# Exchange Rate Volatility and Manufacturing Sector's Performance in Nigeria: A Toda-Yamamoto Approach

**Samuel Orekoya[1] and Joseph Afolabi[2]**
[1] *Department of Economics, University of Ibadan*
[2] *Nigerian Institute of Social and Economic Research, Ibadan*

**Abstract**
This study investigates the effects of volatility in exchange rate on manufacturing sector's performance in Nigeria and the sector's response to shocks from this volatility. It adopts the Toda-Yamamoto variant of vector autoregressive (VAR) model on data from 1986M1 to 2019M12. Exchange rate volatility (ERV) was generated using the ARCH/GARCH model and was found to attenuate rapidly and non-persistence. Impulse response result shows that manufacturing sector's performance responds negatively to shocks from ERV while the variance decomposition reveals that ERV accounts for an increasing change in manufacturing sector's performance in Nigeria. This shows that volatility in exchange rate could be deleterious to manufacturing sector's performance. Interest rate was also found to have significant influence on output. The paper therefore recommends that the monetary authority should continually watch exchange rate with a view to mitigating against its excessive volatility. A moderately low interest rate could also be pursued to aid manufacturing sector's performance as estimation result indicates that a positive shock to exchange rate negatively affects the performance of the sector.

***Keywords:*** *Exchange rate volatility, index of industrial production, Toda-Yamamoto model, VAR*

***JEL Classification:*** *F31, F43, L60.*

## Introduction

Exchange rate plays a crucial role in international economic transactions because no nation can afford to close its border and forfeit the benefits from external factor endowments without its consequences (Ismaila, 2016). Exchange rate, therefore, remains one of the important macroeconomic variables and stabilization tool to be managed carefully by the monetary authority towards harnessing the gains from open economy as it constitutes an institutional arrangement under which nations facilitate transactions among themselves (Rasaq, 2013). In addition, activities in the exchange rate market have crucial implication for a country's balance of payments (BOPs) position, employment and growth (Opaluwa, Umeh, and Abu, 2010). The choice of an exchange rate, according to Obadan (2007), tends to be perhaps the most critical decision in an open economy. This is due to its impact on economic performance, resource allocation, wealth of the citizens, standard of living, income distribution, BOP and other economic aggregates. Thus, Harchaoui, Tarkhani, and Terrence, (2005) surmised that exchange rate movements have important implications on a lot of economic variables.

The Nigerian exchange rate as managed by the Central Bank of Nigeria (CBN) has undergone various regimes. The pre-Structural Adjustment Programme (SAP) of 1959 – 1986 periods were characterized by fixed exchange rate regime while the SAP period ushered in a flexible exchange rate (1986 – date). Over the years, the Nigerian government has adopted different exchange rate policies since the deregulation of the economy following the adoption of SAP in July 1986 to promote growth and development (Ismaila, 2016). Exchange rate volatility (ERV) is associated with flexible exchange rate regime where exchange rate is subject to market forces which are mostly unpredictable. It measures the degree of exchange rate changes over time and became more pronounced after the Bretton Woods agreement broke down in 1973 which led to a situation of flexible exchange rate among world currencies but became more pronounced in Nigeria since the adoption of SAP till date (Opaluwa et al. 2010).

Ever since the adoption of SAP, naira exchange rate to the US dollars has steadily and consistently remained unstable. The nominal exchange rate in Nigeria against the US dollar ranges between ₦1.75 in 1986 and ₦358.81 in 2020 with notable depreciation experienced in 1999, 2009 and 2015. The real exchange rate (RER) ranges between ₦0.03 in 1986 and ₦117.52 in 2020 (WDI, 2020). This huge gap in exchange rate within this period has adverse implication on the cost of imported materials and would even pose more adverse effect if the unpredictable movement is unabated. Owolabi and Adegbite (2013) and CBN (2020) for instance reported manufacturing companies in Nigeria are operating below 40 per cent capacity partly because of uncertain movement in exchange rate adding that most manufacturing company are import dependent, while others (Opaluwa et al. 2010; Adenekan et al. 2019) asserts that this exchange rate movement and the continuous depreciation on Naira has led to a fall in living standards, widespread unemployment and increase in cost of production thus contributing to cost push inflation. This would mean that some activities around the manufacturing sector in Nigeria revolve around exchange rate owing to their dependent on imported raw materials. ERV creates uncertainties and makes investment decision more difficult because it precipitates exchange rate risk which is the tendency to lose money owing to unpredictable exchange rate movement. Hence, the higher the volatility, the higher the risk which has the tendency to scare investors in the manufacturing sectors into cutting down or suspending production activities, thereby hampering the sector's performance.

The performance of the manufacturing sector is very important to the diversification objective of the Economic Recovery and Growth plan (ERGP) and the drive of the nation towards industrialization. Afolabi and Ogunjimi (2020), identifies the performance of the sector as germane to achieving inclusive growth and sustainable development in the country. Therefore, any factor or activities that could threaten the performance of the sector should be carefully examined. Lawal (2016), who pointed out that the performance of the manufacturing sector since 1986 can be attributed to macroeconomic and exchange rate instability, claimed the unstable and unpredictable exchange rate has also undermined the competitive nature of non-oil export and generated uncertainties in economic decision-making both at the micro and macro levels. The end to the instability doesn't seem to be in sight as the incessant fluctuation, with occasional fall, in global crude oil price and the resultant decline in external reserves remain a threat to the ability of the CBN to buffer exchange rate from further depreciation and unpredictable movement in Nigeria. This dwindling external reserve accounts and further depreciation in exchange rate could consequently impact heavily on the manufacturing sector's performance.

Empirical findings into the effect of exchange rate volatility on manufacturing sector performance have produced a somewhat mixed result. While Lawal (2016) and Adesina (2018), Ayobami (2019) reported that exchange rate volatility exerts a positive effect on manufacturing sector performance, Opaluwa et al. (2010), Abdullah (2016), Adegboye, Aiyegbusi, Bamidale, and Akanni (2020), Antonio, Afonso and Hilton (2007) reported adverse effect. It was noted however that these studies adopted annual data which may not capture volatility properly. This study fills the gap by using monthly data and extracting volatility from exchange rate series using the GARCH model with the most recent data set, with the T-Y model of estimation.

This study seeks to empirically examine the manufacturing sector's response to ERV and evaluate its performance under this situation in Nigeria and then proffer informed policy suggestions to concerned stakeholders.

## Literature Review

There are no theories directly linking exchange rate volatility and manufacturing sector performance. Thus, this study adopts the purchasing power parity to capture exchange rate determination, the Keynesian real exchange rate and planned expenditure theory to show the relationship between exchange and real output as well as the Cobb Douglas production function to capture the production function. The linkage between these theories is presented in the theoretical framework in Section 3.2.

## Theoretical Literature Review

Cassell (1918) proposed the purchasing power parity (PPP) theory by adopting the law of one price (LOOP) which posits that similar goods and services in two countries should be priced similarly. According to Taylor and Taylor (2004), PPP is a simple theory which posits that the nominal exchange rate of country A and country B should be equal to the price level in country A over the price level in country B, as such, each country's unit of currency will have the same purchasing power across the two countries. Pilbeam (2006) argued that the exchange rate must adjust to ensure the LOOP applies not only to individual goods but also holds internationally for identical bundle of goods. PPP is simply the application of LOOP to national price levels as against to individual price level. Sarno and Taylor (2002) believed that PPP can be considered as a valid long run international parity condition when deployed to the bilateral exchange rate prevailing among major economically advanced nations, and that reversion in RER display significantly non-linearity. Under the monetary approach, an exchange rate is determined by the relative prices of goods in different countries. Negative exposure to locally listed company would occur when the source country of imports' currency appreciates as a result of demand for the country's goods hence exposing its liabilities and ability to import in the future. The reverse is the case for positive exposure (Pilbeam, 2006). The monetary theory advocates that the PPP of goods traded by a country determines its profitability. Implicitly, if the short run demand for a country's goods is higher and more profitable, then there will be a reduction in the exchange rate exposure (Pilbeam, 2006). The monetary theory also powers the country's aggregate demand as well as the economy's macro and micro economic conditions. The PPP theory is of two forms – One is the absolute PPP which asserts that if the price of bundle of goods in a country with similar goods in a foreign country is compared, the price will be equal when converted by the exchange rate into a common currency of measurement. The other is the Relative PPP which posits that the exchange rate will adjust by the volume of inflation differential between two economies (Pilbeam, 2006). Summarily, PPP explains exchange rate determination and adjustment between countries.

The Keynesian real exchange rate and planned expenditure theory is an extension of the IS-LM model to open economy which assumes the rest of the world consists of a single country. Denoting $\varepsilon$ as the nominal exchange rate – specifically, the price of a unit of foreign currency in terms of domestic currency. It follows therefore that; when exchange rate rises it means that foreign currency is now more expensive and domestic currency has depreciated whereas when $\varepsilon$ falls, domestic currency has appreciated. Denoting $p^*$ as the price level abroad, that is, the price of foreign goods in unit of foreign currency. This implies that the RER is expressed as $\varepsilon p^* / p$ (Romer, 1996).

An increase in real rate of exchange means that foreign goods are now costlier than domestic goods. Thus, domestic consumers and foreigners may probably increase the quantity purchased of local goods in preference to foreign goods because of lower price advantage. The theory suggests that increase in RER would lead to increase in aggregate demand for the domestic economy, hence, increase in national productivity. The planned expenditure of the economy Y is expressed as a function of real exchange rate (RER), government expenditure (G), real interest rate ($i-\pi^e$), and taxes (T) (Romer, 1996). National income here is an increasing function of RER government expenditure (G), national output (Y) and a decreasing function of real interest rate and taxes (T). The Keynesian real exchange rate and planned expenditure theory therefore explains the role of exchange rate in aggregate demand determination of a country.

The Cobb-Douglas function was also introduced to capture the linkages between output and input. This will provide a premise for modifying the model to accommodate the variables of interest as presented in the theoretical framework of the study. The model was essentially developed by Cobb and Douglas, (1928) to address a problem that relates factor inputs to aggregate output. The model is specified as; Y = F(K, L); where Y = output, L = labour, K = capital and F is a functional relationship that is continuously differentiable. It has profit maximizing factor inputs L*(r,w,p) and K*(r,w,p) for each output price level (p), wage rate (w), and capital rental rate (r) represented as,

$$pF(K,L) - wL - rK \qquad (1)$$

The first order condition for an interior maximum includes:

$$pF_L(K^*,L^*) = w \qquad (2)$$
$$pF_K(K^*, L^*) = r \qquad (3)$$

where $F_L$ and $F_K$ represent the marginal products of labour ($MP_L$) and capital ($MP_K$) respectively. The model identifies the distinct contribution of L and K to output to derive the baseline model which is specified as;

$$F(K, L) = AK^{1-\alpha}L^{\alpha} \qquad (4)$$

with (1-α) and α respectively denoting the elasticity of capital and labour to output.

**Empirical Literature Review**

Empirical findings on exchange rate volatility and manufacturing sector performance have produced conflicting results in the literature. Amadi et al. (2018) conducted a study on macroeconomic implications of exchange rate fluctuation on manufacturing sector performance in Nigeria. Using GARCH and VAR estimate, the study found exchange rate fluctuation to negatively affect the performance of the manufacturing sector. This finding was corroborated by the work of Morina, et al. (2020), who examined the effect of exchange rate volatility on total output in the economy as a whole. Contrarily, Ayobami (2019) reported a somewhat contradicting result. In analyzing exchange rate volatility and manufacturing sector performance in Nigeria, the later study found ERV to impact positively and significantly on manufacturing sector performance both in the short and long run. However, while Amadi, et al. (2018) adopted ERV series using GARCH techniques, Ayobami (2019) adopted exchange itself as a proxy for volatility. Hence, the result could interpret the effect exchange rate depreciation on manufacturing sector performance as against the interpretation as volatility.

Studies that reported similar results with Amadi et al. (2018) include the work of Opaluwa et al. (2010) who empirically investigated the effect of fluctuations in exchange rate on manufacturing sector performance in Nigeria between 1986 and 2005. Using the auto-regressive distributive lag (ARDL) model, the study found that long-run volatility in exchange rate negatively impacts macroeconomic performance in Nigeria. Similar findings were reported in the works of Muhammed and Victor (2013) and Adeniran, et al. (2014) from studies conducted on exchange rate volatility and manufacturing sector performance in Nigeria. On the other hand, the works of Enekwe et al (2013); Abdallah (2016) and Lawal (2016) corroborates the findings reported by Ayobami (2019). It was also observed that they all adopted a common proxy (real exchange rate) for exchange rate volatility in their empirical analysis.

Several related studies have also been conducted on this subject on countries outside Nigeria. For instance, Upadhyaya and Upadhyay (1999) examined the effects of devaluation on output with a multivariate model for six Asian countries. The study found that in most of the countries examined, devaluation has no significant positive effect in the short, medium and long-run on output growth. Robyn (2006) investigated the same subject matter between 1988 and 2001 in the Australian manufacturing sector. The study reported that the response of investment to changes in exchange rate varies with the external exposure of industry, varies with export share of sales positively and adversely with the share of imported input into production. Antonio, et al. (2007) conducted a study on the impact of ERV on Brazilian manufactured export and revealed that an absolute one – percentage point increase in the variability of the real effective exchange rate reduces manufacturing export by 0.77 per cent.

Similar examination by Mustafa and Torres (2008) on Mexican manufacturing industry showed that currency depreciation has a direct effect on fixed investment through export channel and ERV impacts mostly on export-oriented sector. It found the sensitivity of investment to exchange rate movement to be stronger on non-durable goods sectors and industries with low markup ratio. Paulo and Werner (2013) used panel data of 39 countries and 22 manufacturing sectors to study RER and the growth of manufacturing sector in Latin America. The study reported that manufacturing sectors in Latin America on the average have been affected more by currency overvaluation than undervaluation. Harchaoui et al (2005) also investigated the effect of exchange rate on investment on 22 Canadian manufacturing industries and reported that the general effect of exchange rate on aggregate investment is minimal.

Most of the studies reviewed used yearly data for their analysis of ERV while volatility is best captured using high frequency data which could help capture movement in exchange rate better. Thus, this study adopts a monthly data to capture the effect of exchange rate volatility on manufacturing sector performance in Nigeria.

## Theoretical Framework and Methodology

### Theoretical Framework

The study takes aggregate demand (AD) and aggregate supply (AS) framework to link exchange rate to production in the economy. The framework is divided into the supply and demand side of the economy while the third equilibrate both sides. The supply side of the economy assumes a Cobb-Douglas production function in the form of Q=F(K, L) = $AK^{1-\alpha}L^{\alpha}$ (see Cobb and Douglas, 1928), where; Q= total economic production (AS), K= capital, L= labour, (K and L are factor inputs in the production function), A= level of technology which is taken to be constant, (1-α) and α are the contributions of capital and labour to production respectively. The demand side of the economy adopts the Keynesian RER and planned expenditure theory, an extension of IS – LM model, to explain the case of an open economy (see Romer, 1996). The planned expenditure (AD) in this theory is expressed as Y=E(Y, i-$\pi^{e}$, G, T, $\frac{\varepsilon P^{*}}{P}$). Where; Y = aggregate demand, E = expectation notation, i-$\pi^{e}$ = real interest, G = government expenditure, T = taxation and $\frac{\varepsilon P^{*}}{P}$ = Real exchange rate.

Equilibrium in the economy is attained at the point where AD and AS intersect. At this point, the economy is said to be operating at full employment level of output with efficiency.

Given that: AS=Q= $AK^{1-\alpha}L^{\alpha}$ (5)

and AD=Y=E(Y, i-$\pi^{e}$, G, T, $\frac{\varepsilon P^{*}}{P}$) (6)

Equating (5) to (6) .i.e. AD = AS, we have;

$$Q= E(Y, i\text{-}\pi^{e}, G, T, \frac{\varepsilon P^{*}}{P}) \qquad (7)$$

Hence, Output (Q) = F(Income (Y), real interest rate ($i\text{-}\pi^{e}$), Government expenditure (G), Taxation (T) and Real exchange rate (RER)). Equation (7) is an economic equilibrium model connecting real exchange rate to economy's production.

**Data Source and Description**

Monthly time series data from 1986M1 to 2019M12 obtained from the CBN statistical bulletin (2020) was adopted for the study. The variables used for the empirical analysis include; the manufacturing sector's output to GDP ratio (MDGPR), exchange rate volatility (ERV) which is derived from GARCH estimates of Exchange rate to measure the unpredictive patterns of exchange rate movement in the model, Monetary policy rate (MPR) which is used to proxy money market interest rate, money supply which measures the level of liquidity in the economy, and inflation. MPR, money supply (MS3) and inflation (INF) are introduced into the model because exchange rate affect output through interest rate as identified in the exchange channel of monetary policy (see Mishkin, 1996).

**Model Specification**

From the expressions in equations (5) to (7), the following model is specified to achieve the objective of the study.

Manufacturing sector's output to GDP ratio $_t$= F(exchange rate volatility$_t$, monetary policy rate$_t$, money supply$_t$, inflation$_t$) (8)

Re-parameterizing the model, in Toda-Yamamoto variant of VAR (see Toda and Yamamoto, 1995; Amiri and Ventelou, 2012) because of the stationarity property of the series {mixture of I(0) and I(1) }, we have the following equations;

$$MGDPR_t = \propto_0 + \sum_{I=1}^{1} \propto_{1i} MGDPR_{t-i} + \sum_{j=1+1}^{1+1} \propto_{2j} MGDPR_{t-j} + \sum_{i=1}^{1} \varphi_{i1} ERV_{t-i} + \sum_{j=1+1}^{1+1} \varphi_{2i} ERV_{t-j} + \sum_{i=1}^{1} \emptyset_{1i} MPR_{t-i} + \sum_{j=1+1}^{1+1} \emptyset_{2i} MPR_{t-j} + \sum_{i=1}^{1} \emptyset_{1i} INF_{t-i} + \sum_{j=1+1}^{1+1} \emptyset_{2i} INF_{t-j} + \sum_{i=1}^{1} \emptyset_{1i} MS3_{t-i} + \sum_{j=1+1}^{1+1} \emptyset_{2i} MS3_{t-j} + \varepsilon_{1t} \qquad (9)$$

$$ERV_t = \beta_0 + \sum_{I=1}^{1} \beta_{1iMGDPR_{t-i}} + \sum_{j=1+1}^{1+1} \beta_{2j} MGDPR_{t-j} + \sum_{i=1}^{1} \varphi_{i1} ERV_{t-i} + \sum_{j=1+1}^{1+1} \varphi_{2i} ERV_{t-j} + \sum_{i=1}^{1} \emptyset_{1i} MPR_{t-i} + \sum_{j=5+1}^{1+1} \emptyset_{2i} MPR_{t-j} + \sum_{i=1}^{1} \emptyset_{1i} INF_{t-i} + \sum_{j=1+1}^{1+1} \emptyset_{2i} INF_{t-j} + \sum_{i=1}^{1} \emptyset_{1i} MS3_{t-i} + \sum_{j=1+1}^{1+1} \emptyset_{2i} MS3_{t-j} + \varepsilon_{2t} \quad (10)$$

$$MPR_t = \sigma_0 + \sum_{I=1}^{1} \sigma_{1i} MGDPR_{t-i} + \sum_{j=1+1}^{1+1} \sigma_{2j} MGDPR_{t-j} + \sum_{i=1}^{1} \varphi_{i1} ERV_{t-i} + \sum_{j=1+1}^{1+1} \varphi_{2i} ERV_{t-j} + \sum_{i=1}^{1} \emptyset_{1i} MPR_{t-i} + \sum_{j=1+1}^{1+1} \emptyset_{2i} MPR_{t-j} + \sum_{i=1}^{1} \emptyset_{1i} INF_{t-i} + \sum_{j=1+1}^{1+1} \emptyset_{2i} INF_{t-j} + \sum_{i=1}^{1} \emptyset_{1i} MS3_{t-i} + \sum_{j=1+1}^{1+1} \emptyset_{2i} MS3_{t-j} + \varepsilon_{3t} \quad (11)$$

$$INF_t = \theta_0 + \sum_{I=1}^{1} \theta_{1i} MGDPR_{t-i} + \sum_{j=1+1}^{1+1} \theta_{2j} MGDPR_{t-j} + \sum_{i=1}^{1} \varphi_{i1} ERV_{t-i} + \sum_{j=1+1}^{1+1} \varphi_{2i} ERV_{t-j} + \sum_{i=1}^{1} \emptyset_{1i} MPR_{t-i} + \sum_{j=1+1}^{1+1} \emptyset_{2i} MPR_{t-j} + \sum_{i=1}^{1} \emptyset_{1i} INF_{t-i} + \sum_{j=1+1}^{1+1} \emptyset_{2i} INF_{t-j} + \sum_{i=1}^{1} \emptyset_{1i} MS3_{t-i} + \sum_{j=1+1}^{1+1} \emptyset_{2i} MS3_{t-j} + \varepsilon_{4t} \quad (12)$$

$$MS3_t = \rho_0 + \sum_{I=1}^{1} \rho_{1i} MGDPR_{t-i} + \sum_{j=1+1}^{1+1} \rho_{2j} MGDPR_{t-j} + \sum_{i=1}^{1} \varphi_{i1} ERV_{t-i} + \sum_{j=1+1}^{1+1} \varphi_{2i} ERV_{t-j} +$$

$$\sum_{i=1}^{1} \emptyset_{1i} MPR_{t-i} + \sum_{j=1+1}^{1+1} \emptyset_{2i} MPR_{t-j} + \sum_{i=1}^{1} \emptyset_{1i} INF_{t-i} + \sum_{j=1+1}^{1+1} \emptyset_{2i} INF_{t-j} + \sum_{i=1}^{1} \emptyset_{1i} MS3_{t-i} + \sum_{j=1+1}^{1+1} \emptyset_{2i} MS3_{t-j} + \varepsilon_{5t} \quad (13)$$

Equation 9,10,11,12 and 13 present model in parametrized form. $\propto_0$, $\beta_0$, $\sigma_0$, $\theta_0$, and $\rho_0$ represent the intercept to MGDPR, ERV, MPR, INF, MS3 model respectively. the slope coefficients of the model are $\propto_{1i}$, $\propto_{2j}$, $\varphi_{i1}$, $\varphi_{2i}$, $\emptyset_{1i}$, $\emptyset_{2i}$ for MGDPR model, $\beta_{1i}$, $\beta_{2j}$, $\varphi_{i1}$, $\varphi_{2i}$, $\emptyset_{1i}$, $\emptyset_{2i}$ for ERV model, $\sigma_{1i}$, $\sigma_{2j}$, $\varphi_{i1,}\varphi_{2i}$, $\emptyset_{1i}$, $\emptyset_{2i}$ for MPR model, $\sigma_{1i}$, $\sigma_{2j}$, $\varphi_{i1,}\varphi_{2i}$, $\emptyset_{1i}$, $\emptyset_{2i}$ $for\ INF, and$ $\sigma_{1i}$, $\sigma_{2j}$, $\varphi_{i1,}\varphi_{2i}$, $\emptyset_{1i}$, $\emptyset_{2i}$ for MS3, while $\varepsilon_{1t}$, $\varepsilon_{2t}$, $\varepsilon_{3t}$, $\varepsilon_{4t}$ and $\varepsilon_{5t}$ are the error terms for model 9, 10, 11, 12 and 13 respectively. The summation symbol presents the limit of the lag length adopted in the model. For the lag length criteria test conducted, the optimum lag by all criterial is 1, hence, lag length of 1 is adopted as seen in the models above. The 1+1 captures the T-Y model peculiarity to account for mixed order stationarity of variables.

**GARCH Model**

The GARCH model is employed to generate volatility in exchange rate. Engel and Bollerslev (1986) opined that GARCH model be used to estimate volatility from the log of RER because it is not directly perceived (see also Sugiharti et al. 2020). Gujarati and Porter (2009) put it that the RER at period t depends on a constant value, a one period lag and the error term in time t. This is specified as;

$$RER_t = \propto_0 + \propto_1 RER_{t-1} + \mu_t \quad (12)$$

$$h_t^2 = \delta_0 + \delta_1 \mu_{t-1}^2 + \delta_2 \mu_{t-2}^2 + \cdots + \delta_q \mu_{t-q}^2 + \theta_1 h_{t-1}^2 + \theta_2 h_{t-2}^2 + \cdots + \theta_p h_{t-p}^2 \quad (13)$$

$h_t^2$ denotes conditional variance of μ at period t, influenced by the squared error in the preceding period (ARCH term) and a conditional variance in the preceding period (GARCH term). The GARCH (p, q) model assists to estimate the value of ERV in equation 13. The conditional variance was obtained from equation 12 for equation 13.

**Result and Discussion**

**Stationarity Test**

Using Phillips-Perron (PP) and Augmented Dickey-Fuller (ADF) unit root tests from Table 1, it suggests that the series are stationary at a mixture of I(0) and I(1). The PP test suggests that both IIP and ERV are stationary at levels, while MPR is stationary at first difference. ADF on the other hand suggests both IIP and MPR are stationary only at first difference while ERV is stationary at levels.

**GARCH Model Result**

From Table 2, the estimated mean equation shows that there is a significant average volatility of 13.35 and the past value of ER positively and significantly influence the current ER. The effect of exchange rate volatility is determined by the variance equation of the ARCH terms that are statistically significant which is 0.49. Since the sum is far below 1, the result suggests that shocks to exchange rate is likely to die out rapidly and does not tend to persist. The choice of ARCH model is based on the fact that it produces the best result when compared to other methods judging by the Schwarz criterion (see Appendices 2 - 4).

**Impulse Response Analysis**

**Responses of manufacturing GDP ratio to shocks in ERV, MPR, INF and Money Supply**

Figure 1 presents the impulse response of manufacturing sector to a one standard deviation shocks in RER volatility, interest rate, inflation, and money supply. The result shows that a one-standard deviation shock in ERV elicits decline in manufacturing sector performance for almost all the ten-period points considered. This reveals that exchange rate unpredictability hinders the effective performance of the manufacturing sector in Nigeria. Just like the effects of shocks from ERV on the manufacturing sector, a one-standard deviation shock in inflation also generates a negative response in the manufacturing sector’s performance. The responses of the sector’s performance to shocks in exchange rate volatility and inflation is not surprising, as volatility in exchange rate and uncontrolled inflation create uncertainty in the economy which inhibits profit maximizing economic agent from making effectively sustainable production plans. Opposing to the responses of manufacturing sector to deviations in ERV and INF, it responds positively to one standard deviation in money supply and interest rate. A one standard deviation in money supply and interest rate cause improvement in manufacturing sector’s performance throughout the ten (10) periods considered. The responses of the sector’s performance to shocks in money supply would be expected in an economy with slacks (i.e, economy with underutilized or untapped resources), such that money moves production, but when all resources have been fully utilized, money supply becomes neutral. The Nigerian manufacturing sector capacity utilization is currently below 50% (CBN, 2019), and as such, money supply is expected to stimulate more output in that sector. Contrary to the classical prediction of negative effect of rising interest rate on output, the manufacturing sector responds positively to shocks in interest rate throughout the ten months periods. This result is however supported by Keynesian assertion that it is anticipated income that drives investment and not interest rate. It was argued that high interest rate could attract more investment if the anticipated returns on investment outweighs the cost of the capital.

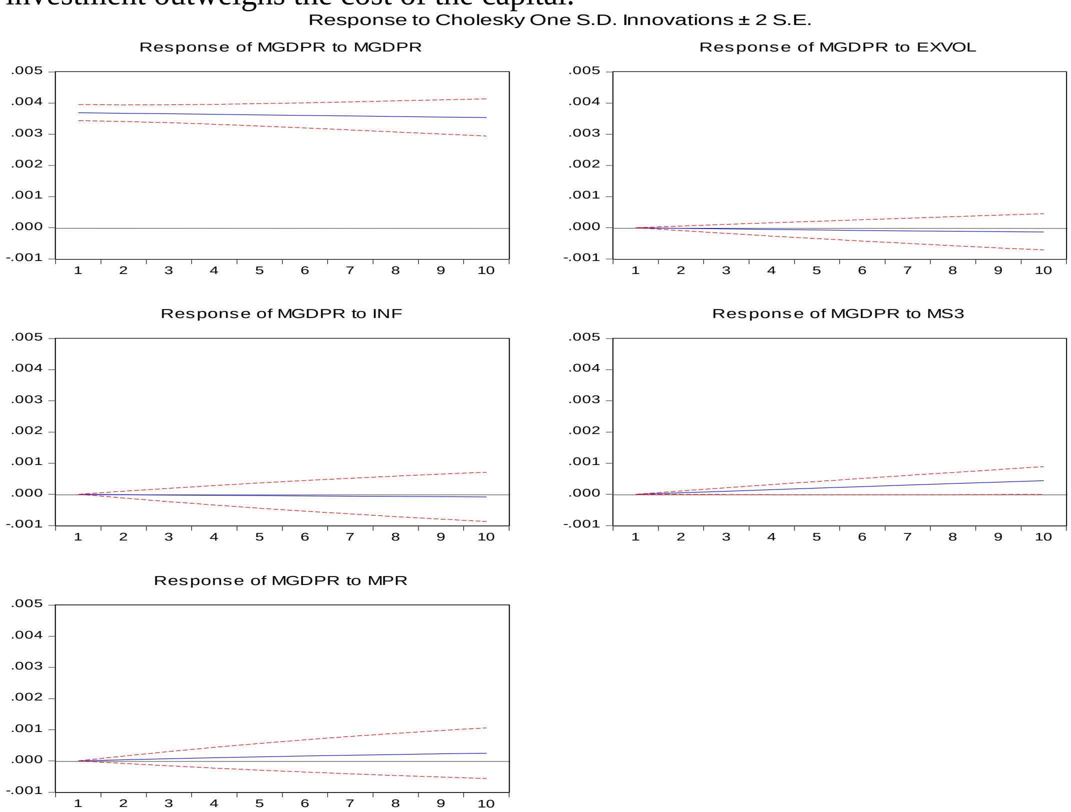


**Figure 1: Responses of manufacturing GDP ratio to shocks in ERV, MPR, INF and Money Supply (M3)**

## Variance Decomposition

Variance decomposition of output (MGDPR) as presented in Table 3 reveals that own shocks accounted for total (100 percent) variation in output in the first month declining slightly to 99.49 percent, 97.37 percent and 92.51 percent in the $4^{th}$, $7^{th}$ and $10^{th}$ months respectively. ERV also reveal a 3month lag between the period of first volatility shock and adjustment in manufacturing sector's performance in Nigeria. ERV accounted for variation in manufacturing sector performance in the 4th month by 0.28 percent and later increased to 0.93 percent and 1.78 percent in the 7th and 10th months respectively. This result reveals that the influence of ERV on manufacturing sector in Nigeria grows over time and could be considered endogenous to the model and as such the effect present volatility in exchange rate might extend into a foreseeable future. Similar to ERV, interest rate (MPR), money supply (M3), and inflation (INF) has a lag of three months and thereafter account for about 0.003 percent, 0.096 percent and 0.532 percent variation in the performance of the manufacturing sector percent in the 7th and 10th months respectively for MPR, 0.008 percent, 0.021 percent, and 0.031 percent for inflation, and 0.22 percent, 1.577 percent and 5.155 percent for money supply. These show that like ERV, the effect of MPR, M3 and INF on manufacturing sector grow overtime in the model.

**Post-estimation Test Results**

The null hypothesis of no auto-correlation in the model is not rejected given the LM-stat and the probability values at 1st, 2nd, and 3rd lags as shown in Table 4. Probability value greater than 0.05 implies null hypothesis of no auto-correlation should not be rejected at 5 percent level in the model. Judging by the probability value greater than 0.05 at each of the lags, it is safe to imply that there is no auto-correlation in the model. The parameter stability test in Figure 2 shows the model is stable within ±1 bound.

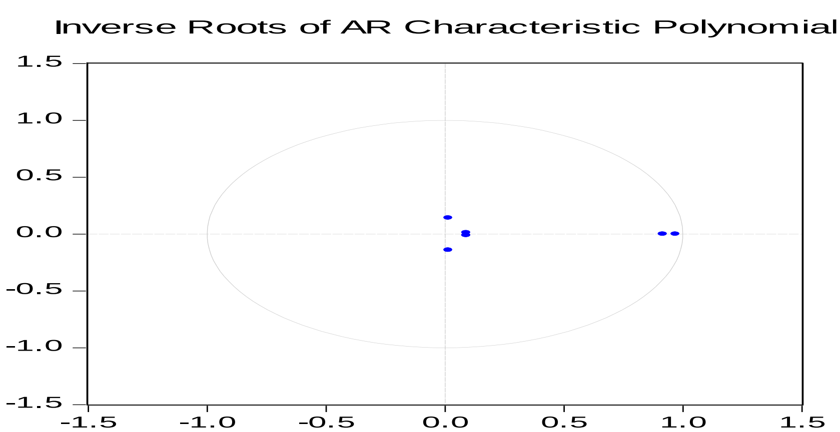


**Figure 2: Parameter Stability Test**

## Conclusion and Policy Recommendations

The study empirically examined the effect of ERV on manufacturing sector performance in Nigeria between 1986M1 and 2018M12 with the objectives of identifying the responsiveness of the manufacturing sector performance to shocks from ERV. In other to capture the dynamic linkages between the variables of interest, vector auto-regressive (VAR) model was adopted, but the stationarity properties of the series {mixture of I(1) and I(0)} informed the specification of the model in Toda-Yamamoto (T-Y) form.

From the estimates, the impulse response shows that the manufacturing sector responds negatively to ERV, indicating that exchange rate unpredictability might be deleterious to manufacturing sector's performance in Nigeria. The variance decomposition also reveals that ERV and interest rate takes a lag of three months before affecting output and have a modest impact on manufacturing sector performance. From these findings, the following recommendations are made:

i. The monetary authority should interfere moderately in the foreign exchange market to mitigate against ERV in the country. This is expected to reduce uncertainty in exchange rate that might affect producers who import most of their raw materials. Foreign currency should be provided at a stable rate with minimum effort to manufacturers whose raw materials are mostly imported pending the availability of local substitutes. This will help minimize uncertainty in the foreign exchange market and risks associated with it.

ii. Finally, given the observation that interest rate plays an important role in the performance of the manufacturing sector in Nigeria, it is recommended that, beyond maintaining exchange rate stability, a low and stable interest rate should be adopted. This is because findings reveal that a positive shock to interest rate reduces the performance of the manufacturing sector.

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**Appendix**

**Table 1: Stationary Test**

| | ADF | | PP | | |
|---|---|---|---|---|---|
| variables | l(0) | I(1) | l(0) | I(1) | I(d) |
| EXVOL | -2.203 | -20.280 | -2.203 | -20.278 | I(1) |
| MGDPR | -1.717 | -20.133 | -1.717 | -20.133 | I(1) |
| MPR | -3.019 | -20.101 | -2.925 | -20.101 | I(0) |
| MS3 | 4.591 | -21.202 | 2.868 | -3.441 | I(1) |
| INF | -2.661 | -20.100 | -2.584 | -20.100 | I(0) |

*****, **, *** represent significance at 1%, 5% and 10 % respectively.

**Table 2: ARCH Model Result**

| Dependent Variable: ER | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| C | 13.351 | 0.120 | 110.882 | 0.000 |
| ER (-1) | 0.136 | 0.008 | 17.684 | 0.000 |
| | | Variance Equation | | |
| C | 14173.00 | 2027.36 | 6.99 | 0.00 |
| RESID(-1)^2 | 0.49 | 0.29 | 1.69 | 0.09 |
| RESID(-2)^2 | 0.01 | 0.01 | 0.55 | 0.58 |
| RESID(-3)^2 | 0.00 | 0.00 | -5.84 | 0.00 |
| T-DIST. DOF | 2.00 | 0.00 | 261252.40 | 0.00 |
| R-squared | 0.019 | Mean dependent var | | 31.28 |
| Adjusted R-squared | 0.016 | S.D. dependent var | | 170.94 |
| S.E. of regression | 169.541 | Akaike info criterion | | 2.34 |
| Sum squared resid | 11267643.000 | Schwarz criterion | | 2.41 |
| Log likelihood | -453.382 | Hannan-Quinn criterion. | | 2.36 |
| Durbin-Watson stat | 1.932 | | | |

**Table 3: Variance Decomposition of MGDPR**

| Months | MGDPR | EXVOL | INF | MS3 | MPR |
|---|---|---|---|---|---|
| 1 | 100.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | 99.490 | 0.275 | 0.008 | 0.224 | 0.003 |
| 7 | 97.374 | 0.931 | 0.021 | 1.577 | 0.096 |
| 10 | 92.511 | 1.770 | 0.031 | 5.155 | 0.532 |

**Table 4: Auto-correlation Test**

| Lags | LM-Stat | Prob |
|---|---|---|
| 1 | 3.571 | 1.000 |
| 2 | 7.808 | 0.954 |
| 3 | 3.843 | 0.999 |

**Table 5: Heteroscedasticity Test**

| Chi-sq | df | Prob. |
|---|---|---|
| 298.8015 | 240 | 0.0058 |

**Table 6: Lag Criteria**

VAR Lag Order Selection Criteria

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -5305.6 | NA | 143000000.0 | 27.3 | 27.3 | 27.3 |
| 1 | -4360.4 | 1870.9* | 1163328.* | 22.5* | 22.6* | 22.5* |
| 2 | -4355.8 | 9.1 | 1189814.0 | 22.5 | 22.7 | 22.6 |
| 3 | -4355.2 | 1.1 | 1242484.0 | 22.5 | 22.9 | 22.7 |
| 4 | -4347.4 | 15.2 | 1249695.0 | 22.6 | 22.9 | 22.7 |
| 5 | -4346.5 | 1.7 | 1302928.0 | 22.6 | 23.1 | 22.8 |
| 6 | -4346.1 | 0.7 | 1362076.0 | 22.6 | 23.2 | 22.9 |

**Table 7: GARCH Model**

Dependent Variable: EXCHVOL

GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.689 | 0.001 | 496.613 | 0.000 |
| EXCHVOL(-1) | 0.956 | 0.000 | 9729.138 | 0.000 |
| | | Variance Equation | | |
| C | 5E-06 | 1E-06 | 4E+00 | 0E+00 |
| RESID(-1)^2 | 1E+00 | 1E-01 | 1E+01 | 0E+00 |
| GARCH(-1) | 7E-06 | 9E-06 | 8E-01 | 4E-01 |
| T-DIST. DOF | 2.412 | 0.047 | 50.985 | 0.000 |
| R-squared | -0.606 | Mean dependent var | | 31.280 |
| Adjusted R-squared | -0.611 | S.D. dependent var | | 170.938 |
| S.E. of regression | 216.930 | Akaike info criterion | | 0.831 |
| Sum squared resid | 18446994.000 | Schwarz criterion | | 0.892 |
| Log likelihood | -157.750 | Hannan-Quinn criter. | | 0.855 |
| Durbin-Watson stat | 2.810 | | | |

**Table 8: E-GARCH**

Dependent Variable: EXCHVOL

LOG(GARCH) = C(3) + C(4)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(5) *RESID(-1)/@SQRT(GARCH(-1)) + C(6)*LOG(GARCH(-1))

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 15.453 | 0.020 | 770.879 | 0.000 |
| EXCHVOL(-1) | 0.000 | 0.001 | 0.041 | 0.967 |
| | | Variance Equation | | |
| C(3) | 1.513 | 0.702 | 2.156 | 0.031 |
| C(4) | 2.549 | 4.141 | 0.616 | 0.538 |
| C(5) | -2.514 | 4.131 | -0.608 | 0.543 |
| C(6) | 0.648 | 0.063 | 10.310 | 0.000 |
| T-DIST. DOF | 2.001 | 0.001 | 1930.147 | 0.000 |
| R-squared | -0.009 | Mean dependent var | | 31.280 |
| Adjusted R-squared | -0.011 | S.D. dependent var | | 170.938 |
| S.E. of regression | 171.888 | Akaike info criterion | | 1.864 |
| Sum squared resid | 11581846.000 | Schwarz criterion | | 1.934 |
| Log likelihood | -360.138 | Hannan-Quinn criter. | | 1.892 |
| Durbin-Watson stat | 1.665 | | | |

**Table 9: GIR-GARCH**

Dependent Variable: EXCHVOL

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 14.379 | 0.001 | 12572.410 | 0.000 |
| EXCHVOL(-1) | 0.075 | 0.000 | 1155.460 | 0.000 |
| | | Variance Equation | | |
| C | 2E-05 | 3E-05 | 7E-01 | 5E-01 |
| RESID(-1)^2 | 8E-01 | 1E+00 | 6E-01 | 6E-01 |
| RESID(-1)^2*(RESID(-1)<0) | 4E+01 | 7E+01 | 6E-01 | 6E-01 |
| GARCH(-1) | 5E-02 | 1E-02 | 5E+00 | 0E+00 |
| T-DIST. DOF | 2.044 | 0.081 | 25.335 | 0.000 |
| R-squared | 0.011 | Mean dependent var | | 31.280 |
| Adjusted R-squared | 0.009 | S.D. dependent var | | 170.938 |
| S.E. of regression | 170.194 | Akaike info criterion | | 0.574 |
| Sum squared resid | 11354728.000 | Schwarz criterion | | 0.645 |
| Log likelihood | -106.118 | Hannan-Quinn criterion. | | 0.602 |
| Durbin-Watson stat | 1.811 | | | |