Exchange Market Pressure, and the Magnitude of Exchange Market Intervention Index in Nigeria

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Abstract

Using monthly data from January 2004 to December 2022 and the two-stage least squares (2SLS) method to estimate the money demand and price equation, this study constructs the exchange market pressure (EMP) and the intervention index for Nigeria by utilising the (Weymark, 1995) model. Findings indicate the value of the Naira is mostly under pressure to depreciate. Notwithstanding the monetary authority's intervention to pressures of appreciation or depreciation, the intervention index indicates absorption of the pressure by the exchange rate (EXR), which is in tandem with floating regime. Hence, the study agrees with the IMF's (2022) Exchange rate Arrangement for as well as Reinhart & Rogoff's (2004) exchange rate analysis for Nigeria. The analysis also revealed the anticipated (EXR) is more erratic than the actual exchange rate.

Keywords: Exchange Market Pressure; Foreign Exchange Reserve; Intervention index; 2SLS
JEL Classification Codes: C32, E58, F31, F37

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1.0 Introduction

Following the fall of the Bretton Woods structure of fixed currency exchange rates in 1970s, a number of economies switched to floating exchange rate. Capital restrictions had sustained the pegged exchange rate system since 1947, but by the 1970s, some of these controls were being circumvented, making it more difficult to maintain fixed rates. This contributed to the collapse of the Bretton Woods structure. Developed countries' transition to floating exchange rates by 1973 signalled the start of a new phase of money market deregulation. By the 1980s, the capital markets had been liberalised, and over the following 20 years, developing countries were added to the list. The early 1970s saw a significant increase in capital mobility, making it more difficult to peg exchange rates. As a result, countries that stuck to fixed exchange rates were more vulnerable to speculative occurrences and exchange rate catastrophes. Consequently, a shift towards broader floated exchange rates occurred by 2000 (Deffenu, 2022).

Yet, extant economic models of exchange rate that relied on the monetary perspective did not fit the facts (Frenkel & Johnson, 2013). Because it was widely believed that central banks were hesitant to let their rates fluctuate because of substantial changes in nominal exchange rates, which could jeopardise other domestic macroeconomic policy goals[1]. To avert further exchange rate volatility, the central banks intervened in the forex markets which is referred to "managed float" or "dirty float". Movements in exchange rates and foreign reserve contributed to the external adjustment associated with managed-float. Put differently, reserve fluctuations (via fixed rate regime) and exchange rate fluctuations (via free-floating regime) both indicated "exchange market pressure," a phrase introduced by (Girton & Roper, 1977).

Exchange Market Pressure (EMP) is a widely used tool for detecting and adjusting money market disequilibrium, particularly in managed-float regimes. The lack of elasticity in the exchange rate to correct for imbalances in the money market makes the pressure undesirable. The intervention index originally developed by (Frenkel & Aizenman, 1982) is used to quantify the magnitude of foreign exchange intervention, or the amount of money market imbalance that exchange rate adjustments resolve. (Weymark, 1995) developed an intervention index, which is different from (Frenkel & Aizenman, 1982), by using the (Girton & Roper, 1977) technique that refers to the percentage of pressure that the monetary authority absorbs by adjusting its foreign reserves.

Nigeria has experienced various periods of exchange rate regimes over the years. The initial period, which spanned from 1960 to 1986, the British pound sterling was used as the benchmark currency to regulate the Naira and later the US dollar in an effort to prevent excessive volatility (Ogiogio, 1996). The other incident was the 1986 structural adjustment programme (SAP), introduce by the International Monetary Fund (IMF) which showed the economy's high reliance on the petroleum sector was not sustainable under the fixed exchange system driven by the joint effects of growing external debt and declining foreign reserves. This liberalised the foreign exchange market by floating the Naira to US dollar through the Second Tier Foreign Exchange Market (SFEM). In the third period, which took place between 1994 to 1999, Nigeria reverts to the fixed exchange rate regime, using the money supply as a stabilising factor and the Naira was pegged to the US dollar. By 1999, Nigeria implemented the Inter-bank Foreign Exchange Market (IFEM) to increase the availability of foreign

[1] The IMF Exchange rate Arrangement in 1997 indicated that about 46 of 184 countries float their exchange rate, though intervened when necessary to stabilise their domestic currency. Also, another IMF Exchange rate Arrangement in 2019 indicated about 778 countries adopt the manage-float system.

currency, hence returning to the floating exchange rate system. In 2002, the Dutch Auction System (DAS) was introduced with the aim of enhancing reliability and transparency in the forex market. Subsequently, the DAS was superseded by the Whole Sale Dutch Auction System (WDAS) in the first quarter of 2006. Successively, the bureaux de change (BDC) were allowed into the WDAS window in the second quarter of 2006 as a result of the foreign exchange market's continued liberalisation. In 2013, the CBN aimed to improve stability and liquidity by reintroducing the Retail Dutch Auction System (RDAS). The economic downturn in 2016 forced the domestic currency to plunge, making it necessary for the CBN to intervene in the foreign exchange market, leading to the creation of the Investors and Exporters (I&E) window in 2017 intended to float the Naira more freely, though with occasional interventions (CBN 2018). Despite the success of the (I&E) window in attracting inflows, the exchange rate continued to depreciate, this decline is attributed to the multiple exchange[2] rates operation, thus calling for unification of the exchange rate.

Similar to Nigeria, a number of other countries engaged in various exchange rate operations, prompting researchers to observe distinctions between the de facto and de jure exchange rates since the 2000s. Given how different national currencies evolved from one regime to another, this has led to the need for a classification system that was based on the real exchange rates of the nation's monetary authority rather than on announcements. Thus, the classification scheme became more popular because of the transparency which is in line with the country's actual monetary policy approaches.

This study is distinct from the earlier ones conducted for Nigeria by using the Weymark (1995) approach. The (Girton & Roper, 1977) technique was mostly employed in studies that constructed the exchange market pressure for Nigeria. These studies include: (Mogaji, 2017; Ojapinwa, & Rotinwa, 2016; Raji, *et al.*, 2014; Yakub, *et al.*, 2012). However, the Weymark (1995) model is more adaptable and relevant to different exchange rate regimes, encompassing a wider array of economic factors than Girton and Roper's (1977) model, which assumed fixed exchange rate regimes. Furthermore, Weymark's (1995) model offers a more sophisticated understanding of EMP by distinguishing between real and target changes in variables, whereas Girton and Roper's (1977) model employs a more straightforward calculation. Additionally, Weymark's (1995) model clearly takes into account the monetary policy decisions made by the central bank, whereas Girton and Roper's (1977) model places more emphasis on direct involvement in the forex market. Overall, considering the CBN has operated under several exchange rate regimes, for instance, the replacement of the DAS with WDAS in 2006, the introduction of the RDAS in 2015 and the creation of the (I&E) window in 2017 demonstrates the suitability of the Weymark's (1995) model to constructing the EMP for Nigeria.

Three objectives are examined in this study. Firstly, the exchange market pressure for Nigeria is constructed using the Weymark (1995) approach. Secondly, the Weymark (1995) model is used to compute the central banks' intervention index. Thirdly, the intervention index is used to determine how Nigeria's exchange rate provisions comply with the exchange rate classification system developed by Reinhart, & Rogoff, (2004) and the exchange rate arrangements and restrictions published by the International Monetary Fund in 2022.

[2] In addition to the IFEM and the I&E window, the CBN also manage other parallel market rates, often referred to as the "black market," which functions outside of the established channels and frequently has higher rates than the IFEM and official exchange rate. Likewise, the Bureau De Change (BDC) window obtains its foreign exchange from the CBN and trades without any restrictions at all, typically at a rate that is substantially greater than that of the other windows.

The remainder of this study is organized as follows. Section 2 presents theoretical model and the empirical literature of exchange market pressure. Section 3 presents the data. Section 4 presents the empirical findings. Section 5 presents the conclusion of the study.

2.0 Literature Review

The theoretical framework and empirical research on exchange market pressure are reviewed in this section. The study primarily focuses on the Weymark (1995) approach to exchange market pressure, the empirical implementations of this model, and other empirical studies related to Nigeria.

2.1 Theoretical Framework

In the theoretical literature, the model-dependent and model-independent are the fundamental models to EMP. The model-dependent method differs in that it makes use of a stochastic macro model to determine the EMP's components, the weights given. However, the model-independent method does not derive the components of EMP or the weights associated with using a macro model. Hence, a model-dependent Weymark's (1995) approach to Exchange Market Pressure is discussed.

2.1.1 The Weymark (1995) Model

Here, the study uses Weymark (1995)'s to estimate the EMP and the CBN intervention for Nigeria. The Weymark's model is given as:

$$m_t^d = p_t + \beta_1 y_t - \beta_2 i_t + u_t \qquad \beta_1 > 0 \; and \; \beta_2 > 0 \qquad (1)$$

$$p_t = \alpha_0 + \alpha_1 p_t^* + \alpha_2 exr_t \qquad \alpha_1, \alpha_2 > 0 \qquad (2)$$

$$i_t = i_t^* + E_t exr_{t+1} - exr_t \qquad (3)$$

$$m_t^s = m_{t-1}^s + \Delta d_t + \Delta fr_t \qquad (4)$$

$$\Delta fr_t = -\rho_t \Delta exr_t \qquad (5)$$

The asterisks imply foreign equivalents of domestic variables, while the expression $Eexr_{t+1}$ assumed the value of the (EXR) at time $t + 1$, as anticipated by rational agents, subject to the knowledge obtainable during period t. Except for the interest rate, all variables are expressed in logarithms.

Equation 1 indicates the real money demand which argues that the demand for nominal monetary demand $(m_{t\ t}^d)$ depends on home price (p) and home income (y_t), which inversely depends on interest rate (i_t). The relationship of income (y_t) and demand for money (m_t) is predicated on the notion of increase in income, individual desire more money to fund their expenses. The policy rate indicates the opportunity cost of saving, and as it increases, consumers invest in interest-generating assets, reducing demand for domestic money balances. Additionally, (u_t) is the stochastic money demand disturbance. Equation 2 illustrates the purchasing power parity (PPP) equation. It asserts that the foreign price level (p_t^*) and exchange rate (exr_t) both have a positive relationship with domestic price p_t. The exchange rate represents the number of domestic currency units in foreign currency, indicating a decline in home currency value and potential deviations from purchasing power parity, reflecting domestic price changes. Equation (2) clearly reduces to purchasing power parity when $\alpha_0 = 0$ and $\alpha_1 = \alpha_2 = 1$. Equation 3 proposes that returns on both local and foreign investments should be equal. Exchange rates are adjusted to achieve parity in asset returns when there is a discrepancy between the local and international interest rates. Equation 4 describes the money supply process depending on money stock. It says that variations in domestic credit (Δd_t),

foreign reserves (Δfr_t), and money stock (m_t^s) all affect the amount of money in circulation.[3] Equation 5 shows the response of the monetary authority when rate of exchange fluctuates. For instance, when the value of the home currency declines ($exr_t > 0$), the monetary authority sells its foreign reserve ($\Delta fr_t < 0$). In similar vein, reserves increase ($\Delta fr_t > 0$) as currency appreciates.

By substituting equation (2) and (3) into equation (1) indicate that the demand for money is defined as:

$$m_t^d = \alpha_0 + \alpha_1 p_t^* + (\alpha_2 + \beta_2) exr_t + \beta_1 y_t - \beta_2 i_t^* - \beta_2 E[exr_{t+1}|t| + \varepsilon_t \quad (6)$$

Assuming that the market clears at $m_t^d = m_t^s$ for all t, and considering the size of the exchange rate required to bring the market back to equilibrium after an eventual disturbance caused by foreign prices, domestic income, foreign interest rates, taking the differencing the equation, the money demand shock yields:

$$\Delta exr_t = \frac{-\{(\alpha_1 \Delta p_t^* + \beta_1 \Delta y_t - \beta_2 \Delta i_t^* + u_t - \Delta d_t - \beta_2 \Delta E exr_{t+1}) + \Delta fr_t\}}{\alpha_2 + \beta_2} \quad (7)$$

The partial derivative of Δexr_t with regard to foreign reserves Δfr_t yields:

$$\lambda = -\frac{\partial \Delta exr_t}{\partial \Delta fr_t} = \frac{-1}{\alpha_2 + \beta_2} \quad (8)$$

This indicate that the exchange rate elasticity (λ) is inversely related to foreign reserves. It demonstrates the inverse fluctuations between exchange rate and foreign reserves.
Thus, the following is the exchange market pressure EMP_t model:

$$EMP_t = \Delta exr_t + \lambda \Delta fr_t \quad (9)$$

The Exchange Rate Pressure (EMP_t) quantifies the magnitude of exchange rate fluctuations necessary to eliminate exchange market pressure in the event that the apex bank intervention is not employed. The EMP assumes either a positive or negative sign.

(Weymark, 1995) created the intervention index, which measures the percentage of currency pressure the monetary authorities ease by buying foreign exchange reserves. It is calculated as the ratio of reserve changes to pressure, and is used when central banks directly intervene in the currency market which is given as:

$$\tau_t = \frac{\beta \Delta fr_t}{EMP_t} = \frac{\beta \Delta fr_t}{\Delta exr_t + \beta \Delta fr_t} \quad (10)$$

$$\tau_t = \frac{\Delta fr_t}{\frac{1}{\lambda} \Delta exr_t + \Delta fr_t} \quad (11)$$

[3] Variations in domestic credit $\Delta d_t = [\sigma_t \delta_t - \sigma_{t-1} \delta_{t-1}]/M_{t-1}$ where σ_t is the money multiplier in time t, δ_t indicate the stock of domestic credit, M_{t-1} indicate the money stock in time t. Also, variations in foreign reserves $\Delta fr_t = [\sigma_t \theta_t - \sigma_{t-1} \theta_{t-1}]/M_{t-1}$ where θ_t is the foreign reserves in time t, while $\sigma_t$and $M_{t-1}$are defined as above.

The intervention index τ_t lies within $-\infty$ to $+\infty$ which indicates that when the exchange rates float freely, the foreign reserves is $\Delta fr = 0$ while the intervention index is $\tau_t = 0$. However, when the central bank implements the intervention index to keep the exchange rate fixed the foreign reserves is $\Delta fr = 0$ while the intervention index is $\tau_t = 0$.when τ_t ranges from 0 to 1, define managed-float exchange rate. However, when the value of the intervention index is negative and ranges outside of 0 and 1, this means that the central bank is "leaning against the wind" by depreciating the domestic currency in proportion to its free float rate.

2.2 Empirical literature

Weymark (1995) estimated the pressure on exchange markets and the level of intervention for the Canadian economy using quarterly data from 1975 to 1990. Findings show that Canadian dollar's value was under constant downward pressure from 1975(11) to 1984 (1V) while the Canadian dollar appreciated from 1985. The Bank of Canada's intervention efforts demonstrated that during the course of the sample time frame, about 96 percent of the pressure is absorbed.

İlhan, et *al.*, (2022) use a regime switching approach to examine the dynamics of EMP in Turkey. Two separate regimes—defined as intervals of either high or low pressure—are shown by the results. The high-pressure regime's dominance during the sample period suggests that depreciation pressure is predominant. The pressure is made worse by this regime's increasing inflation, rise in credit, and the VIX as well as decline in external debt.

Siklar, and Akca, (2020) used the Girton and Roper model to investigate the connexion of EMPI in Turkey and monetary policy from 2002 to 2018. The results show that EMP was in line with monetary policy and trends in the financial markets over the study period. Also, a Granger type causality analysis conducted using a VAR model indicate a bidirectional causal relationship between EMP and interest rate differential, while there is a unidirectional exist between domestic credit growth and EMP as well as domestic credit growth to interest rate differential.

Using an ARDL model, Khalaf, (2018) examined the EMP index and monetary policy intervention in Iraq using the IMF approach between 2013 and 2017. The findings demonstrate that to lessen pressure in the foreign exchange (FX) market, the Central Bank of Iraq (CBI) greatly depends on foreign reserves. Owing to the structure of the Iraqi economy, which relies heavily on oil exports as a source of foreign exchange, the CBI implemented a fixed exchange rate system in order to manage inflation projections. Furthermore, the study revealed that the conventional hedging tools, such domestic credit and the money multiplier, were ineffectual in the context of Iraq.

Stavarek, (2006) estimated the EMP on the currency exchange rates of EU countries namely, Czech Republic, Hungary, Poland, and Slovakia between 1993 and 2006 using a model-dependent technique. According to the data, EMP levels are comparable across all nations, with the exception of Poland. The discovered that EMP was far smaller and less volatile when a floating exchange rate system was in place than when fixed exchange rates were in place.

Yakub, *et al.*, (2012) used quarterly data from 1999 to 2012 to estimate EMP index for Nigeria and analyse the monetary policy's response using the Girton and Roper approach. Based on empirical results using the Vector Autoregressive (VAR), it was found that while domestic credit had an inverse relationship with EMP, interest rate difference and external reserves were

significant determinants. Foreign reserves proved to be the main driver influencing EMP in Nigeria. Using the Girton & Roper (1977) approach, Raji *et al.,* (2014) estimated the EMP for Nigeria over the period 1970–2010 by a dynamic ordinary least squares (DOLS) regression. The findings of the (DOLS) analysis show an inverse relationship between domestic credit and the EMP. Furthermore, by altering the foreign reserves, the central bank absorbs the majority of the pressure in the foreign exchange market. Using similar approach, Ojapinwa, & Rotinwa, (2016) examine the impact of EMP on Nigerian financial sector from 1960 to 2015 utilising autoregressive distributed lag (ARDL) and vector error correction models. Results indicate that EMP has over time led to imbalances in Nigeria's financial sector.

In West African Monetary Zone (WAMZ), Mogaji, (2017) used monthly data from 2001 to 2015 to study how EMP responded to monetary policy-related factors that affected currency risks. The study used the model-dependent method of Girton and Roper (1977) and the model-independent approach proposed by Eichengreen, *et. al.,* (1996). The regression method was used for the estimate of the model-dependent EMP. Findings demonstrated most of the WAMZ's member nations absorbed exchange market pressure by depreciating the national currencies in proportion to depleting reserves.

In another study, an empirical investigation of EMP and intervention in the Nigerian FX was carried out by Itodo *et al.,* (2023). The study demonstrated that a number of factors, including trade imbalances, external shocks, and economic instability, are responsible for the nation's foreign exchange pressure, which significantly affects the exchange rate and reserves. Using data from January 2010 to September 2023, and an ARDL technique, Asuzu, & Akintola, (2023) examine into the relationships of central bank policy and EMP in Nigeria. The results demonstrate the relationship between EMP, managed-float regime, the growing difference between authorised and BDC exchange rates, and the ratio of foreign assets to foreign liabilities. The study also shows that EMP varied during this time in Nigeria.

3.0 Data

The study utilised monthly variables from January 2004 to December 2022 to construct the EMP and the intervention index for Nigeria. The variables include the monetary policy rate (i_t) which is the short-term rate that banks charges one another to borrow funds in Nigeria; monetary aggregate (m_t) which include currency in circulation plus demand deposits; the exchange rate (exr_t) is the quantity of Naira expressed in United States dollars; consumer pricing index show how much it costs the average consumer in Nigeria (p_t) and the United States (p_t^*). Total reserve minus gold is referred to as foreign exchange reserves (fr_t) and US treasury bill rate. To be consistent with the sample data, annual nominal GDP (y_t) is sliced into monthly data using Eviews 12. The data on monetary policy rate, money supply, exchange rate, nominal GDP and foreign reserves were sourced from the Central Bank of Nigeria (CBN) while the consumer price index for Nigeria is obtained from the International Financial Statistics. The US consumer price index and the treasury bill rate were sourced from the Federal Reserve Bank of St. Louis. All the variables were transformed into logarithm with the exception of the i_t and the US treasury bill rate.

4.0 Empirical findings

4.1 Unit root tests result

Table 1 indicates the ADF and PP unit root tests, respectively. It is clear that all the variables are stationary at the first difference under the two-unit root tests. This is because their respective t-statistics are above their critical values at the 5 % level of significance. Therefore,

at first difference, the variables are stationary by rejecting the null hypothesis of non-stationarity.

Table 1: Unit root tests

Variables	Levels		First Difference	
	ADF	**PP**	**ADF**	**PP**
i_t	-1.6382	-1.9221	-14.7434*	-14.9421*
m_t	-2.1107	-2.3422	-14.0394*	-17.6193*
p_t	-1.3825	-0.7436	-9.9201*	-9.2227*
p_t^*	0.4266	-0.4020	-8.8258*	-8.5039*
y_t	-2.0656	-2.0213	-15.4229*	-15.5110*
exr_t	-2.2511	-2.3429	-10.7128*	-10.8405*
fr_t	-2.9178	-2.9174	-15.1043*	-15.1047*

Note: Tests are carried out using intercept and trend. Maximum lag is equal to 14, which was chosen using Scharz (1978) information criteria (SIC) for ADF test and Newey-West Bandwidth for PP test. Mackinnon (1996) critical values are given as -3.9989; -3.4297; -3.1384. Asteriks, *, **, *** indicates that a variable is statistically significant at 1%, 5% and 10% levels.

4.2 Model estimation

To calculate the EMP and central bank intervention indices for Nigeria, the study estimates the interest rate (β_2) and exchange rate (α_2) coefficients in equations 1 and 2, respectively, using the two-stage least squares (2SLS) technique. The 2SLS is used to solve the endogeneity issue that results from simultaneously determining the dependent variable and one or more independent variables, as the ordinary least square (OLS) technique gives inconsistent estimates.

Table 2 presents the estimation results of the money demand equation using the OLS and 2SLS approaches in log-level and first difference with (HAC) standard errors. In all the estimates using the two approaches in log-level and first difference, the apriori sign of equation 1 clearly deviates from the money demand model with the exception of the 2SLS estimate in the first difference.

Table 2: Money Demand Equation

Eq.	Appro.	Independent Variable	Coefficient	T-stat.	T- stat. (HAC)	Durbin Watson Stat.	LM stat.	ARCH	R^2
1	OLS [Levels]	Const.	-32.312	-17.305*	-9.284*	0.067	212.8	189.04 (0.000)	0.75
		i_t	0.051	5.076*	3.449*				
		y_t	1.777	25.508*	13.743*				
2	OLS [Diff.]	Const.	0.013	3.660*	4.651*	2.26	13.969 (0.0009)	26.645 (0.000)	0.0009
		Δi_t	0.0006	0.092	0.100				
		Δy_t	-0.036	-0.448	-0.467				
3	2SLS [Levels]	Const.	-46.92	-16.790*	-10.114*	0.083	209.54 (0.000)	188.374 (0.000)	0.61
		i_t	0.135	4.4429*	2.47*				
		y_t	2.289	21.226*	12.552*				
4	2SLS [Diff.]	Const.	0.015	1.388	0.007	2.07	0.476 (0.788)	0.083 (0.773)	-1.18
		Δi_t	-0.108	-0.531	0.142				
		Δy_t	0.180	-0.126	1.248				

Note: The variables are estimated in levels, first difference (Diff.) and HAC test statistic. Asterisk, *, indicate that a variable is significant. LM test statistic and the ARCH test for autocorrelation and heteroskedasticity.

It is obvious in Table 2 the domestic income and the interest rate are statistically significant in log-level estimates. In addition, the variables are of positive sign which is contrary to what is expected from equation 1. Furthermore, the study fails to reject the null hypothesis of no serial correlation even though the standard errors are adjusted using Newey-West (HAC) standard errors. Additionally, spurious regression and non-stationarity of the variables are indicated by the high R^2 and weak Durbin-Watson test (Garnger and Newbold, 1974). The study also fails to reject the null hypothesis of no heteroskedasticity i.e., the variables are homoscedastic in log-level estimate of equation 1 given the poor F-statistic. On the other hand, the differenced OLS estimate is contrary to what is expected in the money demand equation. In the differenced 2SLS estimate, the positive domestic real income indicates that people hold money to transact as their income increases. However, a negative interest rate estimate implies that people would rather retain their cash in assets that yield interest rates than in cash balances due to the increased opportunity cost of doing so which point to a negative interest rate in the real money demand equation. Moreover, the money demand estimate using differenced 2SLS yields a strong Durbin-Watson test, despite the fact that interest rate sensitivity and real domestic income are insignificant using the usual t-statistic and the Newey-West test statistic. The fact that specification tests indicate no persistent misspecification, is comforting. As a result, the study favours the 2SLS estimate of interest rate difference data when developing the EMP and intervention indices.

Table 3 shows the purchasing power parity equation with OLS and 2SLS estimates at the level and first difference parameters. Overall, the variables have positive estimates in all specifications except the log-level estimates of OLS and 2SLS. As per the purchasing power parity equation, fluctuations in overseas costs and exchange rates have a positive correlation with domestic prices. This is supported by the positive estimations of the foreign consumer price index and exchange rate. In addition, the level estimates are statistically significant, similarly to the money demand equation, the study fails to reject the null hypothesis of no serial correlation heteroskedasticity, respectively.

Table 3: Purchasing Power Parity

Eq.	Appro.	Independent variable	Coefffcient	T- stat.	T- stat. (HAC)	Durbin Watson Stat.	LM stat.	ARCH	R^2
1	OLS [Levels]	Const.	-19.185	-70.058*	-26.932*	0.11	205.87 (0.000)	165.06 (0.000)	0.99
		p^*	4.083	66.037*	25.043*				
		exr_t	0.368	25.720*	9.484*				
2	OLS [Diff.]	Const.	0.008	10.652*	9.295*	1.27	33.37 (0.000)	4.686 (0.030)	0.05
		Δp^*	0.691	3.553*	3.412*				
		Δexr_t	0.021	1.146	1.149				
3	2SLS [Levels]	Const.	-19.152	-61.416*	-26.201*	0.11	204.696 (0.000)	163.74 (0.000)	0.73
		p^*	4.074	64.448*	24.417*				
		exr_t	0.371		9.498*				
4	2SLS [Diff.]	Const.	0.008	8.750*	7.73*	1.22	0.9185 (0.496)	0.5345 (0.327)	0.023
		Δp^*	0.227	3.080*	3.057*				
		Δexr_t	0.025	0.438	0.464				

Note: The variables are estimated in levels, first difference (Diff.) and HAC test statistic. Asterisk, *, indicate that a variable is significant. LM test statistic and the ARCH test for autocorrelation and heteroskedasticity.

Table 3 further depicts that the differenced data are statistically significant except for the domestic exchange rate in 2SLS estimate. Even though HAC standard errors reduced the t-statistics, the variables are significant except the exchange rate. Also, at differenced estimates, the study fails to reject the null hypothesis of no serial correlation in the purchasing power parity equation. In addition, the study also fails to reject the null hypothesis of no heteroskedasticity. Durbin-Watson test further indicate the presence of no serial correlation in the price equation using differenced data.

Overall, the study uses the differenced 2SLS estimates of the interest rate (β_2) and exchange rate (α_2) sensitivities to calculate the exchange market pressure and intervention indices for Nigeria. Prior to that, the study estimates the elasticity of exchange rate to foreign reserve in equation 8 given the coefficient of $\beta_2 = -0.108$ and $\alpha_2 = 0.133$ which yields: $\lambda = -7.519$. Fluctuations in the foreign reserve and exchange rate are implied to move in opposite directions by the negative elasticity (λ). The strengthening of the Naira relative to the US dollar in the foreign exchange market is correlated with a rise in foreign reserves.
The direction of the pressure is ascertained by using equation 9 to generate the EMP. If there is no intervention from the monetary authority, a positive estimate of EMP indicates that the value of the Naira to US dollar currency depreciates $(\Delta exr_t > 0)$. Conversely, a negative EMP value denotes an appreciation in the value of the domestic currency to US dollar. However, fixed exchange rate system indicates the absorption of all the pressure from the foreign exchange market $(\Delta exr_t = 0)$ and the reserves falls $(fr_t < 0)$.

Figure 1: Exchange Market Pressure Index (EMP)

Figure 1 presents the EMP using the (Weymark, 1995) approach. This indicates the domestic currency was under appreciation pressure during the sample's early periods. Between these periods, the New Monetary Policy Framework was created to effectuate monetary policy, with the Monetary Policy Rate (MPR) replacing the Minimum Rediscount Rate (MRR) as the nominal anchor for market rates. The appreciation pressure between these periods could also be related to the increase in external reserves to roughly $28.28 billion in 2005 and then to approximately $47.00 billion in 2007 (CBN 2005; Iwueze e*t al.*, 2013), which eventually led to the use of the Dutch Auction System (DAS) by the Central Bank of Nigeria (CBN) in place of the Whole Sale Dutch Auction System (WDAS) and the introduction of Bureau de change (BDCs) to harmonise the exchange rate between the official and parallel markets, further liberalising the foreign currency market. Nevertheless, as a result of the global financial crisis,

Nigeria's foreign reserves decreased due to a drop-in export and a reduction in capital inflows (AFDB *et al.*, 2011). Furthermore, the exchange rate was under depreciation pressure between 2008 and 2009, as a result of the 2008 oil price collapse and the crisis' aftermath, with the reserve falling to US$42.4 billion in 2009. The depreciation pressure between 2013 and 2015 coincides with the US Fed tapering which resulted in capital reversals from the fixed income market and the decline in crude oil prices. This finding corroborates the results of (Ojapinwa & Rotinwa, 2016) using the (Girton & Roper, 1977) model. Prior to that, the appreciation pressure in 2011 could be related to the sudden increase in crude oil price in the international market. However, given some marginal depreciation, the exchange rates sharply appreciate. The appreciation of the exchange rate can be attributed to the inception of the Investors' and Exporters' (I&E) window which played a crucial role in attracting foreign investors. The mild depreciation pressure that later occurred in may be related (a) degree of uncertainty around the monetary policy of the US and the European Central Bank (ECB), and the Bank of Japan's (BoJ) asset purchase. (b) The global economic lockdown that followed the COVID-19 outbreak, which caused disruptions in international trade and supply chains (c) declining crude oil prices (d) widespread sell-off by investors of gold and emerging market securities in favour of US dollar-denominated assets led to significant capital outflow and increased inflation.

Figure 2 presents the magnitude of intervention as the percentage of pressure dispelled by the apex bank calculated in accordance with equation 11. When the value of the intervention index $\tau_t = 0$, it indicates the absence of any defence against the Naira by the CBN, which corroborates with flexible exchange rate regime. However, the EMP is said to be managed-float when the intervention index lies between $0 < \tau_t < 1$, indicating the utilising exchange rate and reserves to mitigate the pressure.

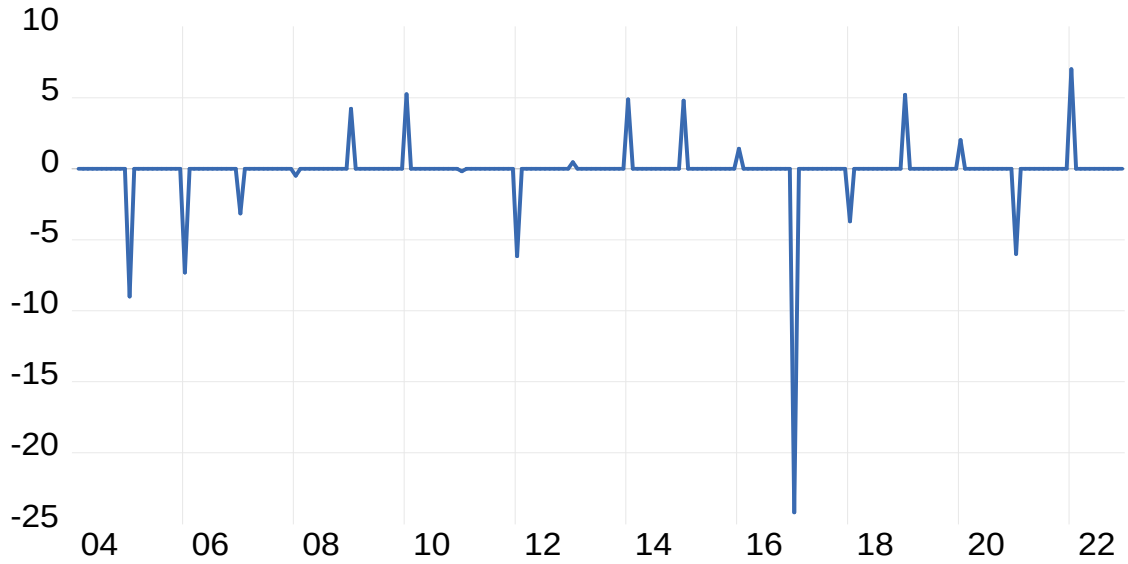

Figure 2: Intervention Index

Given that $\tau_t = 0$ in Figure 2, it indicates that the CBN allowed the exchange rate to float by absorbing a sizeable quantity of the exchange market pressure. However, there is about 9 months in which $\tau_t > 0$, indicating that the corresponding fluctuations in foreign exchange reserves exceeded the amount justified by the exerted pressure. Consequently, the exchange rate began to move in the opposite direction to the direction indicated by the pressure. In addition, there is another 9 months in which the $\tau_t < 0$, indicates a managed-float system where the foreign reserve and the exchange rate were used to alleviate the EMP. This approach

shows how the CBN manages the currency market dynamically by letting the exchange rate (float) absorb market pressure and using foreign exchange reserves to counteract excessive changes. The CBN successfully lessened the impact of exchange market pressure by modifying both the foreign reserve and exchange rate in accordance with each other. All things considered, the information presented in Figure 2 demonstrates the CBN's capacity to keep the currency market stable by combining managed-float and market-driven operations.

The EMP calculates the extent to which exchange rate changes, in the absence of monetary policy intervention, restore the imbalance in the money market. Thus, given the one period lagged observed exchange rate, the study estimates the true exchange rate that would apply in the absence of monetary intervention:

$$EXR^{predicted} = (1 + EMP_t)EXR_t^{observed} \quad (12)$$

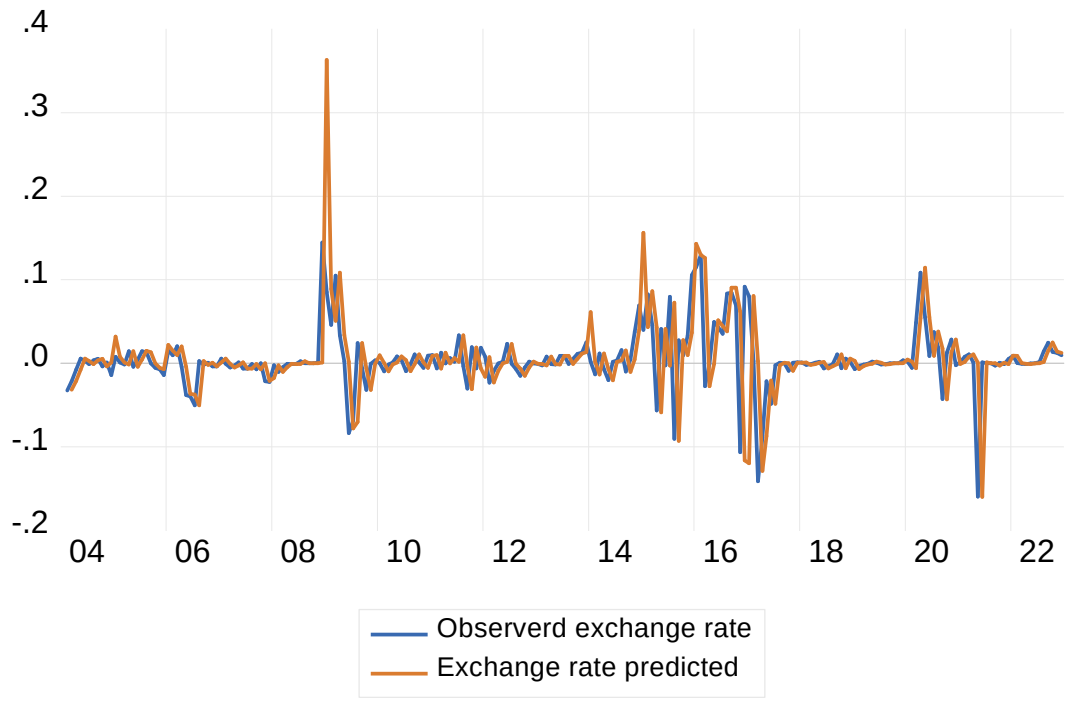

Figure 3: Actual and predicted exchange rate

An understanding of the degree of foreign exchange role can be obtained by comparing the two. The anticipated rate is more erratic than the actual exchange rate, as Figure 3 illustrates. This shows that the goal of the Central Bank's foreign exchange intervention—to lower exchange rate volatility—is being successfully attained.

5.0 Conclusion

Following the Weymark (1995) model, this paper derives the EMP and the intervention index for Nigeria. The notion that depreciating pressure persisted throughout the study period is provided by the exchange market pressure. The exchange rate is generally floated to absorb the pressure, even though the monetary authority actively intervenes in the foreign exchange market to subside volatility and speculative attacks on the Naira. The exchange rate overview is therefore in line with both Reinhart, & Rogoff', (2004) and the International Monetary Fund's 2022 Exchange rate Arrangement for Nigeria.

The fact that the actual exchange rate is less variable than the one that was predicted further suggests that the foreign exchange market intervention's objective of reducing exchange rate volatility has been achieved.

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