Flex-Sticky Price] models of exchange rate determination.

Data on nominal exchange rate, real interest rates, relative money supplies, national income levels and expected inflation rates for the home (Nigeria) and foreign (US) countries were compiled from the IMF's International Financial Statistics Yearbook and the World Bank [World Development Indicator], 2010 edition. Given the time scope of the study, 1975 through to 2010 and the annual frequency of the data, all variables have 35 data points. The inflation utilized is the annual percentage growth rate of CPI. We adopt the Dhakal et al (1993) approach of using the first difference of the log of the current price level generating data for expected inflation data. This approach of computing expected inflation is desirable on the ground that it is consistent with both the rational and adaptive expectation hypotheses. This is in addition to the fact that inflation cannot be filtered to generate expected inflation as in the case of the use of the Hodrick-Prescott filter in generating potential output.

Empirical Analysis

Unit Root Test Analysis

Fundamentally, all variables were tested for stationarity in order to investigate the time series characteristics of our data and hence ensure consistency in succeeding regression estimations. In addition, the unit root test was conducted to determine the order of integration as it is both a necessary and sufficient condition for the possible existence of co-integrating relations [Libanio (2005)]. We utilized the Augmented Dickey-Fuller [ADF], Phillips-Peron [PP] and Kwiatkowski [KPSS] tests to determine the order of integration. While the ADF test the null hypothesis of a unit root, the PP and KPSS test the null that the series are stationary. Thus, a rejection of the null under the ADF is indicative of the absence of unit root and similar rejection of the null under the PP and KPSS is evident of non-stationarity. For the PP test, we utilized the Bartlett Kernel for the spectral estimation. For the ADF test, the lag order was determined by the Schwarz Information Criterion [SIC] given by $2L/N + (k \log N)/N$, where L is the log likelihood, N is the number of observations and k is the number of coefficients in the auxiliary regression.

The test results are as reported in Appendix 1. A critical assessment of the results show explicitly that all the variables in the study only gained stationarity at first difference. By implication, all the variables (nominal exchange rate, domestic money stock, foreign money stock, domestic national income, foreign income level, domestic real rate of interest, foreign real interest rate, and expected inflation rates) trended at levels. This is made evident on the ground that for the ADF and PP, the test statistic(s) in absolute value(s) are greater than the 5 percent critical values of (-3.56) and (-4.57) respectively, while for the KPSS, stationarity was made evident on the ground that the test statistics are smaller than the 5 percent critical value of

(0.226). The robustness of the unit root test results lies in the fact that the test equations include an intercept and a linear trend.

Co-integration Test Results

In the Johansen Maximum Likelihood co-integration procedure, a test for the optimal lag length of the related Vector Auto Regression [VAR] was conducted. This was necessitated because the Johansen's co-integration test is highly sensitive to the appropriate lag length. In such a consideration, the Akaike Information Criterion [AIC], Final Prediction Error [FPE], Likelihood Ratio [LR], Schwartz Information Criterion [SIC] and Hannan Quin [HQ] selection criteria were utilized in choosing the appropriate lag length. The AIC and the SBC in evenhandedness generated the optimal lag order of 2 required for the co-integration test. The Johansen's co-integration results are reported in Appendix 2. Evident from both the trace and the max eigen statistic(s), the hypothesis of non co-integrating relationship amongst the variables in the respective models is rejectable with the conclusion that at least one co-integrating relation exists.

At the 5 percent level, the trace test validates the null hypothesis of at most **3**, **2** and **4** co-integrating relations for the Flex-Price [FPM], Sticky Price Model [SPM] and Hybrid [Flex-Sticky Price] Model respectively. On the other hand, the maximum eigen statistics validates the null of at most **2**, **1** and **4** co-integrating vectors at the 5 percent significance level for the respective models. In all, the results indicate an overwhelming evidence of the existence of a long-run relationship between exchange rate of the naira vis-à-vis the US dollar, relative money supplies, income levels, interest rate and expected rates of inflation in the respective models. The validity of the alternative hypothesis of co-integration of our variables in the monetary models is supported by those of MacDonald and Taylor (1991c), unlike the non-co-integration results obtained by Boothe and Glassman (1987), Meese (1986) and Kearney and MacDonald (1990).

Empirical Analysis of Error Correction Results

The error correction estimates of the model are presented in Appendix 3 below. The dynamic short run ECM coefficients are based on the Schwartz Bayesian Criterion for selecting the appropriate ARDL representation. For the MFPM, all the variables namely, relative money supplies, income levels and expected inflation rates are correctly signed and all statistically significant at the 95 percent and 99 percent levels. Our estimated coefficients of the relative money supplies are not statistically different from unity as predicted by the MFPM. Thus, a one percent increase in the amount of money supplied in the country stimulates 1.242 percent increase in the nominal exchange rate (depreciation). The empirics of the results are straight forward; a domestic economy that inflates her money supply at a faster rate than does her trading partner can expect to suffer depreciation in the external value of her currency. The estimated coefficient for the domestic income level is negative and that of the US is positive just as theoretically predicted by the MFPM. Thus, a one-

percentage point increase in the home national income level will make the nominal exchange rate to appreciate by 1.328 percent. A similar increase in the foreign national income level will induce 0.044 percent depreciation in the naira-dollar exchange rates on the platform of a floating exchange rate system.

The estimation results of the SPM are in general not overwhelming in terms of statistical robustness. This can easily be seen in the low determination coefficient of 42.5 percent which is indicative of the fact that the estimated SPM is not remarkably successful in explaining the exchange rate in the sample. Moreover, some of the coefficient signs do not conform to the theoretical expectations of the SPM. However, our sticky-price model effect as measured by the real interest rate differential is imperceptibly significant. In particular, the results show that a ten percent fall in the real interest differential between Nigeria and the US gives a nominal exchange rate overshoot of about 15.69 percent. This coefficient does not differ from that estimated for the HM. Indeed, both the SPM and the HM cannot be distinguished with respect to the coefficients of the real interest rate differential. The estimated results for the HM shows that if the expected inflation rate of economic agents is raised by ten percent, it leads to a short-run exchange rate overshoot of 11.88 percent. Thus, we agreed with Hallwood and MacDonald (1996) that an ignorance of the expected inflation effect downwardly biases estimates of the short-run exchange rate overshoot. By implication, erroneous expectations in the short-run would trigger an initial nominal exchange rate movement in the expected direction. Such expected direction is actually a wrong direction and hence it make the nominal exchange rate to over-react temporary but however, magnified by the effect of perfectly flexible goods market as a result of the Fisher effect [Hoontrakul (1999)]. Nevertheless, when such expectations are corrected over the long-run period, the exchange rate would return to equilibrium rate. Consequently, government intervention in the foreign exchange market is desirable in this scenario.

The speed of adjustment of the nominal exchange rate from its short-run to its long-run equilibrium value in relation to disturbances arising from relative money supplies, income levels, interest rate and expected inflation rates are 82.8 percent, 53.5 percent and 69.9 percent for the MFPM, SPM and HM respectively. The model's diagnostic tests for serial correlation, functional form, normality of residuals and heteroskedasticity do not indicate any concern for econometric problems. Indeed, the adequacy of the overall regression results is ascertained on the basis of significant F-statistic(s) of 38.2, 22.2 and 50.2 for the three models respectively. This goes a long extent to indicate the existence of a significant linear relationship between the naira-dollar exchange rates and monetary variables in Nigeria. Also, the goodness-of-fit of the regression estimates is instituted on the basis of a significant explanatory power as measured by the adjusted and unadjusted coefficients of model determination. Having adjusted for degrees of freedom, 86.2 percent, 42.5 percent and 80.2 percent of the total variations in the nominal exchange rate are explained by the MFPM, SPM and HM respectively. Evidently, the results reveal that the best fit of the data is obtained for the MFPM. In the main, the probability values

of the Breusch-Godfrey *LM* statistic reported discloses no traces of serial correction in the error component of the estimated monetary models. The Box-Pierce's (*Q*) statistic also shows that the residuals are white noise. These further lend credence to the adequacy of the specification of our models. On the basis of the diagnostic statistical checks, the error correction results are adjudged to be statistically fit and robust.

Synthesis of Our Results with other Empirical Results

In econometrically testing the monetary model of exchange rate determination, we estimated the Flex-Price Model [FPM], the Sticky Price Model [SPM] and the Frankel's Hybrid Monetary Model [HM]. Our regression results provide robust empirical support for the Monetarist Flex-Price Model, than the Sticky Price and Frankel's Hybrid versions. The empirical validity of our MFPM estimates is buttressed by the fact that the coefficient of the difference between the domestic and foreign money supplies is close to unity. These results conformed to the empirical results obtained by Hodrick (1978), Wolff (1987), Schinasa and Swamy (1987), Woo (1985), Finn (1986), Hoffman and Schlagenhauf (1983), MacDonald and Taylor (1991c), MacDonald and Taylor (1993). The validity of the co-integrating relationship of the identified variables in our models corroborates those of MacDonald (1990) as against the non-co-integration results obtained by Boothe and Glassman (1987), Meese (1986), Kearney and MacDonald (1990). As regard the SPM, our empirical estimates and findings are not enormously robust and hence failed to lend significant weight to Frankel's (1979a) sticky-price model effect as measured by the real interest rate differentials, but rather uphold the empirical results earlier obtained by Bilson (1978), Putnam and Woodbury (1980), Driskell (1981) and Smith and Wckens (1990) that estimation of the SPM in recent times will break down.

Model Stability and Robustness Checks

Model stability is established in this study on the basis of the cumulative sum of residuals [CUSUM], cumulative sum of squares of recursive residuals [CUSUMSQ] and the prediction error of the estimated monetary models. The results of the prediction error are provided in Figure 4. Empirically, the recursive residuals in the regressions persistently drift within the standard error bounds of plus-minus two [± 2]. This facilitated the adaptive configuration of the CUSUM test parameters thereby correcting any trace of structural instability. Thus, the n^{th} recursive residuals were generated as the ex post prediction errors for exchange rate. The CUSUM and the CUSUMSQ tests utilize the cumulative sum of the recursive residuals and the squares of recursive residuals based on the first set of observations. This was recursively updated and hence plotted against break points [Brown, Durbin and Evans (1975)]. The results of the stability test are provided in Figure 5. Evidently, stability is easily inferred for the period under analysis. The source of the stability inference derived from the fact that neither the CUSUM nor CUSUMSQ plots cross the critical bounds as

represented by the straight lines drawn at the 5% significance level. This in effect indicates absence of significant structural instability over the study period. This indeed, provides empirical evidence in support of the validity of the null hypothesis of parameter constancy at the 5% level for the estimated coefficients of our error correction representations.

Summary

In econometrically testing the applicability of the monetary models of exchange rate determination for the Nigerian economy, we estimated the Flex-Price Model [MFPM], Sticky Price Model [SPM] and Hybrid Model [HM]. Though, our sticky-price model effect as measured by the real interest rate differential is imperceptibly significant, the estimated set of regressions provide robust empirical support for the Monetarist Flex-Price Model, than the Sticky Price and the Hybrid [Flex-Sticky Price] models. The MFPM shows that relative money supplies and income levels provide better forecasts of the naira-US dollar exchange rate. Thus, the Monetarist Flex-Price Model is the best for modeling the exchange rate in Nigeria. It is therefore an essential device for exchange rate determination policy in the country. The empirical validity of our MFPM estimates is buttressed by the fact that the coefficient of the difference between the domestic and foreign money supply is close to unity. The empirics of the results are straight forward; a domestic economy that inflates her money supply at a faster rate than does her trading partner can expect to suffer depreciation in the external value of her currency. Consequently, any change in the money supply has as a proportionate effect on the exchange rate and hence on the price level. Thus, the money supply process should be stable; otherwise, the exchange rate system in the country will be unstable. The policy significance in this regard is that monetary policy should be positively predicted.

Conclusion

Further empirical finding is the fact that inflation expectations of economic agents are significant determinant of exchange rate volatility. This indeed, makes it prominent for us to agree with Hallwood and MacDonald (1996) that an ignorance of the expected inflation effect downwardly biases estimates of the short-run exchange rate overshoot. By implication, an erroneous expectation in the short-run would trigger an initial nominal exchange rate movement in the expected direction. Such expected direction is actually a wrong direction and hence it makes the nominal exchange rate to overshoot temporary but however, magnified by the effect of perfectly flexible goods market as a result of the Fisher effect. Nevertheless, when such expectations are corrected over the long-run period, the exchange rate would return to equilibrium rate. To put inflationary expectations under control, the implementation of monetary policy should be transparent. Consequently, government intervention in the foreign exchange market is desirable in this scenario. However, the involvement of the government must be such that regularly align with monetary policy framework of implementation.

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Appendices

Appendix 1: Unit Root Test/Sationarity Results in Difference based ADF, PP and KPSS

Variable(s)	Test Statistic(s)			Integration Order	Statistical Inference
	ADF	PP	KPSS		
	Drift and Trend	Drift and Trend	Drift and Trend		
ΔLnM_t	-5.472*	-8.222*	0.028*	I [1]	Stationary
ΔLnM_t^f	-5.255*	-6.545*	0.026*		Stationary
ΔLnY_t	-4.682*	-10.426*	0.088*		Stationary
ΔLnY_t^f	-6.225*	-18.226*	0.152*		Stationary
$\Delta Ln\pi_t^e$	-4.992*	-24.464*	0.204*		Stationary
$\Delta Ln\pi_t^{ef}$	-3.926*	-10.669*	0.220*		Stationary
ΔLne_t^n	-40.822*	-6.644*	0.165*		Stationary
$\Delta(i_t - i_t^f)$	-5.666*	-12.688*	0.589*		Stationary
Critical Value(s)	-3.68	-4.57	0.226		

Note: * indicates first-difference stationary of the series @ the 5% level

Appendix 2: Co-integration Test Results Based on Johansen’s Maximum Likelihood

Approach

Monetarist Flex-Price Model (MFPM)					
Null hypothesis	Optimal VAR Lag Length	Trace Statistic	5% Critical Value	Maxeigenvalue	5% Critical Value
$H_0 : r = 0$	2	182.6*	140.8	142.4*	128.2
$H_0 : r \leq 1$	2	180.2*	138.8	145.2*	122.3
$H_0 : r \leq 2$	2	122.8	132.6	126.6*	124.8
$H_0 : r \leq 3$	2	120.5	105.2	120.8	122.6
$H_0 : r \leq 4$	2	128.5	102.5	108.8	112.2
Sticky Price Model (SPM)					
$H_0 : r = 0$	2	172.2*	138.8	168.5*	152.2
$H_0 : r \leq 1$	2	162.9*	134.8	162.3*	146.6
$H_0 : r \leq 2$	2	150.3*	128.6	140.9	146.2

$H_0 : r \leq 3$	2	120.6	124.5	126.6	130.2
Umoru, D.: Monetary Models and Exchange Rate Determination: The Nigerian Evidence					
Flex-Sticky Price Model: Hybrid Model (HM)					
$H_0 : r = 0$	2	242.2*	132.2	132.8*	123.5
$H_0 : r \leq 1$	2	188.2*	122.5	126.8*	124.6
$H_0 : r \leq 2$	2	132.6*	102.6	125.6*	120.4
$H_0 : r \leq 3$	2	166.3*	128.0	122.3*	112.4
$H_0 : r \leq 4$	2	146.5*	144.2	120.2*	112.2
Notes: r denotes the number of co-integrating vectors; * indicates statistical significance @ 5% level					

Appendix 3: Error Correction Results of the Monetary Approach to the Theory of Exchange Rate Determination in Nigeria

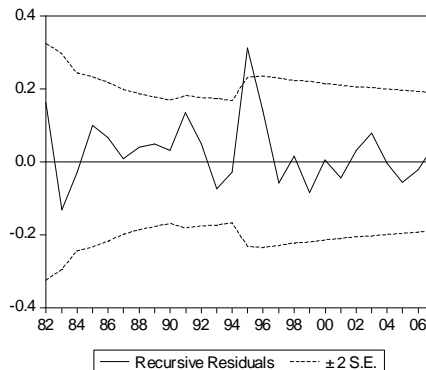
Selected ARDL Model ARDL (1, 0, 0, 0) selected based on Schwarz Bayesian Criterion

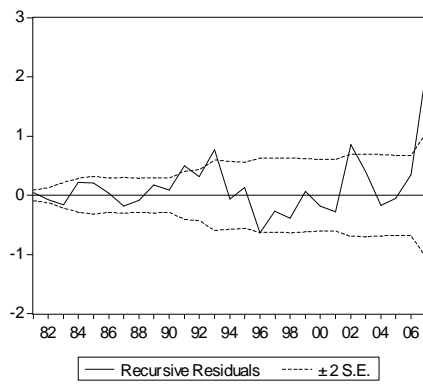
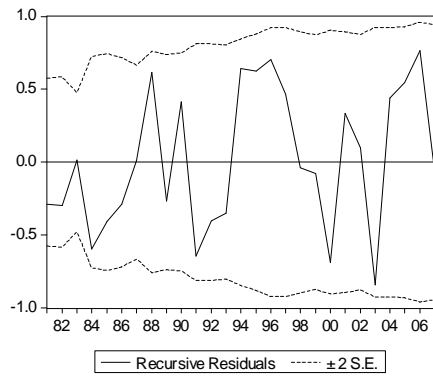
Dependent Variable is the Nominal Exchange Rate ($\Delta \ln E_t^n$)			
Variables	MFPM	SPM	HM
$\Delta \ln M_t$	1.242 (0.103) (12.058)*	-2.452 (1.472) (-1.666)	-1.226 (0.405) (-3.026)*
$\Delta \ln M_t^f$	0.268 (0.092) (2.913)**	0.422 (0.098) (4.306)*	1.458 (1.642) (0.279)
$\Delta \ln Y_t$	-1.328 (0.555) (-2.392)**	1.028 (0.557) (1.846)	-1.032 (0.658) (-1.568)
$\Delta \ln Y_t^f$	0.044 (1.022) (2.499)**	2.428 (0.846) (2.222)**	2.822 (1.246) (0.006)
$\Delta(i_t - i_t^f)$		-1.569 (0.790) (-1.986)***	-1.528 (0.819) (-1.866)***
$\Delta \ln(\pi_t^e - \pi_t^{ef})$	0.628 (0.305) (2.059)**		-1.188 (0.158) (-7.52)*
Constant	2.622 (0.226) (11.555)*	-16.629 (5.878) (-2.829)**	5.422 (0.233) (23.270)*

Dynamic Error Correction Term

ECM _[t-1]	-0.828 (0.252) (-3.285)**	-0.535 (0.220) (-2.424)*	-0.699 (0.102) (-6.852)*
Model Adequacy / Goodness-of-Fit Test Statistic(s)			
R ² (Adj. R ²), F-statistic	89.6%(86.2%), 38.20	52.3% (42.5%), 22.20	82.2% (80.2%), 50.20
Model Diagnostic Statistical Check(s)			
Jarque-Bera Test	0.799(0.0331)	0.886(0.0234)	0.762(0.0445)
Durbin-h statistic	1.22	1.60	1.62
B-G LM statistic	1.056(0.5068)	0.201(0.3002)	0.022 (0.6501)
Box-Pierce's (Q) statistic			
ARCH-Test Statistic	0.045(0.0222)	0.121(0.0123)	1.087(0.0131)
Ramsey-RESET statistic	1.981(0.0451)	1.785(0.0342)	1.966(0.0223)
<p>*(**)(***) indicates variable significance @ 1 %(5%) (10%) levels respectively. Standard errors and t-values are reported in parenthesis below each estimated coefficient.</p>			

Appendix 4: Plot of Prediction Errors of the Estimated Models





Appendix 5: Plot of CUSUM, CUSUMSQ of the Estimated Models

