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EFFECT OF MACROECONOMIC POLICY ON INDUSTRIAL SECTOR PERFORMANCE IN NIGERIA (1981-2016)

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ABSTRACT

Macroeconomic policy and industrial sector performance have been at the centre of economic discourse in recent times. The general assumption is that macroeconomic policy instruments can enhance performance of the real sector. We examined the short and long run effects, of specific policy instruments combination, on each industrial sub-sector by decomposing industry into three major parts. The nonlinear ARDL bound test approach to co-integration is employed as estimation technique. It was found that a long-run bound relationship exists between selected policy variables and each industrial sub-sector. Error correction terms show that short run disequilibrium can be corrected in the long run without extended lag period. Financial deepening, exchange rate depreciation and economic openness are significant in the long run while monetary policy rate is effective in the short run. Deepening of financial system and prudential management of macroeconomic framework are recommended essential for industrial growth in Nigeria.

Keywords: Macroeconomic policy, Performances, Industrial sub-sectors, Bound relationship, Asymmetric effects, Nonlinear ARDL, Nigeria.

INTRODUCTION

Macroeconomic policy and industrial sector performance are two separate phenomena in economics; one probably can complement the other. While industrial sector might be a channel to achieve macroeconomic policy objectives, macroeconomic policy, on the other hand, can set the path to develop industrial sector. In many economies, the performance of industrial sector is the gauge for assessing the effectiveness of macroeconomic policies (Mordi *et al*., 2014). In other words, industrial sector could represent appropriate outcome or target of macroeconomic policy via certain specific transmission channels which invariably fall under three major subsets of macroeconomic policy. These include monetary, fiscal and trade policies.

While monetary policy transmission channels include the interest rate channel, the credit channel, and the exchange rate channel (Mishkin, 1995; Ndekwu, 2013), fiscal policy comprises taxation, government expenditure, balanced budget etc., (Musgrave, 1983). Trade policy in addition, includes net export, tariff and also exchange rate. Although the list of policy instruments representing macroeconomic policy may be endless, nevertheless, the behavioral characteristic of a particular policy instrument in association with others might be relevant to the performance of a specific industrial sub-sector, signaling critical examination. This means there may be specific policy combination appropriate for a particular sub-sector of industry. In this study, specific instruments to be evaluated cover monetary, fiscal and trade policies. It is theorized that the trio can influence growth, not only in the industrial sub-sectors, but also in the entire real sector. The fact is that the duty of macroeconomic policy making solely rests upon government and the apex bank while the implementation responsibility rests on government agencies.

That industrial development is necessary for growth and development to occur is not in doubt. However, development should lead to reduction in poverty, unemployment, and income inequality. Industrial sub-sectors are to generate employment and improve economic capacity of the average citizens of the nation. In the global world, it can help bridge the wide trade gap between developed and developing countries, (Adenikinju & Olofin, 2000; Bird, 2001). A vibrant and productive industrial sector creates more linkages in the economy and promotes internal and external balances (Mordi *et al*., 2014).

In Nigeria, since independence, industrial policies have been tagged under import substitution industrialization (ISI) or export promotion industrialization (EPI). Historically, to sustain the two core policy plans (ISI & EPI), Nigeria adopted duty draw-backs, tariff adjustment, embargo, interest-free credits or credit directives and exchange rate concessions. In spite of these policy thrusts, statistical facts have shown that industrial sector has contributed sub-optimally to Nigeria's gross domestic product (GDP) (Adejugbe, 2006; Ekpo, 2004). It is surprising to discover that while seeking policy solution to address industrial sector performance in Nigeria, some crucial aspects of macroeconomic policy instruments, (such as monetary, fiscal and trade policy instruments) are yet to be adequately employed.

A BRIEF EXCERPT ON THE NIGERIAN INDUSTRIAL SUB-SECTORS AND MACROECONOMIC POLICY

Although, the International Standard Industrial Classification (ISIC) groups industry under various divisions and sub-divisions, the Central Bank of Nigeria (CBN) and the National Bureau of Statistics (NBS) divide the real sector into five broad sectors each of which comprises other sub-sectors. These include Agriculture, Industry, Building & Construction, Wholesale & Retail and Services. However, this paper focuses on industrial sector which consists of three major sub-

sectors: Manufacturing, Crude Petroleum & Natural Gas and Solid Minerals. In the previous literature, the focus of analysis has been mainly on manufacturing sub-sector with meagre consideration given to solid minerals. On the other hand, crude petroleum/natural gas is assumed the main stay of the economy. Performance of the sub-sector is presumed exogenous, therefore, productivity and efficiency are implicitly committed to foreign operators. Consequently, most research studies on these sub-sectors are basically done with little consideration for domestic factors like appropriate macroeconomic framework for revenue maximization; inclusive functional local content and maximization of Nigerians participation.

In addition, the Nigeria's solid minerals, to mention a view, include limestone, iron ore and tantalite. The solid minerals sub-sector looks practically unorganized and few private companies such as Dangote Group and Portland Cement seems to be dominant players. It appears most mineral ores are explored by unorganized private individuals trying to eke out a living. The result is the insignificant contribution of solid minerals to the gross domestic product (GDP). Although, there are few dominant multinational companies, the CBN statistical facts show that capacity utilization in the manufacturing sub-sector is very low and this is worsened by poor infrastructure and high cost of inputs driven by high exchange rate. Consequently, manufacturing contribution to the growth of GDP is very low and has been declining for about a decade. Table 1 below illustrates the summary of industrial sub-sector's contribution to GDP growth rate.

Table 1: Industrial Sub-Sector, Growth Rate of GDP (%)

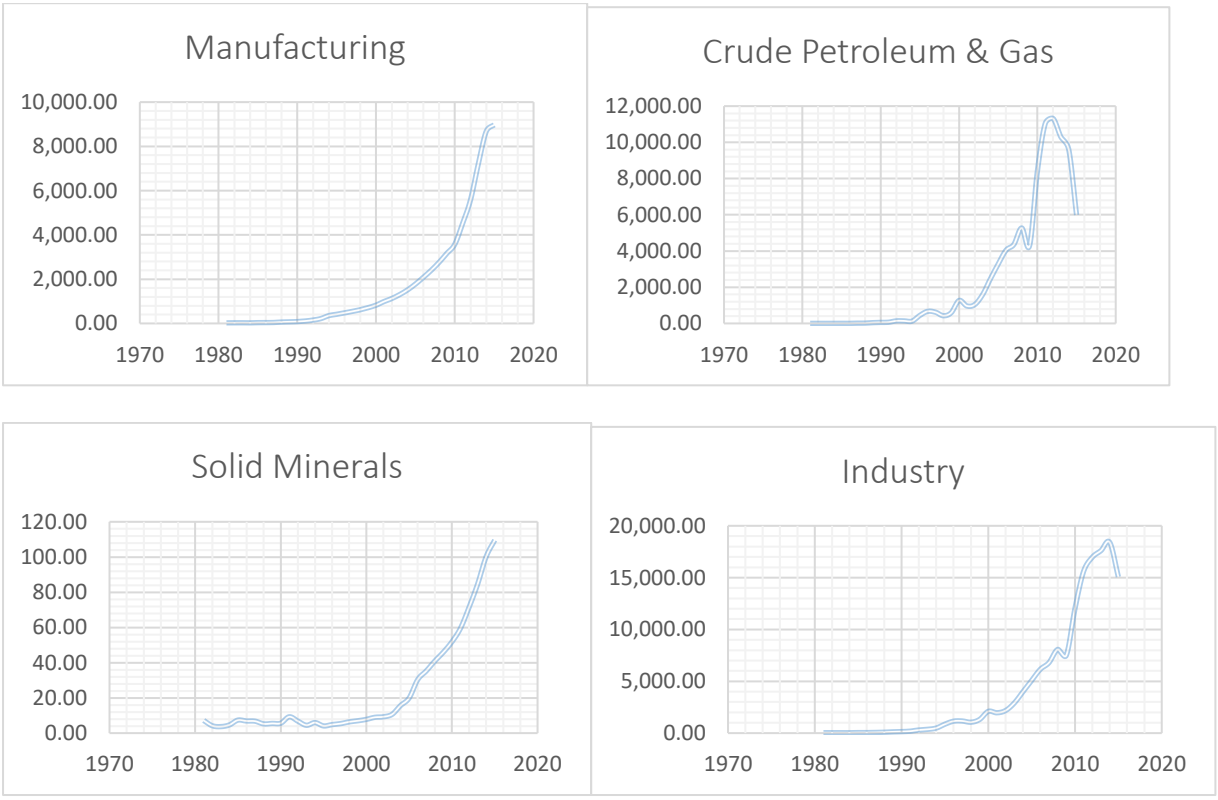
Year	2011	2012	2013	2014	2015
Industry	7	1.2	-0.1	6	-3.4
Crude Petroleum	2.3	-5	-13.1	-1.3	-5.5
Solid Minerals	14.5	19.7	16.5	14.9	7.7
Manufacturing	17.8	13.5	21.8	14.7	-1.5

Source: *CBN Annual Report, 2015*

From table 1, industrial output growth rate is 7% in 2011. The rate decreases to 1.2% and -0.1% in 2012 and 2013 respectively. Yet, an abysmal performance of -3.4% is recorded in 2015. The crude petroleum sub-sector performance with respect to GDP growth rate is negative from 2012-2015. This suggests crude petroleum might not necessarily be of great advantage to the Nigerian economy so far the country engages in export of crude product without much thought to value addition. Also, the solid minerals sub-sector's GDP growth rose from 14.5% in 2011 to 19.7% in 2012 and then decreases from 16.5% in 2013 to 14.9% and 7.7% in 2014 and 2015 respectively. Manufacturing contribution falls from 17.8% in 2011 to -1.5% in 2015. These poor performances appear to have constituted the major reasons for industrial stunted growth and consequent diminishing contribution to GDP growth rate.

There must be a way out. Although there have been varied policies in the past to address the performance of the aggregate sector, but these policies achieved poor results probably because they were mostly industrial or direct government control policies. Therefore, this study attempts empirical study of short run and long run relationships between macroeconomic policy instruments and industrial sub-sectors with the objective to establish which instruments combination would be optimal for a specific industrial sub-sector.

Figure 1: Trends in Nigerian Industrial Sub-Sectors, 1981-2016



Source: *CBN Statistical Bulletin & NBS, Various Issues*

Figure 1 illustrates trends in the Nigerian industrial sub-sectors from 1981 to 2016. Manufacturing and solid minerals show gradual upward movement with some structural breaks. In spite of these, the two sub-sectors' contribution to GDP is very low probably the result of low capacity utilization and small scale mining technique. Crude petroleum/natural gas shows a downward movement from year 2011 probably the result of negative volatility in the industry arising from endogenous factors which cause decrease in production and export. The aggregate industry output starts falling in year 2013 maybe as a lag response to fall in crude oil. This negative trend describes further the abysmal state of the sector.

Table 2: Active Sectors Composition of GDP at 1990 Constant Basic Price (% of Total, 1981-2015)

Year	Total (GDP), (N'Billion)	Agriculture	Industry	Building & Construction	Wholesale & Retail Trade	Services	Manufacturing	Total
1981-1986	244.4	36.8	28.5	1.9	14.6	13.2	5.1	100.0
1987-1993	309.1	39.6	26.8	1.4	14.2	11.9	6.2	100.0
1994-1998	366.3	40.9	27.0	1.3	13.6	13.3	3.9	100.0
1999-2007	500.4	41.9	24.5	1.5	13.6	14.8	3.7	100.0
2008-2016	830.2	40.1	14.9	2.1	19.5	19.3	4.1	100.0

Source: *Author's computation based on data obtained from the NBS & CBN*

Sectoral Performance Under Various Policy Regimes in Nigeria

1981-1986

Table 2 shows percentage contribution of major sector to GDP in Nigeria under various policy regimes. The years 1981-1986 were period of economic control. Manufacturing sub-sector contributed relatively low value of

5.1% to the GDP compared with agriculture, industry, wholesale & retail and services which contributed 36.8%, 28.5%, 14.6% and 13.3 respectively. However, building and construction made the lowest contribution of 1.9%. The low performance of agriculture may be due to high cost of intermediate goods arising from high exchange rate. Low capacity utilization is also a significant factor (Adenikinju and Olofin, 2000; Adeoye, 2004; Loto, 2012). The seemingly robust percentage value of industry was driven by crude petroleum and natural gas which is one of the major GDP components till today. The major agriculture policy variable in the regime was the Operation Feed the Nation (OFN) which received wide acceptance. Towards OFN success, the NBS reported over 5% of government budget was invested in agriculture and related industries including importation of inputs and heavily subsidized agro-allied industries.

1987-1993

This was the economic deregulation regime. Deregulation of the entire economy was a response to the condition laid down by foreign creditors. Performance of agriculture rose during the period. The key programme was the Structural Adjustment Programme (SAP) aimed at curtailing the adverse balance of payments deficits. With an average increment of 7.61% over the previous regime, agriculture seemed to have maintained its position in food supply and raw material provision to infant/small and medium scale industries, (Gockowski and Oduwole, 2001) and (Fashola (2005). The 6.2% manufacturing contribution is an increase of 21.57% over the previous regime, probably an improvement driven by SAP. Government policy mix of import substitution and export promotion, coupled with liberalization, deregulation and self-reliance ensured a rise in manufacturing performance from 5.1% in 1981-1986 to 6.2% in 1987-1993. However, one notices the ambiguity of "Kaldor-Verdoorn's law" in this regime. The law states that growth of manufacturing could be a catalyst to economic growth through sectoral growth nexus. However, from the table though manufacturing contribution to GDP rose by 21.5%, other sectors (apart from agriculture) recorded decrease contribution. Building & construction, wholesale & retail and services recorded decline of 29.32%, 2.75% and 9.85% respective to the past policy period, (1981-1986). Noteworthy is the fact that continuous fall in crude oil & gas price at the international market drove industrial contribution from 28.5% to 26. 8% in the current regime.

1994-1998

The period 1994-1998 was another regulated regime in Nigeria. Policy was based mainly on whims and caprices of "Mr. President". Trade restrictions and incompatibility of trade policy with economy reality ensured manufacturing fell in a wide margin of 37.1% from the last period. For instance, manufacturing statistics for the period revealed a downward movement while agriculture recorded marginal increase. In addition, average composition of agriculture rose from 39.6% (1987-1993) to 40.9% (1994-1998) while manufacturing decreased from 6.2%-3.9%. The lost in employment in manufacturing sector was probably responsible for the shift in services composition from 11.9% to 13.3% as services appeared to have absorbed the unemployed in the manufacturing sub-sector. Decrease performance of 7.14% and 4.23% respectively were recorded in building & construction; and wholesale & retail.

1999-2007

This study particularly tags this period pre-global economic meltdown. It ushered in a new civilian government with great expectations. Consolidation of macro economy was embedded in liberalization, commercialization and consolidation policies. In spite of these efforts to salvage the poor economy, manufacturing performance decreased further by 5.13% from 3.9% to 3.7%; but agriculture continue to show upward improvement, rising by 2.44% from 40.9% to 41.9% However, effect of policy on other sectors is ambiguous, while industry performance decreased from 27.0% to 24.5%, building & construction and services recorded improved performance even though there was decrease in manufacturing output. The decline in industry appeared to be consequent fall in manufacturing component owing to global downward trend in the trade cycle. In the neoclassical growth model, Wagner's law and Kaldoor-Verdoorn' law, linear relationship subsists between manufacturing and economic growth and the transmission mechanism are by employment and sectoral output growth. These dual roles can generate reverse causality and may invalidate policy thrusts. Yet, Nnanna, Alade, and Odoko, (2003), on the other hand, warned policy reversal might occur if characterized by poor implementation.

2008-2016

This period represents post-global economic melt-down. Policy agenda included consolidation of macro economy, empowerment of economic agents and producing firms. Increase in manufacturing contribution from 3.7% to 4.2% coincided with 30.41% rise in services. Economists believed the gradual economic recovery might have emanated from increase crude oil prices and efficient macroeconomic management. Wholesale & retail; building & construction recorded 29.17% and 40% rise respectively in the period. A fall in industry from 24.5% to 15.1%; that is a decrease of 38.37%, obviously was below policy objectives. Nevertheless, Nigerian the nominal GDP continued to rise as indicated by the per capital income increase. This may relate with the neo-classical Solow growth theory which postulates that increase in population increases labour force and aggregate production.

LITERATURE REVIEW

Empirical Literature

There are quite a good number of studies analyzing the effects of macroeconomic policies on industrial sector performance. Several studies address the poor growth syndrome in the industrial sector and how policy can create a change. Observation made revealed that while some authors focus on industrial aggregate or manufacturing, others isolate effect of one policy instrument from another, whereas, policies are formulated concurrently to address diverse economic sectors. We noted that while some authors focus on either fiscal or monetary policy, others are on trade policy. In other words, simultaneous or joint effects of combination of policies on industry are neither explored nor painstakingly examined in previous literature. In Nigeria, key instruments like tariff and direct government control of key macroeconomic variables such as interest rate and credits have been suggested (Adewuyi & Bankole, 2007; Nnanna *et al*., 2003). Other authors have recommended strict import substitution industrialization (ISI) and export promotion industrialization (EPI). However, these policies often do not yield optimal solution. Besides, noticeable in the previous studies is the isolation of one policy from another. This might generate bias and reduces dynamics of policy instruments (Afangideh & Obiora, 2004; Mordi, 2014; Ndekwu, 2013). A combination of policy instruments eliminate bias and incorporates more reliable parameter estimates. In other words, the intricacies of having suitable policy instruments co-integrating with other instruments in an optimal growth-inducing manner is often neglected in the previous studies. The use of manufacturing as the only proxy variable for industrial sector

is also common in previous literature (Adenikinju and Olofin (2000); Adejugbe (2006); Adewuyi and Bankole (2007). Manufacturing alone might be inadequate because industry also comprises solid minerals and crude petroleum/natural gas sub-sectors. Therefore, this study uniquely focuses on the effect of macroeconomic policy instruments on each industrial sub-sector. It intends to derive optimum combination of policy instruments, largely under the deregulated regimes in Nigeria, with a view to address and achieve feasible industrial sub-sector growth in both short and long runs.

For instance, Hayo and Uhlenbrock (2000); Dedola and Lippi (2000); Raddatz and Rigobon, (2003); and Ghosh (2009) have examined the industrial effects of monetary policy shocks. These papers find considerable cross-industry heterogeneity in the impact of monetary policy. Hayo and Uhlenbrock examine the effect of monetary policy shock on the individual industrial sub-sector in the United Kingdom and Germany respectively. Ghosh carried out similar work for India. They found that while some industries exhibit significant positive responses to macroeconomic variables, few, which include clothing, food, mining, and oil refining industries show negative responses. In another findings, Makin, (1982); Mishkin, (1982); Peersman and Smets (2005) and Ghosh (2009) observed that differences in the degree of asymmetry of policy effects appear to be related to diversities in financial structure, particularly, the maturity structure of debt, financial leverage, the coverage ratio, firm size and financial accelerator variables.

With respect to fiscal policy, the effectiveness has a mixed record in Russia and Mexico. For instance, In Russia, Spilimbergo (2007) descriptive analysis showed that budget policy has not contributed to the increase in average demand since 2003 but fiscal position, to some extent has been tight enough to contain the inflationary effect of the exceptional oil windfalls for the economy as a whole. In Mexico, Ahumada (2009), in a structural and non-structural VAR analysis of the short term effects of government revenue on macroeconomic variables, such as output and prices, observed that a fall in public sector revenues raises output and prices on the one hand, but causes adverse trade balance on the other. Angelopoulos and Philippopoulos (2007) found in Greek economy that high public spending may hamper growth but most important is the composition and quality as well as the efficiency of the public sector. Inferences drawn from this review suggest the seemingly ambiguity of the effects of macroeconomic policy instruments may sometimes prompt economic agents to set their priorities on neutral anticipation thereby implicitly alienate the much required synergy to commit to rapid economic development.

Few literature have also attempted examination of mixed macroeconomic policy instruments effects on output, but these focus mainly on manufacturing sub-sector and isolate trade policy instruments. For example, Argy and Salop (1979), Laumas (1991), Nas and Odekon, (1996) attempted investigation of both monetary and fiscal policies effects on industrial output. While some of them focus on manufacturing sector as proxy for industry, others center on multi-sectoral analysis. The major innovation of Laumas (1991) paper is to jointly estimate the effects of anticipated and unanticipated effects of monetary and fiscal policies on real output. These studies confirm previous author's finding asymmetric effects of macroeconomic policy on industrial sector. However, while Laumas study tends to reject the hypothesis that discretionary macroeconomic policies are ineffective in affecting industries output growth, Argy and Salop findings confirm similar outcome but their studies provides more analytical impact of fiscal policy instruments.

In Africa and other developing countries, there are empirical works of Andlib, Khan and Ul Haq (2012); Alam and Waheed (2011). Employing VAR method of estimation, they discover manufacturing respond significantly to macroeconomic policy. In addition, a weak coordination subsists among the policy makers since there is weak response of monetary shock

to fiscal variables and vice versa. They suggest a more coordinated approach among the policy makers to stabilize the entire economy and to insulate it from external shocks. In addition, a panel analysis of seventeen African countries include the work of Adenikinju & Olofin (2000) and Adewuyi and Bankole (2007). These center on impact of government policy on economic efficiency. The reveal that in the selected African countries cost effects of devaluation offset positive impact that may arise as a result of increase competitiveness. Openness index has an insignificant effect on the growth of manufacturing sector. They suggest minimum government spending which can promote manufacturing growth by opening them to competition.

In Nigeria, several studies have also examined the effects of macroeconomic policies on the industrial sector. While most of these studies focus on the effects of policies on manufacturing sub-sectors, only few address other subsectors of industry. In addition, it appears none has examined each sub-sector in relation to macroeconomic policy-mix. Critical effects of combined macroeconomic policy instruments on each industrial sub-sector are yet to be painstakingly examined. Some of these studies include (Adebiyi, 2004; Adebiyi & Dauda, 2004. Others in this context are (Owolabi & Adegbite, 2014; Mordi *et al*., 2014; Osinowo, 2015; Musa, 2016). For instance, Adebiyi and Dauda examined the impact of trade liberalization policy on the index of industrial production in Nigeria spanning 1973-2001 in an error correction model (ECM). Their study shows that trade liberalization policy can play significant role in promoting industrial performance in Nigeria.

On the contrary, Osinowo study, which employ ARDL and error correction methods, reveals that fiscal expenditure positively contributes to all the sectors' output except agriculture. He notes disparity in the sectoral responses to fiscal policy instruments underlines the challenges in conducting even and economic extensive fiscal policy in Nigeria and suggests "best policy approach is to adopt sector specific policy based on their relative strength and significance in each sector of the economy within the overall fiscal policy mechanism framework". The Musa's VAR analysis of combine effects of fiscal and trade policies on manufacturing conclude a mix-effects of policy instruments on manufacturing sector in Nigeria. Conclusion drawn from the literature above reveals a mixed effects of policies on the real sector. That is effectiveness of policy instruments depends on existing macroeconomic conditions. Moreover, the significant relationship effects of a variable may depend on optimal combination with other variables.

THEORETICAL LITERATURE

Macroeconomic Policy and the Real Sector

While macroeconomic policy and industrial sector might be separate entities, the underlying linkage between the two is not unconnected with manipulation of policy instruments to boost aggregate production in the real sector. The Mundell-Fleming model, Mundell (1960); Mundell (1963) and Fleming (1962), explains the link between exchange rate/interest rate and the real sector. The theory postulates that effectiveness of the two policy instruments depends on the extent of capital mobility and domestic macroeconomic conditions. In summary, literature connecting policies and industrial sector comes with several concepts to explain reasons why government might employ mixture of policies at her disposal to improve the real sector performance. Some of these are discussed below.

Timbergen (1952) and Stiglizt, (1996) have postulated the importance of policy on the macroeconomic variables. Timbergen classifies some economic quantities either as targets or instruments. He explains policy makers can control instruments, (interest rate) directly to meet a target, (inflation) or any macroeconomic indicator. In a different observation, Stiglizt (1996) reiterates a stable competitive macroeconomic environment is comparable to having a plane's engine run in full power before take-off. More essentially, government macroeconomic policies involve provision of enabling environment for unhindered economic activities (Nnanna *et al*., 2003). Following this is the development of industrial sector which is expected to lead to economic growth and development. Therefore, the environment can serve as aid to effectiveness of policy and enhances the smooth transmission mechanism between policy and the real sector. Really, the business environment and economic policy of the government play a crucial role in the performance of industry (Fakiyesi, 2000; Ali, Irum, & Ali, 2009).

Policy Instruments and the Real Sector

Traditional theory of monetary policy states that an increase in money supply, ceteris paribus, will lead to a fall in interest rate and increase investment. However, the financial accelerator hypothesis of Mckinnon (1973) and Shaw (1973) differs. The authors claim that interest rate and exchange rate deregulation induce investment via financial instruments availability, and the reason for underdevelopment is insufficient financial instruments to attract savings and investment. In addition, they argue that capital accumulation is limited by the availability of investible funds. On the one hand, Gertler (1989) and Mordi *et al*. (2014) assert that monetary policy will have larger output effects in a recession than in a boom. In addition, Peersman, and Smets, (2005) maintain that financial structure can explain why some industries are relatively more sensitive to monetary policy changes in recession versus inflation. These assertions give us the idea of relevance of monetary policy instruments as a bridge or transmission channels between the real sector and policies.

Fiscal policy includes government expenditure, tax revenue and balance budget, while trade policy comprises economic openness, net export and exchange rate. When government increases spending, especially on capital projects like roads and electricity, cost of production reduces and industrial production as well as employment increases, (Okafo, 2012; Ali, Ahmad & Khalid, 2010). Similarly, if government reduces personal income tax, consumer purchasing power increases and demand for industrial production rises. However, the classical economists postulated that government spending has the potential to "crowding out" the private sector, although the sector is assumed to be the engine of growth. This mean that potential investors or industry owners will have to contend with government for fund in the open market. Romer (1989) and Piazolo (1995) suggest government consumptions may disrupt the smooth running of the market leading to inefficient allocation of resources. Contrariwise, Keynesian economics and public choice theories advocate government has a role to play in an economy (Buchanan & Tullock, 1962; Arrow 1963). Meanwhile, in the context of international trade, exchange rate is the principal determinant of price of imported goods. It could be fixed or floated but once floated, it becomes an important component in the transmission mechanism (Krugman & Taylor, 1978; Lipschitz, 1979). The more open the economy, the greater the importance of exchange rate in the policy process, and the more its feasibility as a policy instrument, (Akano & Adebiyi, 2012). Also, government can use tariff to protect domestic infant industries, it can grant relatively open economy via low tariff and free mobility of capital and resources. However, good governance requires sound economic management which include resistance of totally unguided or unregulated economic openness.

Model Specification[1]

[1] Model specification emerges from the detail theoretical framework equation 1-22 in the appendix 1.

The models developed in this study follow previous authors' literature and theoretical framework as discussed in the appendix. The Ali *et al*. (2009) and Ali *et al*. (2010) autoregressive distributed lag (ARDL) model are augmented to include asymmetric effects of volatile variables stated in the equations. An innovation in this study is the introduction of non-linear auto regressive distributed lag (NARDL) model propounded by Shin *et al*. (2013). The broad process follows Shin (1998), Pesaran *et al*. (2001) and Shin, *et al*. (2009). It begins with the asymmetric co-integrating regression:

$$\mathrm{Y}_t = \alpha^+ X_t^+ + \alpha^- X_t^- + \mu_t \qquad (1)$$

where α^+ and α^- are the associated long-run parameters while, X_t is a k×1 vector of regressors decomposed as:

$$X_t = X_0 + X_t^+ + X_t^- \qquad (2)$$

X_t^+ and X_t^- are partial sum processes of positive and negative changes in X_t :

Assuming; $RINTR_t\_P = X_t^- = \sum_{i=1}^{r} \Delta X_j^- = \sum_{i=1}^{r} \max(\Delta X_j, 0)$ (3)

$$RINTR_t\_N = X_t^- = \sum_{i=1}^{r} \Delta X_j^- = \sum_{i=1}^{r} \min(\Delta X_j, 0), \qquad (4)$$

Where $RINTR_t$ is the real interest in year t.

The Long Run and Short Run Asymmetric Effects of Macroeconomic Policy Instruments on the Performance of Manufacturing Sub-Sector

The objectives are to examine the long and short run, as well as, asymmetric effects of macroeconomics policy instruments on industrial sub-sectors in Nigeria. Assuming each industrial sub-sector is denoted by ΔY_i, therefore, the asymmetric ARDL model can be set as:

$$\begin{aligned}\Delta Y_t = {} & \delta_0 x + \sum_{i=1}^{r} \delta_1 \Delta Y_{t-i} + \sum_{i=0}^{r} \delta_2 \Delta GOVT_{t-i} + \sum_{i=0}^{r} \delta_3 \Delta EOP_{t-i} + \sum_{i=0}^{r} \delta_4 \Delta M2GDP_{t-i} + \sum_{i=0}^{r} \delta_5 \Delta RINTR_{t-1}\_P_{t-i} \\ & + \sum_{i=0}^{r} \delta_6 \Delta RINTR_{t-1}\_N_{t-i} + \phi_1 Y_{t-1} + \phi_2 GOVT_{t-1} + \phi_3 EOP_{t-1} + \phi_4 M2GDP_{t-1} + \phi_5 RINTR_{t-1}\_P_{t-1} + \phi_6 RINTR_{t-1}\_N_{t-1} + \mu_t\end{aligned} \qquad (5)$$

Equation *(5)* is the non-linear auto-regressive distributed lag (NARDL) model developed in this study to capture the effect of macroeconomic policy instruments on the performance of each industrial sub-sector in Nigeria. The model follows Shin *et al*. (2013) and it is derived from the combination of equations *(22B in the appendix*), *(3)* and *(4)*.

Y represents output of industrial sub-sector and it is the proxy for performance. ΔY_t is change in the growth of output of a particular industrial sub-sector in year t. Fiscal policy is proxied by government capital expenditure (GOVT). For trade policy, the study used economic openness (EOP), as a proxy for degree of openness. EOP is the ratio of exports and imports over output (GDP). For the overall economic effects, financial deepening (M2GDP) which is ratio of broad money supply to gross domestic product (GDP) is employed. The asymmetric characteristics of the equation is defined by the real interest rate (RINTR) where RINTR_P denotes sum of positive changes and RINTR_N denotes sum of negative changes. x is a set of deterministic variables like the constant term and trend. δ_0 represents vector of coefficients of deterministic variables Δ = first-difference operator. r = optimal lag length; μ_t = the residual term. Equation *(5)* is the bound test equation and is dis-aggregated into long run and short run asymmetric error correction (AEC) models for coefficient estimates. Equation *(6)* is the long run model, while *(8)* is the short run model.

$$Y_t = \delta_0 x + \phi_1 Y_{t-1} + \phi_2 GOVT_{t-1} + \phi_3 EOP_{t-1} + \phi_4 M2GDP_{t-1} + \phi_5 RINTR\_P_{t-1} + \phi_6 RINTR\_N_{t-1} + \mu_t \quad (6)$$

$$Y_t = \delta_0 x + \phi_1 GY_{t-1} + \phi_2 GOVT_{t-1} + \phi_3 EOP_{t-1} + \phi_4 M2GDP_{t-1} + \phi_5 RINTR_{t-1} + \mu_t \quad (7)$$

Where Y_t is the growth of each industrial sub-sector.

Note that Equation *(7)* is the long run traditional ARDL model. To find the short run coefficients, the following asymmetric error correction equation is given:

$$\Delta GY_t = \delta_0 x + \sum_{i=1}^{r} \delta_1 \Delta GY_{t-i} + \sum_{i=0}^{r} \delta_2 \Delta GOVT_{t-i} + \sum_{i=0}^{r} \delta_3 \Delta EOP_{t-i} + \sum_{i=0}^{r} \delta_4 \Delta M2GDP_{t-i} + \sum_{i=0}^{r} \delta_5 \Delta RINTR_t\_P_{t-i} + \sum_{i=0}^{r} \delta_6 \Delta RINTR_t\_N_{t-i} + \psi\_AECt_{t-1} + \pi_t \quad (8)$$

Where $AECt_{t-1}$ is the asymmetric error correction term and ψ, the coefficient of *AECt* that measures the speed of adjustment and is expected to be negative.

$H_O : \phi_1 = \phi_2 = \phi_3 = \phi_4 = \phi_5 = \phi_6 = 0$ (Long-run relationship does not exist)

$H_1 : \phi_1 \neq \phi_2 \neq \phi_3 \neq \phi_4 \neq \phi_5 \neq \phi_6 \neq 0$ (Long-run relationship exists).

$$\Delta GY_t = \delta_0 x + \sum_{i=1}^{r} \delta_1 \Delta GY_{t-i} + \sum_{i=0}^{r} \delta_2 \Delta GOVT_{t-i} + \sum_{i=0}^{r} \delta_3 \Delta EOP_{t-i} + \sum_{i=0}^{r} \delta_4 \Delta M2GDP_{t-i} + \sum_{i=0}^{r} \delta_5 \Delta RINTR_{t-i} + \psi\_AECt_{t-1} + \pi_t \quad (9)$$

Equation *(9)* is the short run traditional ARDL model of equation *(8)*.

Estimation Technique

The estimation is based on non-linear autoregressive distributed lag (NARDL) model popularized by Shin *et al*. (2011 & 2013). The method is an improvement on the linear ARDL popular for modelling co-integrating relationship and provides robust results in finite samples. It needs no a-priori knowledge about the integrating properties of the variables and can be applied irrespective of the regressors' order of integration (Pesaran & Shin, 1998. Therefore, following Bahmani-Oskooee & Fariditavana (2015), this study is enriched by developing a non-linear modelling framework grounded in traditional ARDL providing a simple and flexible vehicle for the analysis of joint long and short-run asymmetries. The model co-integration approach follows three steps: (i) estimation of regressors by ordinary least square (OLS); (ii) establish the long-run relationship between the levels of the variables (and the unrestricted asymmetric error correction mechanism) by means of a modified F-test using the bounds-testing procedure advanced by Pesaran, *et al*. (2001) and (iii) testing by means of the Wald test for long-run and short run symmetries and perform all other diagnostic tests. In addition, asymmetric cumulative dynamic multipliers is derived to trace out the asymmetric adjustment patterns following positive and negative shocks to the explanatory variables (Shin *et al*., 2011). Data used for the estimation is sourced from the CBN Statistical Bulletin and National Bureau of Statistics. In addition, variables employed for the regression analysis are defined in appendix 2, table A1.

Empirical Results

Table 3: Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) Unit Root Tests

BASED ON SIC & AIC CRITERION						
VARIABLES	**ADF Level**	**ADF 1st-Difference**	**Order of Integration**	**PP Level**	**PP 1st-Difference**	**Order of Integration**
GMANOUT	-4.4043***	-8.7474	I(0)	-4.4421***	-8.7474	I(0)
MPR	-2.6920*	11.7015	I(0)	-2.6894*	-11.7822	I(0)
GOVT	-1.0820	12.1669***	I(1)	-1.0726	12.1674***	I(1)
RCUCP	-1.4524	11.7287***	I(1)	-1.4592	-11.7287***	I(1)
EXR	-2.0117	12.5284***	I(1)	-2.1602	-12.5401***	I(1)
EOP	-2.2195	11.6626***	I(1)	-1.9944	-12.7006***	I(1)
GCNGOUT	-4.4867***	-5.2819	I(0)	-6.2277***	-22.6409	I(0)
GSLDOUT	-5.9637***	6.2569	I(0)	-5.9935***	-20.8532	I(0)
M2GDP	-2.8702	-5.4711***	I(1)	-2.0952	-6.0062***	I(1)
RINTR	-3.0703**	-	I(0)	-29615**	-	I(0)
DBTGDP	-1.2970	-4.0525***	I(1)	-1.5933	-4.0315	I(1)
NEXP	-4.7360***	-	I(0)	-1.7006	-1.7596*	I(1)
GINDOUT	-4.6509***	-	I(0)	-4.5850***	-	I(0)

Source: Author's Computation via (E-views 9.5)

NOTE: ***,** and * indicate the rejection of null hypothesis at 1 percent, 5 percent and 10 percent respectively. SIC = Schwarz information criterion. AIC = Akaike information riterion

Table 3 shows the level and first difference stationarity test results. The table reveals that variables under consideration are integrated of order I(0) and order, I(1). The combination of both order of integrations forms the basis for proceeding to the next step which is the bound testing.

Presentation of Bound Test Approach to Co-integration

The co-integrating method is the bound test approach propounded by Pesaran and Pesaran (1997) and Pesaran and Shin (1999). The decision rule is that a model passes co-integration or bound testing when the computed Wald statistic value is greater than both the lower and upper bound of the Pesaran and Shin's table of values.

Table 4: Bound Test Approach to Asymmetric Co-integration

Model	**Manufacturing Equation**			**Crude-Petroleum & Natural Equation**			**Solid Minerals Equation**			**Industrial Aggregate Equation**		
Lag Order	**AIC**	**SBC**	**F-Test Statistics**	**AIC**	**SBC**	**F-Test Statistics**	**AIC**	**SBC**	**F-Test Statistics**	**AIC**	**SBC**	**F-Test Statistics**
1	7.96	8.96	-	11.45	12.13	2.58	5.42	8.01	1.19	5.42	1.17	1.19
2	8.08	8.81	2.71	11.61	12.69	1.36	8.93	10.6	4.47	7.99	8.54	9.84
3	7.67	8.55	**5.09****	10.29	11.20	**8.16****	11.69	8.77	**9.77****	8.10	9.30	**4.47****

Source: *Author's computation*
** = Computed F-statistics > Pesaran's critical value at 5% level of significance.

Table 4 shows results for long run bound relationship between the dependent variables and the regressors of each sub-sector. Since our computed values, [**]: 5.09, 8.96, 9.77 and 4.47 for manufacturing, crude petroleum & natural gas and solid minerals subsector respectively are (each) greater than Pesaran's upper critical value (table), ranges between 2.5 and 3.6, a bound relationship is established for equation representing each sub-sector. This means that regressors have long run

association with the dependent variables. That is, macroeconomic policy-mix has long run effects on the three major sub-sectors of industry. The study proceeds further to estimate the long run and short run asymmetric coefficients for each sub-sector.

Table 5: Empirical Result of the Long Run Effects of Macroeconomic Policy Instruments on the Output Performance of Manufacturing and Crude Petroleum & Natural Gas Sub-sectors.

Regressors	**Dependent Variable = GMANOUT Coefficients**	**Probability**	**Dependent Variable = GCNGOUT Coefficients**	**Probability**
GMANOUT(-1)	-1.0811*** [-6.03]	0.0000	-	-
GCNGOUT(-1)	-	-	0.1118 [1.22]	0.2343
GOVT(-1)	-17.4625** [-2.5835]	0.0158	2.2583 [-0.15]	0.8842
MPR	-	-	-23.2304 [-1.10]	0.2809
EOP(-1)	13.7056 [1.41]	0.1691	12.1918*** [5.38]	0.0000
M2GDP(-1)	14.1966 [1.4125]	0.1696	17.4190*** [4.72]	0.0001
R-Squared	0.6187	-	0.8675	-
Adjusted R-Squared	0.5307	-	0.8178	-
F-statistics	7.0326	0.0001	17.46	0.0000
D.W Statistics	2.0000	-	2.3925	-
LM	0.0727	0.9300	1.5392	0.2368
$\chi 2$	2.3568	0.0596	1.3460	0.2710

*****, **, *** = Significant at 1%, 5% and 10% level; [ ] = T-statistics; ( ) Probability value

From table 5, the long run effects of government expenditure on crude petroleum and natural gas is positive but not significant at 10%. On the other hand, the effect on manufacturing sub-sector is significant at 5% but the coefficient carries a negative sign (contrary to a-priori expectation) probably owing to distortion in the process of executing capital projects. This deviates from Keynesian theory and the Wagner's law that government expenditure is effective in addressing the real sector. Previous authors (Argy & Salop, 1979; Laumas, 1991; Nas & Odekon, 1996) have also found such asymmetric effects of fiscal policy on the real sector. Monetary policy rate relates negatively with crude petroleum sector. That is when interest rate falls, investment demand of crude petroleum and natural gas rises. Economic openness and money supply are positively related with manufacturing and crude petroleum sub-sectors. In fact, the long run effect of openness is significant at 1% in the crude petroleum sub-sector. This finding is consistent with economic theory and previous findings of (Olofin & Iyaniwura, 1983; Adeoye, 2004; Mordi *et al*., 2010). However, the degree of openness remains a debate in the literature. It is generally believed the economies of most developing countries are too opened and susceptible to external shocks. It also confirms Adebiyi and Dauda's findings that liberalization policy enhances trade advantage. The long run monetary expansion is not significant probably owing to imperfection of the financial system in Nigeria, however, based on the result, money supply growth (relative to GDP) can stimulate demand for real sectors' output and enhances production and output and growth of the industrial sector.

Table 6: Empirical Result of the Long Run Effects of Macroeconomic Policy Instruments on Output Performance of Solid Minerals Sub-sector and Industrial Sector Aggregate.

Regressors	**Long Run Model**		**Long Run Model**	
	Dependent Variable = GSLDOUT Coefficients	**Probability**	**Dependent Variable = GINDOUT Coefficients**	**Probability**
GSLDOUT(-1)	0.0070 [0.03]	0.9702	-	-
GINDOUT(-1)	-	-	0.1196 [0.71]	0.4821
RCUCP(-1)	4.3175 [0.64]	0.5242	-	-
DBTGDP(-1)	12.6699 [0.66]	0.5150	-8.1546 [-1.39]	0.6984
GOVT(-1)	-	-	5.9203 [0.54]	0.5907
M2GDP(-1)	-42.3067 [-1.59]	0.1267	88.1017*** [4.54]	0.0004
NEXP	-	-	0.0046 [1.36]	0.1934
NEXP(-1)	0.0024*** [3.48]	0.0001	-0.0030 [-0.60]	0.5512
R-Squared	0.4481	-	0.8528	-
Adjusted R-Squared	0.0705	-	0.6861	-
F-statistics	2.1868	0.0357	5.1156	0.0013
D.W Statistics	2.1360	-	2.5837	-
LM	1.2633	0.3079	2.6109	0.1284
$\chi 2$	0.7642	0.6854	0.5751	0.8636

*****, **, *** = Significant at 1%, 5% and 10% level; [ ] = T- statistics; ( ) Probability value

In table 6, the coefficient of next export is significant at 10% and positively related with the growth rate of solid minerals output. This shows that an increase in the value of export over import induces growth of the solid minerals. Trade policy that promotes export will contribute substantially to the growth of solid minerals sub-sector. Ratio of capital to current expenditure; debt to GDP, as well as broad money supply, are not significant. This implies that in the long run both fiscal and monetary policies might be ineffective as core policy measures to address solid minerals sub-sector. Though, being co-integrated with other policy instruments signifies their long run relevance. One period lag of financial deepening is positively related with industrial output growth and significant at 10%. Industry own lag is not significant in determining present period output. Both trade and fiscal policy instruments are not significant to address industrial output aggregate in the long run. Financial deepening displays a positive relationship all through. This means the entire industrial sector would grow with improved financial system.

Table 7: Empirical Result of the Short Run Effects of Macroeconomic Policy Instruments on the Performance of Industrial Sub-Sectors in Nigeria.

Regressors	Dependent Variable: ΔGMANOUT Coefficients	Dependent Variable: ΔGCNGOUT Coefficient	Dependent Variable: ΔGSLDOUT Coefficient	Dependent Variable: ΔGINDOUT Coefficient
D(GMANOUT(-1))	3.4168 [1.7081]	-	-	-
D(GCNGOUT (-1))		0.2066 [0.39]	-	-
D(GSLDOUT(-1))	-	-	-3.1489 [-0.46]	-
D(GINDOUT(-1))	-	-	-	-0.3740 [-1.27]
D(DBTGDP(-1))	-	-	81.9361 [1.07]	13.8800 [1.41]
D(DBTGDP(-2))	-	-	-27.3964 [-0.43]	-
D(GOVT(-1))	1.2134 [0.27]	-75.7977*** [-3.06]	-	-16.4972* [-1.77]
D(MPR(-1))	-	-.107.0657*** [-3.4344]	-	-
D(EOP(-1))	-36.8100 [-1.41]	91.0223*** [3.4859]	-	-
D(M2GDP(-1))	69.4196* [1,75]	114.9728** [2.17]	9.9445 [0.09]	73.8560*** [4.29]
D(NEXP)	-	-	-	0.0048** [2.33]
D(NEXP(-1))	-	-	0.0032 [0.12]	-
D(NEXP(-2))	-	-	0.0214 [0.65]	-
AECT(-1)	**-0.5138** [-2.53]**	**-0.4859* [-2.15]**	**-0.2251*** [-2.90]**	**-0.2871** [-2.20]**
R-Squared	0.6439	0.9428	0.9624	0.8838
Adjusted R-Squared	0.4377	0.8991	0.4559	0.7749
F-Statistics	3.1235 (0.0142)	21.5809 (0.0000)	1.9003 (0.4032)	8.1182 (0.0000)
D.W Statistics	2.0983	2.1949	2.6255	2.4303
LM	0.2372 (0.7913)	2.9505 (0.0831)	15.8426 (0.0517)	11.2584 (0.0543)
χ^2	1.3711 (0.2630)	1.0224 (0.4739)	0.5386 (0.8244)	1.5158 (0.2090)

*****, **, *** = Significant at 1%, 5% and 10% level; [ ] = T-statistics; ( ) Probability value

The relationship between macroeconomic policy instruments and industrial subsector is ambiguous in the short run as presented in table 7. Financial deepening is significant in all sub-sectors except solid minerals. Coefficients of fiscal, monetary and trade policies are significant in the petroleum sub-sector but government capital expenditure fails a-priori expectation. Capital expenditure has positive effect on manufacturing as expected, but it is negatively related with petroleum and industrial sector. This means that short run effects of macroeconomic policy is predicated on the individual sub-sector. In the short run, trade liberalization is negatively related with manufacturing. This may be as the result of dumping prevalent in Nigeria. Imported finished goods also compete with domestically manufacturing goods resulting in unemployment of resources. The estimated asymmetric error correction terms (AECT(-1) are negative and significant. This means that a long run relationship exists among the variables. In other words, macroeconomic policy instruments and the

performance of industrial sub-sectors are related and that any short run disequilibria can be corrected in the long run. The speed of adjustment to long run equilibrium is higher in both manufacturing and crude petroleum sub-sectors. A lower value is recorded in the aggregate industrial sector. This proves that both manufacturing and solid minerals respond more rapidly to policy adjustment mechanism in the long run, whereas solid minerals and industrial aggregate respond slowly.

Table 8: Empirical Result of Long Run Asymmetric Effect of Macroeconomic Policy Instruments on the Output Performance of Industrial Sub-sectors and Industrial Sector Aggregate.

Regressors	Long Run Asymmetric Effect of Policy Instruments on Industrial Sub-Sectors			
	Dependent Variable = GMANOUT Coefficients	**Dependent Variable = GCNGOUT Coefficients**	**Dependent Variable = GSLDOUT Coefficients**	**Dependent Variable = GINDOUT Coefficients**
EXR_P(-1)	-	-0.2039 [-0.73]	-	-0.1499 [-0.54]
EXR_N(-1)	-	0.9811 [0.96]	-	5.0105* [2.01]
RINTR_P(-1)	-1.6344** [-2.39]	-	-5.3779* [-1.86]	2.1392 [1.39]
RINTR_N(-1)	-0.1704 [-0.23]	-	-1.9891 [-1.10]	-1.4620 [-1.18]

*****, **, *** = Significant at 1%, 5% and 10% level; [ ] = T-statistics

The result of the long run asymmetric analysis is presented in table 8. The result is extracted from broad NARDL model regression results. This is done to distinguish the coefficient of asymmetric variables for clarity. The NARDL method results show an improvement over the Pesaran & Pesaran (1997) and Pesaran & Shin (1999) traditional ARDL method for generating responses to negative and positive changes in volatile variables and slight changes in the coefficient estimates. This study derives asymmetric cumulative dynamic multipliers that allow the researcher to trace out the asymmetric adjustment patterns following positive and negative shocks to the explanatory variables.

From the result, positive variable (exchange rate appreciation) carry negative signs in the crude petroleum and industrial sector (aggregate), whereas, the negative variable has positive sign. This implies that the long-run effects of exchange rate changes are asymmetric. It is found that at least at 10 % significant level the positive variable, real exchange rate is negatively related to crude petroleum and industrial sector but the relationship is not significant in the long run. That is exchange rate appreciation may be detrimental to the two sectors. A rise in value of naira, against major foreign currencies, like dollars and Pounds Sterling, reduces foreigners' purchasing power who might substitute Nigerian products for cheaper ones. Exchange rate depreciation is directly related with crude petroleum sub-sector and industrial sector, but the relationship is significant only in the industrial sector. Nigerian industrial sector aggregate depends on inputs which are mainly imported. Therefore, exchange rate depreciation may result to incremental production cost leading to output cut. Consequently, prudential management of exchange rate is a key factor in achieving effective industrial output balance.

There is no long run co-integration between policy instruments and crude petroleum & natural gas sub-sector. Real interest rate is asymmetrically related to manufacturing sub-sector; both the positive and negative changes have negative relationship with manufacturing and crude petroleum sub-sector. However, the magnitude of the coefficients change is asymmetric in manufacturing and solid minerals sub-sectors. It is found that manufacturing performance will respond faster to positive change but slower to negative change in interest rate. The rate of interest is the price of capital and investment therefore, a rise or fall in interest rate will lead to a corresponding fall or rise in investment demand and

increasing/decreasing cost of production inputs. This is consistent with Keynes model advocating fall in rate of interest will induce new investment, opposite to McKinnon (1973) and Shaw, (1973) thesis.

In the solid minerals sub sector, interest rate rise or fall will induce investment in new capital to boost output of the sector. Asymmetric effect is also depicted in the aggregate industrial sector. The a-priori relationship as well as the magnitude of change is asymmetric. However, none of the relationship is significant at 10%. This shows that interest rate changing positively or negatively will not significantly affect entire industrial sector in Nigeria.

Table 9: Empirical Result of the Short Run Asymmetric Effect of Macroeconomic Policy Instruments on the Performance of Industrial Sub-sectors.

Regressors	**Short Run Asymmetric Effect of Policy Instruments on Industrial Sub-Sectors**			
	Dependent Variable = ΔGMANOUT	**Dependent Variable = ΔGCNGOUT Coefficients**	**Dependent Variable = ΔGSLDOUT Coefficients**	**Dependent Variable = ΔGINDOUT Coefficients**
EXR_P(-1)	-	-1.5933** [2.25]	-	-0.2728* [-1.79]
EXR_N(-1)	-	-4.3024 [-0.80]	-	-4.1753* [-1.81]
EXR_N(-2)	-	16.7389** [2.67]	-	-
RINTR_P(-1)	1.8203* [1.9920]	-	-4.3855 [-0.71]	2.1839 [1.53]
RINTR_N(-1)	0.0528 [0.05]	-	-11.9827 [-1.92]	-1.9837* [-2.09]

*****, **, *** = Significant at 1%, 5% and 10% level; [ ] = T-statistics

Result of the short run asymmetric analysis is presented in table 9 and it is extracted from the broad regression result. It appears to be an improvement over the traditional ARDL method following the ability to generate (short run) responses to negative and positive changes in the volatile variables.

The short run effects of exchange rate on crude petroleum sub-sector and industrial aggregate sector tend to be symmetrical in table 9. Both appreciation and depreciation of exchange rate inversely affect the two sectors. Two period lag of exchange rate depreciation tends to directly affect crude petroleum sub-sector. The advantage of asymmetric analysis reveals that in the short run, appreciation of exchange rate decreases output performance in the crude petroleum sub-sector, whereas, depreciation insignificantly, increases it. The same asymmetric trend is recorded in the industrial sector aggregate, that is, when exchange rate depreciates, industrial sector performance generally increases. This is in line with the existing literature that liberalization or deregulation of exchange rate is effective in the short run. However, the reverse may be the case in the long run when prices of imported inputs rise in response to increase exchange rate or purchasing power parity.

Manufacturing performance relationship with real rate of interest is ambiguous, a negative relationship is expected. The effects of positive and negative real interest rate changes directly affecting manufacturing reflect ambiguity of policy effects in Nigeria. More often, short run process of smooth policy implementation is difficult probably owing to implementation and adjustment lag. However, this requires further investigative analysis. Short run interest rate relationship with solid minerals sub-sector conforms with to a-priori expectation and the sector responds faster to low interest rate than high interest rate. In other words, a fall in real interest rate leads to a rise in output performance of the sector. Interest rate decrease, however, can lead to increase performance of industrial aggregate in Nigeria.

Sensitivity Analysis

Quite a good number of macroeconomic variables are employed in the process of regression analysis. The most robust variables are chosen for our analysis. Robustness of variables is apparent from the diagnostic tests. To ascertain the goodness of fit of the NARDL model, stability diagnostics tests are conducted. The stability tests of the regression coefficients are conducted by employing the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSq) of the recursive residual test for structural stability (Brown, Durbin, and Evans (1975). The tests are applied to the residuals of all the four long run and short run models. The null hypothesis that the coefficients of error correction model (as well as the long-run model) is not stable is rejected. This is because the regression equations appear stable given that neither the CUSUM nor the CUSUMSq test statistics exceed the bounds of the 5% level of significance (Pesaran & Pesaran, 1997). This also suggests that the regression coefficients are generally stable over the sample period. The long run model of CUSUMq shows some elements of instability for solid minerals sub-sector from 1st quarter, 1999 to the 4th quarter of 2002. Also, the short run of CUSUM and CUSUMq tests portend instabilities. However, these tests (CUSUM & the CUSUMSq) are known to have low power and thus may have missed important breaks (Pesaran *et al.*, 2001).

The diagnostic test examines the serial correlation, functional form, normality and heteroscedasticity associated with the model. The Breusch–Godfrey serial correlation Lagrangian multiplier (LM) test for long run and short run diagnostic tests reveal there is no serial correlation among variables because functional form of the models are well specified. Autoregressive conditional heteroscedasticity (ARCH) is also not present in the models following the ARCH tests which suggest that the errors are homoskedastic and independent of the regressors. There is also no evidence of white heteroscedasticity. The functional forms of the models are correctly specified following Ramsey RESET Test, no omitted variable error. Jarque-Bera (JB) test is engaged in order to test the normality of error term. All the models pass the normality tests, suggesting the errors are normally distributed.

The R-square and adjusted R-squared are relatively high in each sub-sector showing that there is a relatively strong correlation between the dependent and independent variables. However, in the solid minerals sub-sector, R-squared and adjusted R-Squared are very low indicating a weak relationship between macroeconomic variables and the sub-sector. Except in the solid minerals sub-sector, F-statistics are significant in all the models as indicated by probability F-statistics.

In addition, the asymmetric coefficients in table 8 and 9 show varied values for negative and positive coefficients of exchange rate and real interest rate. Giving improve coefficient results of NARDL over traditional ARDL, one may conclude that the former is better that the latter because it reduces heteroscedasticity and serial correlation.

SUMMARY AND CONCLUSION

This study has painstakingly examined the effects of macroeconomic policy instruments on the performance of industrial sub-sector in Nigeria in a bound test approach. Macroeconomic policy and industrial sector performance are two critical economic issues that need to be properly addressed to step up economic growth and attain long term economic development. For the Nigerian economy, the paper empirically examined the long and short run effects of policy instruments from 1981 to 2016. Quite a fact is that industrial sector contribution to the national output has been economically unacceptable since the early 1980s. To achieve a comprehensive analysis in this study, industry is divided

into three components: Manufacturing, Crude Petroleum/Natural Gas and Solid Minerals. We also examine the effect of policy on industrial aggregate. Statistics reveal the three sub-sectors of industry contribute inadequately to the national output resulting in retarded growth of the economy. The paper established both long-run and short run asymmetric relationship between macroeconomic policy instruments and performance of industrial sub-sectors. The major optimal policy instruments employed to address each sub-sector's performance are selected based on the bound test approach to co-integration. Relatively, the instruments appear co-effective enough to address the poor performance in each sub-sector. It is found that policy instruments, if mixed appropriately, can cause desirable positive change in the growth of each sub-sector.

The suggestions offered are that there should be definite prudential guidelines for monetary policy instruments. For instance, for the Nigerian economy, monetary poly rate (MPR) is a key monetary policy instrument which the apex bank has at its control to influence other interest rates and to curb inflation rate in the short term. Also, since the MPR implicitly has a link with financial deepening, output and demand factors, sagacious management of the variable will include painstaking strategies that can enhance macroeconomic stability. In this regard, the monetary policy committee of the CBN is charged with the commitment to ensure this recommendation is being practiced.

Exchange rate depreciation might be an instrument to boost export demand, but wide margin depreciation of exchange rate must be avoided. Unavoidable depreciation of naira against foreign currency must be executed with much consideration given to the real sector especially to the manufacturers who would need importation of raw materials. Liberalization and deregulation of the economy as well as deepening of the financial system should be implemented in a way not to generate policy reversals.

Finally, increase manufacturing investment is recommended for utilization of products from solid minerals and crude petroleum/natural gas sub-sectors. As a complementary factor, small businesses and medium term entrepreneurial activities should be stimulated by both government and private individuals to complement balanced multi-sectoral growth. The government can also boost the trend by providing adequate infrastructures like electricity and good road network as incentives to entrepreneurial ventures.

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Appendix 1.

Theoretical Framework

The framework derived in this study is a hybrid of fiscal, monetary and trade policies discussed in the literature. It incorporates knowledge derived fundamentally from the classical and Keynesian models as well as the Mundell-Fleming model. The focus is on monetary, fiscal and trade policy instruments. It is theorized that these instruments can represent transmission channels between policy and the real sector. Inter alia, the Cobb-Douglas function, Solow-Swan (1956) models and the absorption approach which are variants of classical or Keynesian models, are employed to formulate the underlying framework. In addition, it draws from Mckinnon and Shaw (1973), Stiglitz (1996), Nnanna *et al*. (2003), and Mordi *et al*. (2014) postulations, which at one point or another explained the theoretical relationship between policy instruments and the real sector.

The classical Cobb-Douglas function is given as: output (Y) is a function of capital stock *(K)* and labour *(L)***:**

$$Y = f(K, L), \qquad f' > 0, f'' < 0 \qquad (1)$$

Y in equation *(1)* strictly represents industrial output and its determining factors are limited to labour (employee) and capital (industrial machines).

In Majeed (2010), equation *(1)* can be augmented to include productivity:

$$Y_t = A_t\, f(K_t, L_t) \qquad . \qquad (2)$$

Where Y_t , K_t , $L_t$and A_t are industrial output, physical capital stock, labour force and productivity respectively in year *t* . Exponential form of equation *(2)* is given as:

$$Y = AK^{\alpha} L^{1-\alpha}, \qquad 0 < \alpha < 1 \qquad (3)$$

Where A measures state of technological. Dividing both sides of equation *(3)* by *L*, gives Y/L = y, and K/L = k ; this gives the following equation:

$$y = Ak^{\alpha} \qquad (4)$$

Where y denotes output-labour ratio and k denotes capital-labour ratio. Equation *(4)* represents Solow growth model with population growth and hence, labour force growth. Assuming output increases with capital, capital accumulation can be given as:

$$_g k = sY - (N + \delta)k, \qquad 0 < s, \delta < 1 \qquad (5)$$

s is the propensity to save, $N > 0$ and the rate of exogenous population growth, δ denotes the rate of depreciation of physical capital. It illustrates increment in capital in a period, holding labour constant, is determined by saving portion of national income *Y*, minus depreciation of capital and the proportion of population growth in a particular period. Note that equation *(5)* is the equilibrium state of the goods market (the steady state) or by similarity equilibrium of investment, *I* and saving, S, in Hicks (1937) ISLM model, that is

$$I = sY. \qquad (6)$$

Setting α in equation *(4)* to 1 gives the simple form of the *Ak* model proposed by Rebelo (1991):

$$Y = Ak \qquad (7)$$

Where k = *K/L*, although in the conventional model of Solow, k represents capital output ratio, but in this model, K denotes the broad measure of capital comprises both physical and human capital stock. The production function is assumed to be linear and exhibits constant returns to scale without yielding diminishing returns to capital. A in equation *(7)* is equivalent to A in equation *(4)* that captures the level of technology.

Refer to capital accumulation in equation *(5)*, the steady-state growth rate of the capital stock per worker can be shown as:

$$g_k = sA - (N + \delta) \qquad (8)$$

And per capita steady-state growth rate is also given as:

$$g_y = sA-(N+\delta) \quad (9)$$

These expressions mean that the rate of growth for $sA > N+\delta$ and positive and the level of per capita income increases without bound, (Agenor & Montiel, 2008). The backdrop of Rebelo's equation is that national savings largely increases per capital growth rate and demand factor. In addition, Agenor and Montiel postulate that an increasing variety or quality of machinery or intermediate inputs offsets the propensity to diminishing returns, in the interpretation of equation *(7)*, *K* (as in *K/L* above) now represents the variety or quality of inputs.

As complementarity to the augmented classical model above, the absorption approach also explains the effectiveness of exchange rate devaluation on the real sector. It is a modified simple Keynesian model viewing economic condition in the context of aggregate demand and supply relative to domestic currency devaluation while aiming at balancing the current account. Following Tule (2013), a simple national income mathematical notation can be derived to explain the absorption approach as equation 10 below:

$$Y = C + I + G + X - M \quad (10)$$

$Y =$ National Income; C = Consumption expenditure (of the private sector); I = Private investment expenditure; G = Government expenditure; *X* = Export and *M* = Import.

Note that *Y* in equation *(10)* is different from *Y* in equation *(1)* because, unlike equation *(1)*, its determinants are not limited to labour and capital only, but also include policies and external factors that can explicitly or implicitly change the national output quantity. Assuming;

$$A = C + I + G \quad (11)$$

In equation *(11)*, A is the domestic demand or "absorption" identity. The current account CA is $X - M$. Other items like official development assistance (ODA) grants and factor income etc, are held constant. Assuming $CA = X - M$, it can be expressed that $X - M = Y - A$ or $CA = Y - A$

This model implies that a country facing a deficit probably has two options: either increase Y or decrease A. Increasing Y is a supply-side problem. The International Monetary Fund (IMF) suggestion is that economic liberalization instruments like free trade, privatization, deregulation, among others, would favour private sector investment and boost output. On the-other-hand, decreasing A is a demand-side problem. Usually, it means austerity-tight budget and tight money (Edwards, 1988; Tule, 2013).

Refer to equation 10, ($Y = C + I + G + X - M$), given equation *(12)*:

$$\frac{M}{P} = L(i,Y) \ \ldots\ldots\ L_r < 0, L_Y > O \quad (12)$$

Equation 18 indicates that the supply of money supply, M or the real balance is equal to money demand. The demand for money is negatively related to the interest rate and positively related to the level income Y .Note that money supply is deflated by the price level (consumer price index), P. The balance of payments (BOP) $X - M$ bears linkage with the absorption approach where by domestic output and absorption regulate (BOP) is given as

$$BOP = CA + KA \quad (13)$$

Where CA is the current account and KA, the capital account. The *IS* component is given as:

$$C = C(Y_t - T, i - E(\pi) \quad (14)$$

Where C is consumption, T, taxes, $E(\pi)$, expected rate of inflation, other variables are as defined before.

$$I = I(i - E(\pi), Y_{t-1}, G) \quad (15)$$

Where Y_{t-1} is the previous period GDP. $G = G_0$ government spending which is an exogenous variable.

$$NX = f(e, Y, Y^*) \quad (16)$$

Where NX is the net exports, e, the real exchange rate, Y^* the GDP of a foreign country

The BOP component is $CA = NX$,

$$KA = \eta(i - i^*) + k \qquad (17)$$

Where η is the level of capital mobility, i^* the foreign interest, k is investments but not related to i in previous equations, i is an exogenous variable.

This model shows a possible upward pressure on the local interest rate following increase in the global interest rate in a flexible exchange rate regime. The pressure declines as the local rate tends towards equality with the global rate. Assuming a positive disparity between the global and the local rates, with the LM curve constant, capital flows out of the domestic economy. Consequently, the domestic currency depreciates and locally produced goods become cheaper. This induces exports and boost industrial performance. Rising net exports shift the IS curve to the right and continues until the domestic interest rate rises to the level of global rate. The reverse is the case in the event of a decrease global interest rate.

Following Argy and Salop (1978), the labour market concept can also be added to the model represented by equations *(18)* and *(19)*:

$$Y = A\left(\frac{w(1-s)}{P_d}\right)^B \qquad (18)$$

$$\frac{w}{p}(1-t) = \frac{(1-n)(1-t)}{P} + N \qquad (19)$$

These equations represent the supply side of the economy and they are critical in determining the division of the effects of expansionary policies between prices and output (Argy & Salop, 1978). Equation *(18)* shows that output *Y* is a function of labour wage rate, that is (derived) demand for labour and it is deflated by domestic price of output P_d . Note also that:

$$Y = Zk^A L^{1-B} \qquad (20)$$

That is in equation *(20)*, *A* and *B* are parameters of type Cobb-Douglas production function. If diminishing marginal productivity is assumed in production level, then the real wage must fall if production growth must be profitable. *s* in equation *(18)* is the employment subsidy which cause the difference between the wage paid to labour and the marginal cost to the firm for employing additional labour. Equation *(19)* is the wage rate equation. The model states that labour supply is perfectly elastic at the present after-tax wage. It means employer is a price taker who then decides the volume of employment and production with respect to equation *(18)*. Equation *(19)* also tries to prove the concept of money illusion to cause real wages to vary with price level and tax rate. That is, if $n = 1$, there is no money illusion and after tax real wages are invariant to the price level. If $n < 1$, they vary inversely with the price level. In reality, labour uses the consumer price index to measure the real wage, while the producer use output price. The producer decision is consistent with the theory of firm that profit is maximized when labour is hired up to the level where marginal revenue product equals the nominal wage.

The macroeconomic models above can also be buttressed by the Barro and Sala-i-Martin (1992 & 1995) and Mendoza *et al*. (1997) models which incorporate public policies. The authors contend that government (fiscal) policy affects the level of output path and the steady-state growth. This is explained in the Barro and Sala-i-Martin (1992). As illustrated in Bleany (2001), there are n number of producers each producing output Y in line with the production function:

$$Y = Zk^{1-\alpha} L^{\alpha} \qquad (21)$$

Where k represents private capital and L denotes inputs provided by the public sector, Z is a constant. In addition to the component of L , a transformed or augmented L is desirable in this study so that L in equation *(21)* = G , that is the extended L representing government policies to include not only fiscal policy, but also monetary and trade policies. These policies are assumed essential to improve industrial performers in an economy. Equation *(21)* can then be transformed as follow:

$$Y = ZG^{\rho} k^{1-\rho} \qquad (22)$$

Where ρ represents proportion of government inputs monetary, fiscal and trade policies and $1-\rho$, proportion of private capital inputs. k in equation *(22)* is the privately provided embodied capital broader than capital-labour ratio in equation *(4)*.

Taking the log-linear form of equation *(22)*, yields equation *(22A)* below:

$$Y = Z + \rho \log G + 1 - \rho(\log k) \qquad (22A)$$

Assuming Y_i implies industrial sub-sectors *i* and G & *K* represent macroeconomic variables, equation *(22A)* can be augmented to a dynamic linear model. Following Pesaran and Pesaran, (1997) and Pesaran, Shin, & Smith (2001), the traditional or linear auto-regressive distributed lag (ARDL) model can be developed into the following equation:

$$\Delta Y_i = \delta_0 x + \sum_{i=1}^{r} \delta_1 \Delta Y_{t-i} + \sum_{i=0}^{r} \delta_2 \Delta GOVT_{t-i} + \sum_{i=0}^{r} \delta_3 \Delta EOP_{t-i} + \sum_{i=0}^{r} \delta_4 \Delta M2GDP_{t-i} + \sum_{i=0}^{r} \delta_5 \Delta RINTR_{t-1} - P_{t-i} \qquad (22B)$$

$$+ \sum_{i=0}^{r} \delta_6 \Delta RINTR_{t-1} - N_{t-i} + \phi_1 Y_{t-1} + \phi_2 GOVT_{t-1} + \phi_3 EOP_{t-1} + \phi_4 M2GDP_{t-1} + \phi_5 RINTR_{t-1} + \mu_t$$

Where ΔY_t is change in the growth of output of industrial sub-sector i. (GOVT) is the government expenditure. (EOP) is economic openness, (M2GDP) is financial deepening which is the ratio of broad money supply to gross domestic product (GDP) and (RINTR) is the real interest rate. x = set of deterministic variables like the constant term and trend. δ_0 = vector of coefficients of deterministic variables Δ = first-difference operator. r = optimal lag length; μ_t = the residual term.

Following Shin *et al*. (2013) equation *(22B)* is augmented into the NARDL model.

Still on equation *(22)* the assumption in this study is that the law of increasing returns holds, therefore, if (government) policy achieves the desirable growth objective, then, $\rho + (1-\rho) \geq 1$ in equation *(22)*, but if government policy fails, then $\rho + (1-\rho) \leq 1$ such as the Cobb-Douglas production function in equation *(3)*.

Appendix 2

Table A1: Variables Used for the Regression Analysis and their Sources

Variable (Abbreviation)	Description
GMANOUT	Annual growth rate of manufacturing output and it is the proxy for manufacturing performance.
GCNGOUT	Annual growth rate of output of the crude petroleum and natural gas sub-sector
GSLDOUT	Annual growth rate of solid minerals output sub-sector.
GINDOUT	Annual growth rate of aggregate industrial sector
MPR	Monetary policy rate. It represents the foundation of interest rates in Nigeria.
GOVT	Government capital expenditure (GOVT). The expenditure is supposed to provide adequate infrastructure and boost sectoral output in Nigeria.
RCUCP	Ratio of current to capital expenditure. A high ratio is not desirable because it signifies high re-current expenditure which might not be for productive purposes.
EXR	Real exchange rate
EOP	EOP is the ratio of exports plus imports over output (GDP)
M2GDP	Financial deepening. It is the ratio of broad money supply to GDP. The variable gives information about how money supply, relative to output, affects aggregate economy.
RINTR	Real interest rate. The variable facilitates asymmetric characteristics of a specific equation.
DBTGDP	This represents fiscal policy. It measures the overall financial and credit worthiness of the nation.
NEXP	The net export is the difference between export and import, and it measures trade surplus/deficits.

Source: *Author's computation*.

Note: All variables employed for the regression analysis are sourced from the CBN Statistical Bulletin and the National Bureau of Statistics (NBS) various issues.