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Testing the Theoretical Proposition of Exchange Market Pressure: The Nigerian Experience

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In this paper, monetary model of Exchange Market Pressure (EMP) is applied to Nigerian economy over the period 1970 to 2010. In support of the EMP propositions, dynamic ordinary least squares (DOLS) results reveal that domestic credit has stable significant negative relationship with exchange market pressure. The findings also provide evidence that Nigerian monetary authorities absorbed most of the exchange market pressure by adjusting the foreign reserves. The overall results indicate that the Nigeria's experience provides another good example to test the theoretical propositions of the Girton-Roper monetary model of exchange market pressure.

1. Introduction

The Bretton Woods system known as the international monetary regime existed from the end of World War II until the early 1970s. Under the Bretton Woods system, all the member countries consented to tie their currency to US dollar and to peg their exchange rates. These countries also agreed to purchase and sell U.S. dollars in order to maintain their currencies within 1% of the fixed rate (Strange, 1976). In addition, these countries had right to alter their par value when necessary and in line with agreed procedures to correct basic external imbalances. The central banks of countries other than the United States did this by intervening in foreign exchange markets. If a country's currency was too high relative to the dollar, its central bank would sell its currency in exchange for dollars, driving down the value of its currency. Conversely, if the value of a country's money was too low, the country would buy its own currency, thereby driving up the price. The economic implication of maintaining currencies within 1% of fixed rate is to avoid excessive depreciation or appreciation against US dollar. Thus, countries with

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large trade surpluses often sell their own currencies in an effort to prevent them from appreciating and thereby hurting exports. On the other hand, countries with large deficits often buy their own currencies in order to prevent depreciation, which raises domestic prices. This intervention has limit especially for countries with large trade deficits. A country that intervenes to support its currency may deplete its foreign reserves. Such country will not be able to further its support for the currency and leaves it with its inability to meet its international obligations.

During this period when exchange rates were fixed, researchers focused their attentions on the influencing factors of a country's balance of payment. This approach is known as the monetary approach to balance of payment.

The monetary approach to balance of payment has emerged since 1950s after reviving the formal view of Hume (1752) on the theory. The works of Polak (1957), Hahn (1959), Mundell (1968) and Dornbush (1973) became the sources. Centre to this approach is the assertion that "the balance of payment is essentially a monetary phenomenon" (Frenkel and Johnson, 1977:21). Under this approach, any excess demand for goods, services and assets or securities, resulting in a deficit of the balance of payment, reflects an excess supply of the stock of money. In analyzing the money account, the monetary approach focuses on the determinants of the excess domestic flow demand for or supply of money (Frenkel and Johnson, 1977).

The year 1971 witnessed the collapse of Bretton Woods system due to inflation and increasing trade deficit of the United States that were making the value of the dollar to be less strong and secured (Strange, 1976). Following the end of the Bretton Woods system, member countries have been allowed to operate freely floating exchange rates system. By 1973, majority of the world strong economies had left their currencies against the dollar to float freely. The transition was a rocky type, characterized by plummeting stock prices, skyrocketing oil prices (following the Middle East crisis), bank failures and inflation (James, 1996).

During this period of floating exchange rates system, attentions of researchers were directed towards finding out the determinants of exchange rates. This approach is known as monetary approach to the exchange rate determination. The monetary approach to the exchange rate determination deals with the explanation of the impact of domestic money market disequilibrium on the exchange rate where the economy is operating a fully flexible system of exchange rate (Frenkel, 1976). The main essential points expressed by the monetary approach to the exchange rate determination according to Caves and Feige (1980) is the claim that the distortion in the rate of exchange is to a greater extent explained by changes in the relative money supplies of the countries. Therefore, the monetary approach suggested that the supply of money could play a useful role in forecasting the rates of exchange. This implies that exchange rates variation has causal relation to the change in money supply.

In another development, Girton and Roper (1977) introduced a new monetary model of exchange market pressure (EMP). The model is based on the monetary approach to the Balance of Payments and a monetary approach to the exchange rates determination. According to the monetary model of exchange market pressure, the imbalances in external sector brought about by the difference in domestic demand and supply of money can be corrected by either adjusting exchange rates or international reserves or the two means simultaneously.

The current study applies monetary model of EMP of Lance Girton and Don Roper to monetary experience in Nigeria over the period 1970-2010. This period has witnessed shifts from one regime of exchange rate to another. For example, Nigerian monetary authorities in 1986 changed from fixed exchange rate system which was in operation since 1960 to floating exchange rate regime and this continued until 1994 when exchange rate was again fixed at 22 Naira per US dollar (Nigeria Deposit Insurance Cooperation, NDIC, 1994). Coincidentally, this fixed rate was the same rate as the prevailing rate determined by the exchange rate market. In 1995, autonomous foreign exchange market was introduced but the Central Bank of Nigeria (CBN) could intervene where necessary (Jimoh, 2004). To ensure a competitive economy performance, the exchange rate was completely left for market determination in 1996 (NDIC, 1996). With this development, Nigeria has been fully operating floating exchange rate system from 1996 till date while the deficit in balance of payment still persists.

The EMP model has been tested by some studies in various developed and developing countries to determine its sensitivity and to determine how an economy absorbs external imbalances. For example, studies that have applied the EMP model include the study of Girton and Roper (1977) for Canada, Connolly and da Silveria (1979) for Brazil, Modeste (1981) for Argentina, Kim (1985) and Mah (1991, 1995) for Korean, Thornton (1995) for Costa Rica, Parlaktuna (2005) for Turkey, Bielecki (2005) for Poland, Ghartey (2002) for Jamaica and Ghartey (2005) for Ghana. Nigeria is a small economy opened to the rest of the world and accepts world prices and monetary conditions as given. In spite of this fact, EMP model has not been applied to its data to test the model's proposition and to determine the sources by which the country absorbs exchange market pressure or overall balance of payment disequilibrium. Closing this gap is an important motivation for this study.

Although Jimoh (2004) examined how relevant was the monetary approach to a floating exchange rate in Nigeria over the period 1987 to 2001, yet he did not actually apply monetary model of EMP which encompasses both exchange rate and foreign reserves as its components. The current study therefore, attempts to apply the monetary model of EMP to Nigeria data as Nigeria's experience will contribute to the existing literature in this field. Paying attention to EMP instead of emphasizing the amount of exchange rate variation according to IMF is practically relevant, as 82% of the currencies in the world are being either fixed, freely float or managed float (IMF, 2009).

In consideration of the above arguments, this paper intends to test the theoretical propositions of EMP in the context of Nigeria and determine the main means by which the exchange market pressure or external imbalance is absorbed by the monetary authorities in Nigeria.

The rest sections of the paper are as follows: section 2 is about the monetary model of EMP. In section 3, the methodology and data are discussed while the interpretation of empirical findings is done in section 4. The last section deals with the study's conclusion.

2. The Monetary Model of Exchange Market Pressure

The exchange rate and balance of payment theories focus on tensions in the foreign exchange market under floating or fixed rates. Girton-Roper defined EMP as the endogenous variable of net foreign assets (or international reserves) and exchange rates changes which absorb the pressure exerted by the excess increase in the supply of money over its demand, given a freely, fixed, or managed floating exchange rate system.

The basis of the EMP model is that any domestic supply of money in excess of demand can be normalized by depreciation of exchange rate (domestic currency) or by losing international reserves or by the two means simultaneously in an economy with managed flexible system of exchange rate. Similarly, any domestic demand for money in excess of its supply can be corrected by the appreciation of exchange rate (domestic currency) or by gaining international reserves, or by the two means simultaneously in an economy with managed flexible system of exchange rate. In a fully fixed exchange rate system, there is no variation in exchange rate and so, changes in the net international reserve serve as the medium of adjustment to make demand for money equal to supply of money. This implies that any domestic supply of money in excess of its demand can be normalized by losing international reserves. In this case, the EMP is absorbed by loss of reserves. In a fully floating exchange rate system on the other hand, there is no variation in international reserves and so, variations in the net exchange rates serve as a medium of adjustment to make demand for money equal to supply of money. This means that any domestic supply of money in excess of demand can be normalized by depreciation of exchange rate (domestic currency). In this case, the EMP is absorbed by domestic currency depreciation (Parlaktuna, 2005; Pilbeam, 1998; Salvatore, 2001). The above analysis makes the monetary model of EMP to be applicable to all spectrums of exchange rate regime (Henk and Klaassen, 2010).

The adjustment to equilibrium of any disturbance caused by the determinants of demand and/or supply of money is emphasized by the monetary model of EMP based on the monetary approach to balance of payments and a monetary approach to the exchange rates determination. The monetary model of EMP is formulated from the money demand function, money supply function and from purchasing power parity (Connolly and da Silveria, 1979; Ghartey 2002, 2005; Kim, 1985; Mah, 1991, 1995; Modeste, 1981; Parlaktuna, 2005; Thornton, 1995). The money demand function is given in equation (1) as:

$$M^D = k.DP.RY.IR \quad (1)$$

Where M^D is the money demand, DP is the domestic price level (consumer price index), RY is the real income (real gross domestic product), IR is the nominal interest rate and k is a constant, expressing the proportion of real income preferred to be held as cash balance by individual. In the studies for Canada, nominal interest rate was included in the money demand function by Girton and Roper (1977) and Weymark (1995, 1997). Therefore, nominal interest rate has been included in the money demand function. Under the presumption of a small country, the purchasing power parity (PPP) holds and expresses the ratio of domestic price level (DP) to the world price level (WP) via the nominal exchange rate (EX). The expression is given in equation (2).

$$EX = DP/WP \quad (2)$$

From equation (2), DP is made the subject of formula and is substituted in the money demand function (1) to get

$$M^D = k\ .EX\ .WP.RY.IR \quad (3)$$

The money supply function following Mundell (1971) is given in equation (4) where M^S is the domestic money supply, FV is the international asset, and DC is the domestic credit or domestic asset. The money multiplier is constant and taken to be unity. The equation (4) is a process of money supply which comprises variation in international reserves through the balance of payment and a variation in domestic credit through the banking system.

$$M^S = FV + DC \quad (4)$$

At equilibrium, change in domestic money demand ΔM^D must equal change in domestic money supply ΔM^S as given in equation (5).

$$M^D = M^S \quad (5)$$

By substituting equations (3) and (4) into equation (5), taking logarithm, differentiating the expression and expressing the outcome in the form of percentage changes gives equation (6).

$$\Delta lnFV - \Delta lnEX = -\ \beta_1 \Delta lnDC + \beta_2 \Delta lnWP + \beta_3 \Delta lnRY + \beta_4 \Delta lnIR \quad (6)$$

Equation (6) is a fundamental equation of EMP to test the hypotheses that: one, domestic credit (DC) is expected to be negative such that an increase in the domestic credit growth rate will lead to a proportional loss of international reserves (FV) and/or exchange rate (EX) increase (depreciation); two, world price (WP) is expected to be positive such that when the world price increases, it will lead to proportional gain of international reserves and/or exchange rate decrease (appreciation); three, we expect interest rate (IR) to carry a negative sign such that an increase in it will lead to a depletion of international reserves (FV) and/or exchange rate (EX) depreciation; and finally, real income (RY) is expected to be positive such that when the real income increases, it will cause a proportional appreciation of domestic currency and/or international reserves inflow. In addition, Fleming (1962), Mundell (1963) and Obstfeld (2001) have argued that where there is perfect capital mobility, any rise in the real income has the tendency of causing demand for money to rise. As a result, interest rate will increase thereby leading to an inflow of foreign assets and appreciation of domestic currency.

In order to test how sensitive is the measure of EMP to changes in exchange rate and foreign reserve, and to verify the means by which the pressure is absorbed by change in each of these constituent variables of EMP, Girton and Roper (1977) added the ratio of exchange rate to foreign reserve (EX/FV) to EMP equation. However, Connolly and da Silveira (1979) observe that this is appropriate where there is no discontinuity in (EX/FV) such that there is no frequent change of surplus to deficit and deficit to surplus during the study period. They point out that where there is discontinuity, $S = (EX-1)/(FV-1)$ is the appropriate variable to use. Since there is discontinuity in the case of Nigeria, this study follows Connolly and da Silveira (1979), Ghartey (2005), and Parlaktuna (2005), and by adding variable S to the EMP equation (6), the resulting expression is given in the equation (7).

$$\Delta\ln FV - \Delta\ln EX = -\beta_1\Delta\ln DC + \beta_2\Delta\ln WP + \beta_3\Delta\ln RY + \beta_4\Delta\ln IR + \beta_5 S \ldots \quad (7)$$

From the results obtained in equation (7), one can conclude that there is no discrimination in the absorption of exchange pressure if the parameter estimate of variable S is not significant and the estimated results of other exogenous variables (DC, WP, RY and IR) are left unaltered as in EMP equation (6). This implies that EMP is insensitive to its constituent variables. Hence, the amount of intervention needed to realize a targeted exchange rate by the monetary authorities can be determined by using both reserves and domestic currency depreciation (Connolly and da Silveira, 1979; Ghartey, 2005; Girton and Roper, 1977; Parlaktuna, 2005; Stavarek, 2007). Suppose the parameter estimate of variable S is positively significant while the results of (DC, WP, RY and IR) remain the same with EMP result, it means that exchange pressure is absorbed by forfeiting international reserves only. On the other hand, if the parameter estimate of variable S is negatively significant while the results of (DC, WP, RY and IR) remain the same with EMP result, then domestic currency depreciation is used to absorb the exchange pressure, cetiris paribus (Ghartey, 2005; Parlaktuna, 2005; Stavarek, 2007).

In order to test the efficiency of EMP and verify the true endogenous variable, the composition of EMP is split into foreign reserves and exchange rate, and each of them separately serves as a dependent variable to the explanatory variables of the EMP equation. The international reserves (or balance of payments) and exchange rate equation using the EMP exogenous variables are specified in equation (8) and (9) respectively.

$$\Delta lnFV = -\ \beta_1 \Delta lnDC + \beta_2 \Delta lnWP + \beta_3 \Delta lnRY + \beta_4 \Delta lnIR \qquad (8)$$

$$\Delta lnEX = -\beta_1 \Delta lnDC + \beta_2 \Delta lnWP + \beta_3 \Delta lnRY + \beta_4 \Delta lnIR \qquad (9)$$

Each of the equation is estimated and the endogenous variable between the two whose results give better estimates is taken to have borne the brunt of absorbing the external imbalances or exchange market pressure. The results obtained are to confirm those obtained from EMP equation (6) for the efficiency sake.

3. Methodology and Data

Unit root and stationarity tests are conducted using Augmented Dicky-Fuller (1981). This is important because the properties and behaviour of a series can highly be influenced by the stationarity or non-stationarity of a series in which case, ‘shocks’ to the system will wipe away gradually from one period to another in the case of a stationary series as compared with non-stationary series where the shocks will be continuous indefinitely (Brooks, 2008).

To estimate the monetary model of Exchange Market Pressure, the current study employs the leads and lags regression of Stock and Watson (1993), otherwise known as dynamic ordinary least squares (DOLS) regression. The leads and lags regression has the fundamental objective of obtaining efficient parameter estimates with normal distribution (Choi and Kurozumi 2008). The technique of DOLS solves the problems associated with endogeneity and biasness associated with small sample, thus making the estimates to be robust (Stock and Watson, 1993). In addition, DOLS regression employs Newey-West estimator in order to further address the likely problem of autocorrelation and heteroscedasticity associated with the model's error terms overtime. By employing the estimator procedure it corrects the standard errors of the parameter estimates to achieve its robustness (Newey and West, 1987).

The study employed annual time series data over the period 1970 to 2010. Data on the world price (US consumer price index) were collected from World Bank Development Indicators. Data on real income (gross domestic product), domestic credit, exchange rate and foreign reserves were sourced from the Central Bank of Nigeria statistical bulletin.

4. Empirical Results

Before the estimation of the models, analysis of the data was done by conducting the Augmented Dickey Fuller (ADF) tests on domestic credit (DC), world inflation measured by the U.S consumer price index (WP), real income (RY), foreign reserves (FV), exchange rate (EX), and exchange market pressure, EMP (EX + FV). The results of the unit root test presented in Table 1 accept the null hypothesis of presence of unit root at level for all the variables except WP with the constant/trends model, FV and EMP with the two types of model (constant; and constant/trends). These variables which are stationary at level have their ADF test statistics more than the 1%, 5% and 10% critical value. Other variables (DC, WP, RY, IR and EX) which were non-stationary at level were differenced once and they became stationary, thus rejecting the null hypothesis of presence of unit root.

Table 1: Results of the unit roots tests (ADF statistics)

Variable	Model Types	ADF Statistics (At Level)	ADF Statistics (First difference)	Order
DC	Constant	1.60	4.97***	I(1)
	Constant/trends	0.04	5.03***	I(1)
WP	Constant	-2.03	-5.16***	I(1)
	Constant/trends	-4.30***	-	I(0)
RY	Constant	1.97	-5.30***	I(1)
	Constant/trends	- 0.46	-5.83***	I(1)
IR	Constant	-1.47	-9.92***	I(1)
	Constant/trends	-1.57	-9.84***	I(1)
FV	Constant	14.69***	-	I(0)
	Constant/trends	15.81***	-	I(0)
EX	Constant	0.55	-5.78***	I(1)
	Constant/trends	-1.48	-6.07***	I(1)
EMP	Constant	-5.55***	-	I(0)
	Constant/trends	-5.49***	-	I(0)

Note: *** represents 1% level of significance

The fundamental Exchange Market Pressure equation (6) given as EMP (ΔlnFV + ΔlnEX) can be represented in equation (10) using DOLS approach as

$$\begin{aligned} EMP_t = {} & \beta_0 + \beta_1 lnDC_t + \beta_2 \Delta lnDC_t + \beta_3 \Delta lnDC_{t+1} + \beta_4 \Delta lnDC_{t-1} \\ & + \beta_5 lnWP_t + \beta_6 \Delta lnWP_t + \beta_7 \Delta lnWP_{t+1} + \beta_8 \Delta lnWP_{t-1} \\ & + \beta_9 lnRY_t + \beta_{10} \Delta lnRY_t + \beta_{11} \Delta lnRY_{t+1} + \beta_{12} \Delta lnRY_{t-1} \\ & + \beta_{13} lnIR_t + \beta_{14} \Delta lnIR_t + \beta_{15} \Delta lnIR_{t+1} + \beta_{16} \Delta lnIR_{t-1} + u_t \end{aligned} \tag{10}$$

By following Stock and Watson (1993), an arbitrary leads and lags are chosen. This is followed by adding the first difference of independent variables, lead of the first difference of the independent variables and lag of the first difference of the independent variables as specified in the equation (10). The β is the respective coefficient, Δ is the first difference operator, and ln is the natural logarithm. In order to give room for the interpretation of the parameters estimates as elasticities (Brooks 2008; Gawronka-Nowak and Grobowski, 2011), all the variables (expressed as percentage changes) have also been expressed in natural logarithm. The results of estimation of EMP equation (10) are presented in Table 2.

The results show that the domestic credit has the expected negative sign with its coefficient not different from unity and is statistically significant at 1% level. This evidence is in line with the proposition of monetary model of exchange market pressure. It also supports the monetary argument that excess increase in money supply resulting from excess increase in domestic credit causes the Nigerian reserves to continually decrease and/or the country's currency (*Naira*) to depreciate in value. Given that all other things are constant, a rise in the growth of domestic credit causes an outflow of Nigerian foreign reserves and depreciation in domestic currency. For example, with the coefficient of DC being -2.85, it means that an increase in domestic credit by 10% results in foreign reserves outflow by 28.5% or exchange rate depreciation by 28.5% or by proportion of the two simultaneously.

Table 2: DOLS results of exchange market pressure

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.62	0.26	2.34	0.03**
D_LDC	-2.85	0.67	-4.23	0.00***
D_LWP	0.51	0.30	1.69	0.11
D_LRY	-1.81	0.77	-2.33	0.03**
D_LIR	-0.68	1.19	-0.56	0.57
D_D_LDC	1.30	0.43	2.97	0.01**
D_D_LDC(1)	-0.57	0.21	-2.62	0.02**
D_D_LDC(-1)	0.79	0.47	1.66	0.12
D_D_LWP	-0.14	0.55	-0.25	0.80
D_D_LWP(1)	0.89	0.52	1.69	0.11
D_D_LWP(-1)	0.64	0.73	-0.86	0.40
D_D_LRY	1.15	0.51	2.24	0.04**
D_D_LRY(1)	0.11	0.18	-0.65	0.52
D_D_LRY(-1)	0.72	0.34	2.12	0.05**
D_D_LIR	-0.84	0.96	-0.87	0.39
D_D_LIR(1)	-1.10	0.88	-1.24	0.23
D_D_LR(-1)	-0.56	0.66	-0.84	0.41

Note: All variables are in natural logarithm (L). ** and *** represent 5% and 1% level of significance respectively

This has important implication for the Nigerian monetary authorities in the sense that it determines the level of their independence. Attempt to increase the grow rate of domestic credit calls for the readiness to lose foreign reserve or depreciate the domestic currency. The result of the first test obtained with respect to domestic credit is similar to those gotten in the similar studies by Burdekin and Bukell (1990), and Girton and Roper (1977) for Canada, Connolly and da Silveira (1979) for Brazil, Parlaktuna (2005) for Turkey, Ghartey (2002) for Jamaica, Ghartey (2005) for Ghana, and Kemme and Lyakir (2009) for Czech Republic.

From the results table, world price and interest rate maintain their positive and negative signs respectively. However, they are not significant in influencing EMP. In these cases, the propositions of exchange market pressure model are not supported by these tests. By comparison, these results contradict the findings of previous studies (Connolly and da Silveira, 1979; Girton and Roper, 1977; Kim, 1985; Parlaktuna, 2005; Ghartey, 2002, 2005; Panday, 2011). This may be due to the inclusion of interest rate in the model which some previous studies (Connolly and da Silveira, 1979; Ghartey, 2002, 2005; Modeste, 1981; Thornton, 1995) argue could lead to a problem of simultaneous equation bias in the EMP model. This is possible according to these authors particularly if the monetary decision making body decides to vary domestic credit to pay for changes in international reserve or net foreign assets.

The EMP results indicate that real income is negatively signed. This test's result is in contrary to the proposition of the EMP model that real income is expected to be positive such that when the real income increases, it will cause a proportional appreciation of domestic currency and/or international reserves inflow. The impact of real income on EMP in Nigeria is negative and statistically significant at 5% level and its coefficient is not different from unity as hypothesized. This implies that a 1% increase in the real income causes almost a 2% domestic currency depreciation and/ or the international reserves deterioration. Studies of EMP measurement which have obtained negative values for the coefficient of real income include Ghartey (2002, 2005) for Jamaica and Ghana respectively, Garcia and Malet (2007) for Argentina, Obstfeld (1982) for West Germany, and Panday (2011) for Nepal.

Plausible explanation could be given in the case of Nigeria for the negative relationship of real income with EMP. For instance, when there is increase in real income, demand for money increases and as a result, aggregate demand for both domestic and foreign goods and services increases. The demand for foreign goods and services requires foreign currency. Therefore, the pressure on foreign currency depreciates the domestic currency. On the other hand, as the demand for money increases due to increase in real income, the aggregate demand for both foreign and domestic good and services increases. Consequently, adjustment is needed to bring money demand equal to money supply through the international reserves adjustment. In this process, the monetary authorities buy domestic currency and the international reserves, money demand and aggregate demand begin to fall in that order.

DOLS regression employs Newey-West estimator in order to further address the likely problem of autocorrelation and heteroscedasticity associated with the model's error terms. The estimator corrects the presence of correlation and heteroscedasticity effects in the error terms of the time series regression overtime (Newey and West, 1987). As suggested by Stock and Watson (1993), chi-square is used for making inferences following the DOLS regression. In the Table 3, the results of the residual diagnostic test show that the null hypothesis of no autocorrelation and that there is absence of ARCH (Heteroscedasticity) cannot be rejected since their p-values are greater than 5% level of significance. The residual also displays that its behaviour is non linear as the RESET test (with the use of square of fitted values) indicates a p-value exceeding 5% level of significance. The functional form therefore confirms the right specification of the model. Lastly, Jarque-Bera test of normality also indicates that the residuals are normally distributed since the p-value is greater than 5% level of significance.

Table 3: Results of residual diagnostic test of EMP model

	Obs*R-squared	**Prob. Chi-Square**	**Order**
Breusch-Godfrey Serial Correlation	3.41	0.06	1
Heteroscedasticity Test: ARCH	0.84	0.65	2
Ramsey RESET Test	0.58	0.31	1
Jarque-Bera Normality Test	0.75	0.68	

Figure 1 shows the explanatory power of the monetary model of exchange market pressure (EMP). Comparison is made between the actual movement and the predicted movement in dependent variable, EMP which composes the summation of the rate of EX and the change in FV. As shown by the Figure 1, the prediction of the model appears reasonable as the predicted values or movements have better reflection of the actual values. It can also be observed that the fitted values closely track down the movement of the actual values.

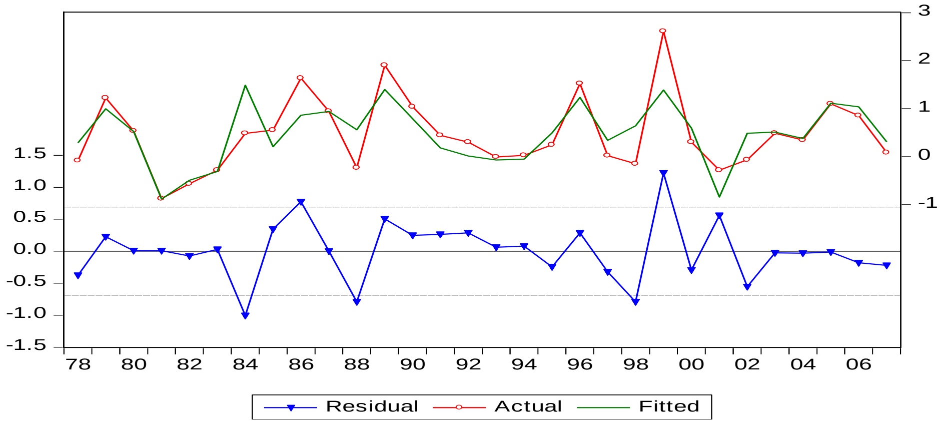

Figure 1: Actual and fitted exchange market pressure

In order to determine the main means by which the exchange market pressure is absorbed by the Nigerian monetary authorities, S variable is included in the explanatory variables of EMP model (10) and this gives equation (11).

$$\begin{aligned} EMP_t = {} & \beta_0 + \beta_1 S_t + \beta_2 \ln DC_t + \beta_3 \Delta \ln DC_t + \beta_4 \Delta \ln DC_{t+1} + \beta_5 \Delta \ln DC_{t-1} \\ & + \beta_6 \ln WP_t + \beta_7 \Delta \ln WP_t + \beta_8 \Delta \ln WP_{t+1} + \beta_9 \Delta \ln WP_{t-1} \\ & + \beta_{10} \ln RY_t + \beta_{11} \Delta \ln RY_t + \beta_{12} \Delta \ln RY_{t+1} + \beta_{13} \Delta \ln RY_{t-1} \\ & + \beta_{14} \ln IR_t + \beta_{15} \Delta \ln IR_t + \beta_{16} \Delta \ln IR_{t+1} + \beta_{17} \Delta \ln IR_{t-1} + u_t \end{aligned} \quad (11)$$

This process also tests how sensitive is the measure of EMP to changes in exchange rate and foreign reserves changes. The results of the estimation as shown by Table 4 imply that there is no discrimination (no choice is made between EX and FV) in the absorption of exchange pressure (monetary shocks) by the Nigerian monetary authorities and so EMP is insensitive to its constituent variables. It further means that the monetary authorities can determine the amount of intervention needed to realize a targeted exchange rate by using both the international reserves and exchange rate depreciation. Previous studies that have obtained similar results as this include Stavarek, (2007) for Hungary in a study of 8 new European countries, Connolly and da Silveira (1979) for Brazil, and Girton and Roper (1977) for Canada.

Table 4: DOLS results of EMP model with S variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.58	0.27	2.09	0.05**
D_LDC	-2.76	0.73	-3.74	0.00***
D_LWP	0.53	0.31	1.71	0.11
D_LRY	-1.84	0.76	-2.42	0.03**
D_LIR	-0.60	1.29	-0.46	0.65
S	-0.00	0.00	-0.32	0.75
D_D_LDC	1.24	0.45	2.72	0.01**
D_D_LDC(1)	-0.55	0.23	-2.39	0.03**
D_D_LDC(-1)	0.76	0.46	1.63	0.12
D_D_LWP	-0.16	0.59	-0.27	0.79
D_D_LWP(1)	0.92	0.59	1.56	0.14
D_D_LWP(-1)	-0.60	0.81	-0.74	0.46
D_D_LRY	1.16	0.51	2.25	0.04**
D_D_LRY(1)	-0.13	0.18	-0.72	0.48
D_D_LRY(-1)	0.73	0.35	2.08	0.05**
D_D_LIR	-0.85	1.01	-0.84	0.41
D_D_LIR(1)	-1.09	0.94	-1.16	0.26
D_D_LR(-1)	-0.53	0.71	-0.74	0.47

Note: All variables are in natural logarithm (L). ** and *** represent 5% and 1% level of significance respectively

Table 5 displays the results obtained from the diagnostic test of the residuals following the DOLS regression. The results show that the null hypothesis of no autocorrelation and that of absence of ARCH (Heteroscedasticity) cannot be rejected since their p-values are greater than 5% level of significance. The residual also displays that its behaviour is non linear as the RESET test indicates a p-value (0.26) exceeding 5% level of significance. The functional form therefore confirms the right specification of the model. Lastly, Jarque-Bera test of normality also indicates that the residuals are normally distributed at 5% level of significance.

Table 5: Residual test results of EMP model with S variable

	Obs*R-squared	Prob. Chi-Square	Order
Breusch-Godfrey Serial Correlation	3.3	0.06	1
Heteroscedasticity Test: ARCH	1.18	0.55	2
Ramsey RESET Test	0.65	0.26	1
Jarque-Bera Normality Test	0.73	0.69	

In order to analyze the explanatory power of the EMP model with the inclusion of S as independent variable, Figure 2 displays the actual values and the fitted values of the monetary model. A close look at the figure shows that the predicted values appear to have tracked down the actual values considerably well. The movement of the predicted values has the reflection of the actual movement and the two trends follow the same pattern. This implies that the EMP model with the inclusion of independent variable S demonstrates a goodness of fit.

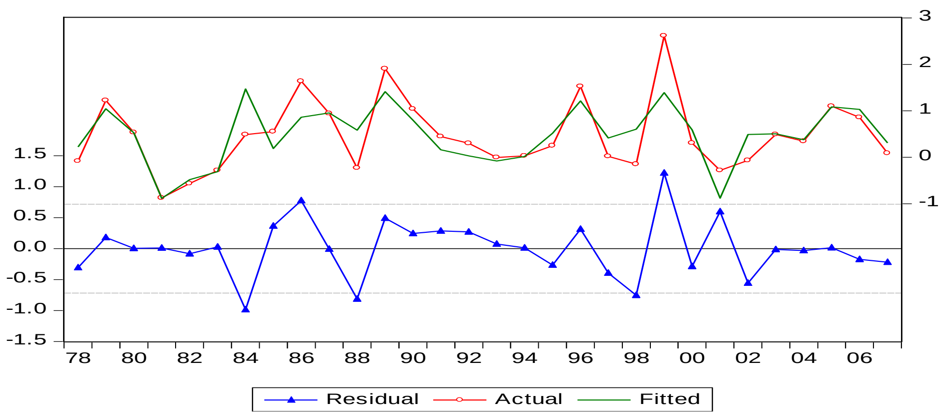

Figure 2: Actual and fitted exchange market pressure with S variable

In order to examine the efficiency of the exchange market pressure (EMP), attempt is made to compare the results obtained from the regression of each component of EMP (ΔFV and ΔEX) as individual dependent variable on EMP's explanatory variables. When the rate of change in foreign reserves (ΔFV) is singly used as dependent variable with EMP's explanatory variables, the reserves (or balance of payments) equation (8) is represented in equation (12).

$$\begin{aligned}\Delta lnFV_t = {} & \beta_0 + \beta_1 lnDC_t + \beta_2 \Delta lnDC_t + \beta_3 \Delta lnDC_{t+1} + \beta_4 \Delta lnDC_{t-1} \\ & + \beta_5 lnWP_t + \beta_6 \Delta lnWP_t + \beta_7 \Delta lnWP_{t+1} + \beta_8 \Delta lnWP_{t-1} \\ & + \beta_9 lnRY_t + \beta_{10} \Delta lnRY_t + \beta_{11} \Delta lnRY_{t+1} + \beta_{12} \Delta lnRY_{t-1} \\ & + \beta_{13} lnIR_t + \beta_{14} \Delta lnIR_t + \beta_{15} \Delta lnIR_{t+1} + \beta_{16} \Delta lnIR_{t-1} + u_t \end{aligned} \quad (12)$$

The DOLS results obtained are presented in Table 6. The results of the parameter estimates appear to be considerably good with R-squared equal to 0.79 and the F-value statistically significant at 5% level.

Table 6: DOLS estimates of foreign reserve model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.26	0.20	1.28	0.22
D_LDC	-2.69	0.55	-4.88	0.00***
D_LWP	0.64	0.28	2.27	0.04**
D_LRY	-1.56	0.49	-3.14	0.00***
D_LIR	-1.88	1.07	-1.75	0.10
D_D_LDC	1.18	0.38	3.07	0.00***
D_D_LDC(1)	-0.55	0.16	-3.38	0.00***
D_D_LDC(-1)	0.60	0.36	1.65	0.12
D_D_LWP	-0.22	0.23	-0.97	0.34
D_D_LWP(1)	0.79	0.34	2.27	0.04**
D_D_LWP(-1)	-0.38	0.52	-0.73	0.47
D_D_LRY	0.89	0.31	2.83	0.01**
D_D_LRY(1)	-0.09	0.16	-0.56	0.58
D_D_LRY(-1)	0.53	0.18	2.94	0.01**
D_D_LIR	-0.43	0.71	-0.61	0.55
D_D_LIR(1)	-1.35	0.58	-2.34	0.03**
D_D_LR(-1)	-0.54	0.48	-1.12	0.27

Note: All variables are in natural logarithm (L). ** and *** represent 5% and 1% level of significance respectively

From the results, the estimated coefficients of the domestic credit and real income are negative and significantly different from zero while that of world price is positively significant. However, interest rate does not play any significant role in this model. The results of residual diagnostic test of foreign reserves model presented in Table 7 show that there is no problem of autocorrelation and heteroscedasticity. Ramsey RESET Test of functional form is also okay and the residual of the model is normally distributed at 5% level of significance.

Table 7: Diagnostic test results

	Obs*R-squared	Prob. Chi-Square	Order
Breusch-Godfrey Serial Correlation	3.73	0.06	1
Heteroscedasticity Test: ARCH	0.55	0.75	2
Ramsey RESET Test	0.77	0.84	1
Jarque-Bera Normality Test	1.09	0.57	

The explanatory power of the Nigerian foreign reserves is shown in Figure 3. The figure presents the movements of the actual and the predicted values of the reserve model. By comparison, the predicted values closely trace out the actual values. Considerably, the movement of the actual values is reflected by that of predicted values. Hence, the figure displays a better goodness of fit for foreign reserves model.

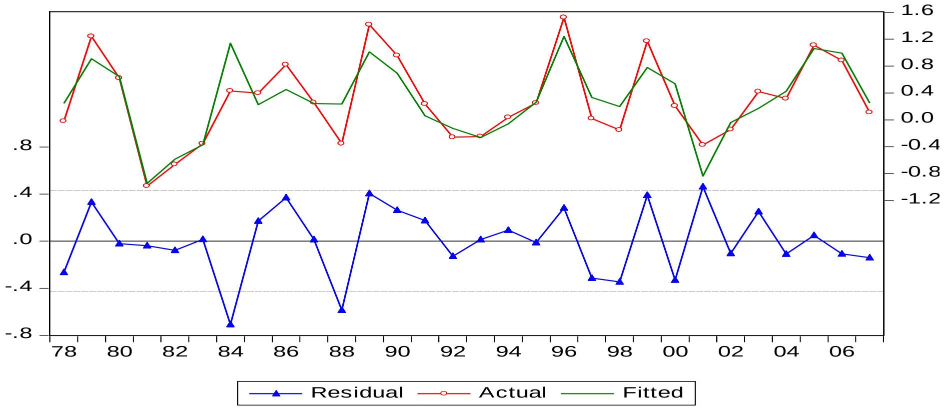

Figure 3: Actual and fitted foreign reserve

When percentage in exchange rate (ΔEX) is singly used as dependent variable with EMP's explanatory variables the exchange rate equation (9) is represented by equation (13).

$$\begin{aligned}\Delta \ln EX_t &= \beta_0 + \beta_1 \ln DC_t + \beta_2 \Delta \ln DC_t + \beta_3 \Delta \ln DC_{t+1} + \beta_4 \Delta \ln DC_{t-1} \\ &+ \beta_5 \ln WP_t + \beta_6 \Delta \ln WP_t + \beta_7 \Delta \ln WP_{t+1} + \beta_8 \Delta \ln WP_{t-1} \\ &+ \beta_9 \ln RY_t + \beta_{10} \Delta \ln RY_t + \beta_{11} \Delta \ln RY_{t+1} + \beta_{12} \Delta \ln RY_{t-1} \\ &+ \beta_{13} \ln IR_t + \beta_{14} \Delta \ln IR_t + \beta_{15} \Delta \ln IR_{t+1} + \beta_{16} \Delta \ln IR_{t-1} + u_t \qquad (13)\end{aligned}$$

The results of the estimation are presented in Table 8. From the results, domestic credit maintains its right sign while the world price, real income and interest rate are not correctly signed. With the exception of interest rate, these variables are not significant in impacting the exchange rate. In addition, the result of R-squared appears to be very low (0.41) and the F-value is insignificant (0.85). The estimated results of the exchange rate model do not yield better estimates of parameters when compared with the estimated results of the foreign reserves model. Therefore, it is concluded that the main means of absorbing most of exchange market pressure in Nigeria is by adjusting foreign reserves rather than exchange rate adjustment. Such absorption results in depleting the country foreign reserves more than the exchange rate depreciation.

Table 8: DOLS estimates of exchange rate model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.36	0.20	1.79	0.09
D_LDC	-0.15	0.38	-0.40	0.69
D_LWP	-0.12	0.16	-0.74	0.46
D_LRY	-0.24	0.51	-0.48	0.63
D_LIR	1.20	0.44	2.67	0.01**
D_D_LDC	0.12	0.19	0.62	0.54
D_D_LDC(1)	-0.01	0.10	-0.19	0.85
D_D_LDC(-1)	0.18	0.18	0.98	0.34
D_D_LWP	0.08	0.37	0.22	0.82
D_D_LWP(1)	0.09	0.24	0.40	0.69
D_D_LWP(-1)	-0.25	0.24	-1.02	0.32
D_D_LRY	0.25	0.29	0.86	0.40
D_D_LRY(1)	-0.02	0.14	-0.16	0.87
D_D_LRY(-1)	0.19	0.20	0.95	0.35
D_D_LIR	-0.40	0.48	-0.83	0.42
D_D_LIR(1)	0.25	0.37	0.68	0.50
D_D_LR(-1)	-0.01	0.24	-0.06	0.94

Note: All variables are in natural logarithm (L). ** represents 5% level of significance

The results of residual diagnostic test of exchange rate model presented in Table 9 show that there is no problem of autocorrelation and heteroscedasticity. Also, Ramsey RESET Test of functional form is okay. However, the residual of the model is not normally distributed at 5% level of significance.

Table 9: Diagnostic test results

	Obs*R-squared	Prob. Chi-Square	Order
Breusch-Godfrey Serial Correlation	0.48	0.48	1
Heteroscedasticity Test: ARCH	1.06	0.58	2
Ramsey RESET Test	3.15	0.22	1
Jarque-Bera Normality Test	16.50	0.00	

The explanatory power of the exchange rate model is presented in Figure 4. From the figure, the movements of the actual values and the predicted values when compared perform better in reflecting each other in the first 7 year. After the first 7 year, the two values (actual and predicted values) deviate till the end of the period. This suggests that the model of exchange rate has poor fit.

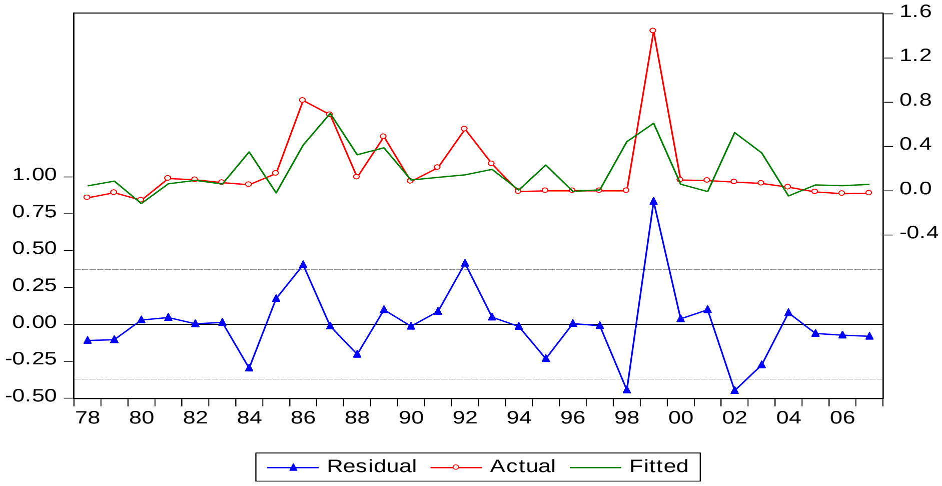

Figure 4: Actual and fitted exchange rate

5. Conclusion

In this study, the leads and lags regression method of Stock and Watson (1993), otherwise known as dynamic ordinary least squares (DOLS) regression is employed for the estimation of the monetary model of Exchange Market Pressure (EMP) over the period 1970-2010. The fundamental proposition of the EMP model is that any excess supply of money domestically is offset via the balance of payments and exchange rate adjustment. DOLS results indicate that the rate of domestic credit and the rate of exchange market pressure are negatively related. Therefore, the estimated results of EMP in the context of Nigeria buttress the EMP propositions. Results of another test, the measure of EMP indicate that there is no discrimination (no choice is made between percentage change in exchange rate and in foreign reserves) in the absorption of exchange pressure (monetary shocks) by the Nigerian monetary authorities and therefore, EMP is insensitive to its constituent variables. The Nigeria's experience shows that the main means of absorbing most of exchange market pressure is by adjusting foreign reserves rather than exchange rate adjustment.

This study is significant in that the measurement of the EMP may furnish useful information to both the public and private sectors regarding exchange rate, international reserves, level of income and interest rate that could influence the nature and degree of transactions. It may also provide information that could be useful to monitor monetary and financial policy domestically and internationally. Such information has the potential of guiding the policy makers in making useful monetary policy.

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Appendix: Derivation of Monetary Model of EMP

The monetary model of Exchange Market Pressure is formulated from the money demand function, money supply functions and from purchasing power parity. The money demand function is given in equation 1 as:

$$M^D = k.DP.RY.IR \tag{1}$$

Where M^D is the money demand, DP is the domestic price level (consumer price index), RY is the real income (real gross domestic product), IR is the nominal interest rate, and k is a constant, expressing the proportion of real income preferred to be held as cash balance by individual. Under the presumption of a small country, the purchasing power parity (PPP) holds and expresses the ratio of domestic price level (DP) to the world price level (WP) via the nominal exchange rate (EX). Thus, it is given as:

$$EX = DP/WP \tag{2}$$

From equation 2, make DP the subject of formula and substitute for DP in the money demand equation 1 to get

$$M^D = k.EX.WP.RY.IR \tag{3}$$

The money supply function is given in equation 4 where M^S is the domestic money supply, FV is the international asset, and DC is the domestic credit or domestic asset. The money multiplier is constant and taken to be unity. The equation 4 is a process of money supply which comprises variation in international reserves through the balance of payment and a variation in domestic credit through the banking system.

$$M^S = FV + DC \tag{4}$$

At equilibrium, change in domestic money demand ΔM^D must equal change in domestic money supply ΔM^S and it is given as follows:

$$M^D = M^S \tag{5}$$

Substitute M^D from equation 3 and M^S from equation 4 into equation 5 to get the resulting equation 6

$$FV + DC = k.EX.WP.RY.IR \tag{6}$$

The two sides of equation 6 are expressed in logarithm form to give equation 7 (Ghartey, 2005; Parlaktuna, 2005) and by differentiating equation 7 with respect to time t, we have equation 8:

$$log(FV + DC) = logk + logEX + logWP + logRY + logIR \tag{7}$$

$$\frac{\partial}{\partial t}(FV + DC) = \frac{\partial}{\partial t}(k) + \frac{\partial}{\partial t}(EX) + \frac{\partial}{\partial t}(WP) + \frac{\partial}{\partial t}(R) + \frac{\partial}{\partial t}(IR) \qquad (8)$$

The expression in equation 8 can be written as in equation 9 with k taken to be constant

$$(\Delta FV/\Delta t)/(FV + DC) + (\Delta DC/\Delta t)/(FV + DC)= 0 +(\Delta EX/\Delta t))/(EX)+(\Delta WP/\Delta t)/(WP)$$
$$(\Delta RY/\Delta t)/(RY)+(\Delta IR/\Delta t)/(IR) \qquad (9)$$

The expression in equation 9 as percentage changes can be expressed in the form of equation 10.

$$\Delta FV/(FV + DC) + (\Delta DC)/(FV + DC)= (\Delta EX))/(EX)+(\Delta WP)/(WP)+(\Delta RY)/(RY) + (\Delta IR)/(IR) \quad (10)$$

The specification in equation 10 can be simplified to give the expression in equation 11.

$$(FV- FV_{t-1}) /(FV + DC) + (DC- DC_{t-1})/(FV + DC)= (EX- EX_{t-1})/(EX)$$
$$+ (WP- WP_{t-1})/(WP)+(RY- RY_{t-1})/(RY) + (IR- IR_{t-1})/(IR) \qquad (11)$$

Further simplification of the equation 11 for the elimination of the denominators gives the expression in equation 12.

$$[(FV) /(FV + DC) – (FV_{t-1})/(FV + DC)] + [(DC) /(FV + DC) – (DC_{t-1})/(FV + DC)] =$$
$$[(EX)/(EX) – (EX_{t-1})/ (EX)]+[(WP)/(WP) – (WP_{t-1})/(WP)]+ [(RY) /(RY)-(RY_{t-1})/(RY)]$$
$$+ [(IR)/(IR) - (IR_{t-1})/ (IR)] \qquad (12)$$

By solving equation 12 , taking logarithm into consideration, it gives equation 13 and 14 respectively.

$$[FV- FV – DC- (FV_{t-1} - FV – DC)] + [DC - FV - DC – (DC_{t-1} - FV - DC)] =$$
$$[EX - EX – (EX_{t-1} - EX)] + [WP - WP – (WP_{t-1} - WP)] + [RY – RY - (RY_{t-1} - RY)]$$
$$+ [IR – IR - (IR_{t-1} – IR)] \qquad (13)$$

$$[FV- FV – DC- FV_{t-1} + FV + DC] + [DC - FV - DC – DC_{t-1} + FV + DC] =$$
$$[EX - EX – EX_{t-1} + EX] + [WP - WP – WP_{t-1} + WP)] + [RY – RY - RY_{t-1} + RY]$$
$$+ [IR – IR - IR_{t-1} + IR] \qquad (14)$$

Addition and subtraction of like terms in equation 14 result in the expression in equation 15

$$[FV - FV_{t-1}] + [DC – DC_{t-1}] = [EX – EX_{t-1}] + [WP – WP_{t-1}] + [RY - RY_{t-1}] + [IR - IR_{t-1}] \qquad (15)$$

In their logarithm form, equation 15 can as well be expressed in their percentage changes as given in equation 16

$$\Delta lnFV + \Delta lnDC = \Delta lnEX + \Delta lnWP + \Delta lnRY + \Delta lnIR \tag{16}$$

In its general form, equation 16 can be re-specified to give equation 17 by adding the parameters and in which all the parameters are non-negative.

$$\Delta lnFV - \Delta lnEX = -\beta_1 \Delta lnDC + \beta_2 \Delta lnWP + \beta_3 \Delta lnRY + \beta_4 \Delta lnIR \tag{17}$$

Equation 17 is a fundamental equation of the monetary model of Exchange Market Pressure (EMP = ΔlnFV + ΔlnEX).