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Macroeconomic Instability Index and Threshold for the Nigerian Economy

B. A. G. Amoo
Central Bank of Nigeria, bagamoo@cbn.gov.ng

J. K. Achua
Central Bank of Nigeria, jkachua@cbn.gov.ng

N. P. Audu
Central Bank of Nigeria, naudu@cbn.gov.ng

B. Hamma
Central Bank of Nigeria, bhamma@cbn.gov.ng

Macroeconomic Instability Index and Threshold for the Nigerian Economy

Amoo B. A. G., Achua J. K., Audu N. P. and Hamma B. *

Abstract

The paper employed statistical algorithms, factor analysis and threshold autoregressive models to address the gaps in management of macroeconomic instability in Nigeria. Using data spanning 2010q1 to 2017q2, the findings showed that the values of macroeconomic instability index (MII) fluctuated between 0.316 and 0.609, with a threshold of 0.461. This showed an inverse relationship between macroeconomic instability and economic growth. This framework could serve as a mechanism to gauge early warning signal of instability in Nigeria.

Keywords: Macroeconomic Instability Index, Threshold Autoregressive, Self-exciting Threshold Autoregressive, Nigeria

JEL Classification Numbers: E1, E6, O2, O4

I. Introduction

The prevalence of macroeconomic instability has become evident in global, regional and country-specific economic crises in the 21st century. Even though it is a global phenomenon, developed and developing countries experience macroeconomic instability, differently. Developing economies experience more chronic cyclical macroeconomic instability than developed ones (Easterly, 2001a). These experiences are associated with dire consequences. In Sub-Saharan Africa, for instance, macroeconomic instability is highly associated with political instability, social unrest and political violence (Ibe, 2002). In the business sphere, macroeconomic instability has been identified as the main constraint to firm growth in South Africa (Beaumont-Smith et al., 2003). In Nigeria, the 2016-2017 economic recession has highlighted the negative impact of macroeconomic instability, including spiralling inflation, unstable exchange rates, escalating debt levels and dwindling economic activities. These accentuate high unemployment, prevalent poverty and high social insecurity.

* *The authors are staff of the Real Sector Division, Research Department, Central Bank of Nigeria. The usual disclaimer applies.*

Consequently, the nature, causes and measures of macroeconomic instability have continued to be a source of concern to economists and policy makers. The phenomenon is complex and multi-dimensional, due to the multiplicity of its consequences on growth potential of economies, diverse causes and the numerous methods of measurement (Cariolle & Goujon, 2015). This accounts for the lack of effective measuring methods to monitor the phenomenon, especially in developing economies, over time. In the literature, however, attempts have been made to develop measuring tools for macroeconomic instability condition indices for different developing countries. The results include construction of macroeconomic instability index (MII) for 20 developing countries across Europe and Asia (Kaminsky, 1998), Latin American countries (Herrera & Garcia, 1999), Turkey (Ismihan, 2003), as well as the Dominican Republic and Haiti (Jaramillo & Sancak, 2007). These indices became important economic tools of an early warning system (EWS) of macroeconomic conditions and planning (Herrera & Garcia, 1999).

Even though the Nigerian economy has always been prone to macroeconomic instability, due to its oil-dependency syndrome, literature reveals that MII is yet to be modelled for the economy. Rather, policy makers, academics and analysts have continued to examine the economy based on disaggregated macroeconomic stability factors (Kolawole, 2013). This deficiency poses the challenge of deriving a holistic indicator of instability to reflect the economy's macroeconomic condition. This measurement gap has implications for researchers and policy makers because a positive relationship exists amongst measurement, theory and decision-making (Jacobs & Šlaus, 2010). The need for MII to provide clear objectives for policy and decision-making has become apparent with Nigeria's experience of 2016-2017 economic recession.

In order to fill the research gap, this paper developed a threshold effect of macroeconomic instability indicator for Nigeria. Specifically, the paper sought to: (i) construct a MII that captures the aggregate macroeconomic instability trajectory for the Nigerian economy; and (ii) determine the threshold for the macroeconomic instability condition, as an early warning system. The study is imperative due to knowledge gaps in terms of analytical framework and methodology.

Following this introduction, the rest of the paper is organised as follows. Section 2 provides the literature review made up of conceptual and methodological framework. Section 3 highlights the methodology of the study, data characteristics and estimation procedure and techniques while Section 4 presents the empirical findings, results and discussions of the study. Section 5 concludes the paper.

II. Literature Review

The concept and paradigm shift in modelling macroeconomic instability index have continued to receive attention in economic literature.

II.1 Conceptual Issues

Macroeconomic conditions are the aggregate outcomes of economic behaviour, arising from fluctuations in monetary and fiscal economic variables that affect the overall business activities at the national level. According to Fischer (1993, p. 487):

> *Macroeconomic framework can be described as stable when inflation is low and predictable, real interest rates are appropriate, fiscal policy is stable and sustainable, the real exchange rate is competitive and predictable and the balance of payments is perceived as viable.*

Macroeconomic stability condition is attained when an economy minimises vulnerability to external shocks and increases its prospects for sustained growth. On the other hand, macroeconomic instability is an imbalanced economic condition, characterised by protracted fiscal deficits, mounting outstanding loans, unfavourable balance of payments, declining foreign exchange reserves, persistent currency depreciation, and escalating inflationary pressure, leading to low confidence level in the crisis prone economy. The spontaneous impact of these creates a condition of macroeconomic imbalance, which render traditional monetary policy ineffective; thus, requiring intervention of unconventional monetary policy to correct the distortions and reverse the economic downturn.

The dichotomy between macroeconomic stability and instability accounts for economic growth differences (Ramey & Ramey, 1995; Dabušinskas et al., 2012). While macroeconomic stability is the centerpiece for sustainable economic growth (Easterly, 2001b), macroeconomic instability impedes economic growth (Ali & Rehman, 2015). There are obvious linkages between macroeconomic instability and economic growth (Bleaney, 1996). Firstly, instability in inflation and nominal exchange rates causes a higher real exchange rate risk for investments in export-oriented and import-dependent productions. This is because potential earnings depend on these highly unstable variables. Secondly, domestic demand is affected both directly and indirectly by variability in inflation and exchange rates. These fluctuations directly affect the terms-of-trade; thus, shifting demand from domestically produced goods to imported goods, or the other way round. Thirdly, it indirectly affects the levels of production, income, and consumption demand in the economy. These developments increase the level of uncertainty about future earnings of firms, due to investment risks.

Studies have shown that developing economies experience more severe consequences of macroeconomic instability than developed economies (Easterly, 2001a). Developing countries are exposed to fluctuations of commodity prices, which are occasioned by booms, bursts and slumps that often define their macroeconomic volatility conditions(Céspedes & Velasco, 2012 and Jacks, 2013). These economies enjoy favourable external credit funding in boom days but suffer credit contraction during burst and slump episodes. Commodity price burst and credit retractions constrain fiscal and monetary policy options from smoothening the decline in output, as the economies become choked up by high country premia (Daniel, 2011). Thus, failure to make the right investments and savings decisions, during the boom period, exposes developing countries to macroeconomic instability (Powell, 2015).

The established link between economic growth and macroeconomic behaviour, within the context of an economy, has attracted development economists' attention to causes of macroeconomic instability. Kharroubi (2006) identifies three main sources of instability in economic growth of developing countries, as: (i) significant external influences, which originate from financial markets and external trade terms; (ii) domestic influences, due to inherent instability; and (iii) self-inflicted policy faults. It should be noted that, apart from financial market shocks, countries that depend on resource extraction and exports of commodities could run into adverse commodity price shocks that portend macroeconomic risks to them and the risks are greater for economies that are less diversified and more dependent on commodities (UNCTAD, 2012).

It has also been observed that domestic shocks create more macroeconomic instability than external shocks in developing nations (Raddatz, 2007). This stance was strengthened by Kraay & Ventura's (2007) argument that the adoption of traditional technologies and unskilled labour by developing countries make their output more volatile. Yet another important source of economic instability in developing countries is what has been described by De Ferranti & Ferreira (2000) as 'weak shock absorption capacity'. Dornbusch & Edwards (1990), Onis (1997) and Easterly & Kraay (2000), all conclude that the predominance of macroeconomic instability in developing countries is characterised by poor management of fiscal and monetary policies, as well as structural inequality in income distribution.

Some economists have attempted to define macroeconomic instability condition without the theoretical underpinnings, for precise policy implications. It is not surprising, therefore, that several authors have used inflation as a proxy for measuring macroeconomic instability (see Azam, 1999; Caballero, 2007; Iqbal & Nawaz, 2010; Shahbaz, 2013). The plausibility of this measure lies in the fact that high inflation leads to high volatility in relative prices, thus, making investments riskier. For instance, the entire financial system is at risk when the banking system is exposed to firms and households during inflation. Consequently, high inflation affects the standard of living in an economy negatively by lowering growth and redistributing inequitably real income and wealth.

However, the need to determine macroeconomic instability by assessing the combined effect of the various relevant macroeconomic variables, concurrently with a single indicator, has been emphasised by Fischer (1993) and Sahay & Goyal (2006) because macroeconomic factors impact simultaneously on the economy. In some cases, multiple macroeconomic influences are counteracting, making interpretation of a clear economic trajectory very difficult. For instance, low exchange rate may be maintained at the cost of depleting international reserves and constraining exports. In an analysis of the relationship between macroeconomic factors and economic growth in Nigeria, spanning from 1980 to 2011, Kolawole (2013) establisheD that while real interest rate significantly affects growth positively, external debt and real exchange rate have negative impact on growth. This ambiguity is common when macroeconomic factors are examined individually, to establish their relative effects on growth. This does not clearly indicate whether the economic condition is stable or not.

Barro (1991), Baker (1998) and Caballero (2007) emphasised the contemporaneous influences of internal and external factors on macroeconomic instability. It follows that a measure of macroeconomic instability that does not encompass all relevant factors, that impinge substantially on the economic situation concurrently, amounts to partial analysis. When the factors, leading to macroeconomic instability in an economy, become prevalent, a single variable may not give a clear indication of the economic path. An incorporation of all the different relevant components of the instability drivers is necessary to provide an optimal indicator (Kaminsky, 1998). These factors are dynamic; and any effective model has to be adaptable to changing macroeconomic influences within the economic context. Consequently, Azam (2001) suggested that a MII, comprising inflation and nominal exchange rate, would be a more appropriate macroeconomic instability measure, rather than relying on inflation rate only.

The need to devise tools to facilitate informed predictions of economic conditions necessitates the development of MII. Kaminsky (1998) constructed a complex multi-stage indicator for forecasting financial crises. First, the leading indicators were selected and examined, individually. A composite indicator was then developed from the individual indices by aggregating the individual indicators through several techniques, such as quadratic probability score, the log probability score, and the global-squared bias score, for the selected composite indicators. This was then compared to exchange rate, which was adjudged empirically to be the best univariate indicator. The score statistic was reported as “Crisis Times” and “Tranquil Times”, separately to test the variability of the key indicators across regimes. Overall, the composite index performed more accurately in predicting financial crises than the leading indicator.

Herrera and Garcia (1999) developed a variation of MII as a precautionary measure for imminent macroeconomic distortions for several Latin American countries. The models' out-of-sample predictive ability on economic crises was successfully tested in several Latin American vulnerable economic situations in the late 1990s. The interesting thing about this model is its use of fewer variables, which are widely available and reported with timeliness to generate the index. In addition to the operational tool, which the index provides, it also generates an early warning signal. Apart from the aggregation of the variables, which produce the composite index, the procedure can generate signals with each variable individually.

A MII for Turkey was modeled by Ismihan (2003), consisting of inflation and exchange rates along with external debt to GNP public and deficit to GNP ratios. The model was constructed in two steps. The framework explored several macroeconomic issues, especially the links between overall macroeconomic performance and fiscal decisions. The main feature of this model was that it made a distinction between productive and non-productive public spending. Sanchez-Robles (1998) employed error correction model to develop MII for the Spanish economy, using inflation, deficit balance, various types of public expenditure in relation to gross domestic product (GDP), and market distortions as variables.

Over time, more variables were progressively included in the determination of MII. A more inclusive approach to the concept of macroeconomic stability by Ocampo (2005) encompassed price stability, fiscal policy, public debt, as well as private and public sector balance sheets. The framework, which was specially modelled for developing countries, was elaborate and a broad view of macroeconomic stability, involving multiple objectives and significant tradeoffs. It also emphasised counter-cyclical dimensions of macroeconomic and financial policies. Jaramillo & Sancak (2007) constructed MII as the weighted sum of inflation and exchange rates volatility, less-accumulated foreign reserve, as a percentage of monetary base at the beginning of the period, minus the fiscal balance, as a percent of GDP. Each variable in the model was weighted by the inverse of its standard deviation. The weighting standardised the variables to normalise the volatilities of all the components of the index and ensured that the index was not overwhelmed by the most volatile components. The model was such that an increasing value for the index indicated increasing instability.

Several economists had taken advantage of the lack of consensus that pervades the concept and definition of macroeconomic instability to devise differing measures. Iqbal & Nawaz (2010) had constructed Misery Index, consisting of inflation and unemployment rates, as a measure of macroeconomic instability in Pakistan. The authors employed ordinary least squares (OLS) and Gaussian Mixture Model (GMM) models. Ali (2015) employed inflation and unemployment rates, together with budget and trade deficits for measuring macroeconomic instability in Pakistan by applying the error correction model.

Though the varieties in methodologies have produced useful macroeconomic instability indices in different contexts, lack of consensus is still a major challenge. The real problem is that the criteria for the selection of variables for MII are hardly clearly articulated. Therefore, the variations suggest that merely deriving MII from two or several variables would not fully explain the macroeconomic condition of an economy. Hence, the reality of the economic context defines the composition of macroeconomic instability of an economy at any given period.

Although theory is yet to provide unambiguous conditions as to the precise causes of macroeconomic instability, it has provided reasonable clarifications as to what could amount to possible proxies of macroeconomic instability. These indicators range mostly between monetary and fiscal policy variables, including inflation, exchange rate, interest rate, foreign reserves, base money, fiscal balances, public debts, trade deficits and foreign direct investment. These variables could constitute building blocks in the construction of the indicators of macroeconomic instability.

Literature reviewed so far has revealed that there was no conscious effort to construct MII for the Nigerian economy. Considering the importance of the index as a tool for early warning signal and planning, it has become imperative to fill the gap, especially with Nigeria's experience of the 2016-2017 economic recession.

II.2 Modelling Macroeconomic Instability

Over time, several methodologies had been employed to determine macroeconomic instability indices. Ismihan (2003) and Ismihan et al., (2005) employed Turkey data, ranging from 1963 to 1999, to establish a MII based on four macroeconomic instability indices - inflation rate, changes in exchange rate (variability of exchange rate), public deficit to GDP and foreign debt to GDP ratios. Each factor was calculated, using the formula in equation (1).

$$MII_t = \frac{X_t - X_{min}}{X_{max} - X_{min}} \quad (1)$$

The simple average of the variables was then computed as the MII, with values ranging between +1 and 0.

Jaramillo & Sancak (2007) constructed MII as total weighted rate of inflation (cpi), exchange rate (er) fluctuation minus accumulation of foreign reserves (res) as a percentage of monetary base (bm) at the start of each period and financial balance as a ratio to GDP. The model appeared thus:

$$MII_t = \frac{\boldsymbol{ln}\left(\frac{cpi_t}{cpi_{t-1}}\right)}{\boldsymbol{\sigma}_{cpi}} + \frac{\boldsymbol{ln}\left(\frac{er_t}{er_{t-1}}\right)}{\boldsymbol{\sigma}_{er}} + \frac{\boldsymbol{ln}\left(\frac{res_t - res_{t-1}}{bm_{t-1}}\right)}{\boldsymbol{\sigma}_{res}} - \frac{\boldsymbol{ln}\left(\frac{fbal_t}{gdp_t}\right)}{\boldsymbol{\sigma}_{fbal}} \quad (2)$$

Each variable in model (2) was converted to natural logarithm, then weighted inversely to the standard deviation of its numerator. The study was targeted at small economies of Dominican Republic and Haiti.

Haghighi et al. (2012) combined features of Ismihan (2003) and Jaramillo & Sancak (2007) macroeconomic instability indices to model a macroeconomic instability condition index as total weight of inflation rate (inf), real exchange rate(er) fluctuations, and change in the budget deficit (bd) and fluctuations in the terms of trade (tot) relationship. As shown in the model (3), each variable's weight varied equivalently to its standard deviation.

$$MII_t = \alpha\left(\frac{inf_t - inf_{min}}{inf_{max} - inf_{min}}\right) + \beta\left(\frac{er_t - er_{min}}{er_{max} - er_{min}}\right) + \gamma\left(\frac{bd_t - bd_{min}}{bd_{max} - bd_{min}}\right) + \varphi\left(\frac{tot_t - tot_{min}}{tot_{max} - tot_{min}}\right) \quad (3)$$

The relationship between the coefficients and MII were determined, such that their sum was equal to one, that is $\alpha+\beta+\gamma+\varphi=1$. Vector normalisation and determination of the coefficients' significance were carried out, using maximum likelihood ratio.

Though several macroeconomic instability indicators have been modeled over time, each has several drawbacks. Some of the models are mainly confined to limited key macroeconomic variables, like inflation and exchange rate, to reflect the general picture of macroeconomic instability situations even though their interrelationships only have partial information within the system. Dearth of discernible statistical test of fitness is yet another shortcoming. For instance, even though Ismihan (2003), Ismihan et al., (2005) and Jaramillo & Sancak (2007) variables were normalised to take care of volatilities, the models were, nonetheless, deficient in statistical tests of fitness. This limitation, noted in the configuration and the structure of the models, was improved upon by Haghighi's et al., (2012) model, which employed maximum likelihood techniques to check for the model's statistical fitness. However, the common weakness to all of the models is the intuitive basis of their structure. Consequently, the identification, selection and employment of appropriate variables appear to be based on whims and caprices. Thus, a meaningful comparative interpretation of macroeconomic instability across borders has remained a challenge.

III. Methodology

To overcome the difficulties in the identified in the models discussed above, this study isolated several monetary, fiscal and socio-economic indicators as possible variables and processed them through factor analysis techniques to identify the latent macroeconomic instability variables for Nigeria. Factor analysis is a complex, multi-step method, which is appropriately designed for exploring a data set (Costello & Osborne, 2005). The main concept of this analysis is that several identified variables have similar patterns of behaviour, which may be explained by their association with the latent variable. The overarching goal of the analysis is to establish statistical patterns of relationships among the variables that can largely or entirely explain an underlying "latent factor" common to all the measures. The use of factor analysis to select the model variables recognises the fact that each economy is unique.

III.1 Data Robustness

This study employed two varieties of factor analysis, namely: Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) for selection of an optimised dataset for the model. The EFA specifies the pattern of relationships among the variables to explore the likely underlying factor of an observed dataset without imposing a preconceived construct on the outcome (Child, 1990). The aim is to test whether a relationship exists between observed variables and their underlying latent constructs. The model also suggests the nature of those factors, the pattern of relationships among the variables, how well the hypothesised factors explain the observed data, and the randomness or unique variance of each observed variable. Therefore, embed in the EFA are inbuilt measures for determining the econometric robustness, or otherwise, of the model.

Several variables were identified from monetary, fiscal, and socio-economic spheres of the macroeconomic environment of Nigeria, out of which four were eventually selected by the EFA, as shown in Appendix I. The factor loadings were good measures in determining the appropriateness of latent variables. The other measures of importance were communality and uniqueness. Communality is the variance of observed variables accounted for by a common factor. A large 'communality' value indicates a strong influence by an underlying construct. 'Uniqueness' is the variance that is distinct to the variable and not shared with other variables. The lower the 'uniqueness' of a variable, the greater is the relevance of the variable in the factor model. Reliability and interpretability play a significant role in the determination of the factor structure. Appendix II shows that the model exhibited good reliability on all threshold test parameters espoused by Costello & Osborne (2005) and Hu & Bentler (1999), as shown in Appendix III.

The CFA technique of Principal Components Analysis (Appendix IV) confirms the robustness and corroborates that of EFA in both magnitudes and dimensions. A good model should have at least three variables with significant loadings (>0.30) that share some conceptual meaning (Suhr, 2006). The strength of the weights and correlations between each variable and the factor depend, on the relationship theoretically assumed to exist between the latent variable and observed indicators. The absolute magnitudes of factor loadings, derived from CFA, are one of the most important factors in determining reliable factor solutions (Field, 2000). The higher the loading, the more relevant the variable is in defining the factor's dimensionality. A negative value indicates an inverse impact on the factor.

III.2 Data Characteristics

The EFA and CFA techniques ensure the macroeconomic instability index variables are selected according to the theoretical underpinnings and empirical dictates. Both techniques confirm the robustness of variability in fiscal balance to GDP ratio, foreign reserves to base money ratio, inflation, and the ratio of non-performing loans to total loans of deposit money banks (DMBs), as macroeconomic instability variables for the Nigerian economy.

III.2.1 Fiscal Balance to GDP Ratio

A fluctuation in fiscal revenue is a function of the tax system. A tax system based on income and consumption is an automatic stabilisation device. However, if revenue is highly dependent on price of a commodity, the destabilising effect is that revenues decrease precisely when the commodity price decreases, thereby generating a fiscal deficit at the same time as a trade deficit. Consequently, the difficulty in solving fiscal deficit creates an inflation bias as the effects of public expenditure that are not properly financed, which rely heavily on the inflation tax, are completely undermined. Therefore, the long-term macroeconomic consequence of fiscal balance depends on whether it is a surplus or deficit; and how the surplus is invested or whether the deficit arises due to stimulus for infrastructure or grants to businesses. Fiscal profligacy undermines the growth objectives (Fatima et al., 2011). As a stimulus, however, fiscal deficit positively affects economic growth in Nigeria (Odhiambo et al., 2013; Maji and Achegbulu, 2012).

III.2.2 Foreign Reserves to Base Money Ratio

The foreign reserve to base money ratio is a potentially useful indicator for resident-based capital flight from the currency. In assessing foreign reserves adequacy, sizable money, stock in relation to reserves, suggests a large potential for capital flight (Cervena, 2006). Money-based measures of reserves adequacy are a measure of potential impact of a loss of confidence in the domestic currency that have played a very successful role as predictors of recent crises in emerging markets (Supriyadi, 2014). The ratio, as a signaling or external vulnerability indicator, is used to ensure that countries accumulate sufficient foreign reserves, to avoid negative assessment by the international community. Though, it is important to note that, in economies with stable money demand and high confidence in the domestic currency, domestic money demand tends to be larger and the foreign reserves over base money ratio relatively small without much risk (IMF, 2000).

III.2.3 Inflation

Inflation has been used as a proxy for macroeconomic instability (Azam, 1999; Caballero, 2007; Iqbal & Nawaz, 2010; and Shahbaz, 2013). The plausibility of this measure lies in the fact that high inflation leads to high volatility in relative prices, thus, making investments riskier. Stable low inflation encourages higher investment, which is a determinant of improved productivity and non-price competitiveness. On the other hand, very high inflation rates are detrimental to economic growth, which negatively affects the standard of living in a society.

III.2.4 Non-Performing Loans (NPLs) Ratio

Monetary policy tools leverage on the fact that economies are heavily dependent on credit provision by banks to influence the cost of credit in the private sector. It has been established that changes in the rate of NPLs is inversely related to economic growth in Nigeria (Morakinyo & Sibanda, 2016) and other developing economies (Ishfaq et al., 2016; Rajha, 2016; Muthami, 2016; Farhan et al., 2012). Of the 33 banking crises studied by Hoggarth and Sinclair, 2004, it was found that high NPLs was the main feature of the crises between 1977 and 2002. The consequences of an increase in NPLs include decline in aggregate credit, increased inflation, exchange rate volatilities and low output growth.

III.3 MII Model Specifications

This study adapted Jaramillo & Sancak's (2007) MII model mainly because of its non-linearity construct. The PCA, which has been employed to reduce the dimensionality of multivariate dataset does not have the property of linearity (Mishra, 2016). The adapted MII model for this study is:

$$MII_t = \frac{\left(\frac{fbg_t}{fbg_{t-1}}\right)}{\sigma_{fbg}} + \frac{\left(\frac{fbm_t}{fbm_{t-1}}\right)}{\sigma_{fbm}} + \frac{\left(\frac{inf_t}{inf_{t-1}}\right)}{\sigma_{inf}} + \frac{\left(\frac{npl_t}{npl_{t-1}}\right)}{\sigma_{npl}}, \mathrm{t} = 1,2,3, \ldots \mathrm{N} \quad (4)$$

In model (4), MII represents macroeconomic instability index, fbg is the ratio of fiscal balance to nominal GDP, fbm is the ratio of stock of foreign reserves position to base money, inf is the headline inflation rate, npl is the ratio of non-performing loans to total loans of deposit money banks (DMBs), t is time and σ is the standard deviation. The variables are standardised to normalise the volatilities in the components of the index (Supriyadi, 2014). The model assumes that deviation of observed values of a broad spectrum of macroeconomic indicators from their reference or trend value causes the occurrence of deviations around the trend of aggregate macroeconomic stability (Cariolle & Goujon, 2015). This implies that more variance in some crucial macroeconomic variables has higher rates of instability (Cardenas & Urrutia, 1995). The closer the index is to 1, the higher the rate of instability.

Unlike Jaramillo & Sancak (2007), the data in this model are not logged because the goal of the model defines which scale is important. This model is designed for real data such that its values are assumed to have absolute scale. This informed the transformation into ratios and further normalisation by the standard deviations of the respective variables to neutralise the scales of measurement and make their values compatible. With this transformation, the variables are scale-free and, therefore, additive to calculate a cumulative index to represent some construct or concept. In addition, the variables are selected, using the maximum likelihood technique of EFA to eliminate the problem of multicollinearity and heteroscedasticity.

III.4 MII Threshold Model Estimation Procedure and Techniques

Thresholds serve as an important EWS, which is described as a system of behavioural control on economic parameters indicating that exceeding predetermined threshold limits is considered the likely occurrence of future crisis (Berg et al., 2004). Several models provide detailed algorithms for MII threshold estimation procedures and techniques. Apparently, macroeconomic instability threshold would be an important issue for effective economic growth. There is a likely threshold level of macroeconomic condition, below which growth becomes difficult or even reversed.

III.4.1 Sameti Statistical Model

Sameti et al. (2012) devised a simple model for computing MII threshold for the Iranian economy. In this model, the periods in which the MII was more than 1.5 times of the standard deviation of the entire sample were considered as the critical periods. This crisis threshold was represented in model (5).

$$MII_t > mean(MII) + 1.5 \times stdev(MII), t \in (sample\ startpoint{:}\ sample\ endpoint) \quad (5)$$

In this model, stdev stands for the standard deviation of the macroeconomic instability. The choice of the threshold ensures that the number of estimated crises in the samples should be, at least, 5 per cent of the entire sample size. The advantage of this model is its simplicity of construction and interpretation. Its major shortcoming, however, is lack of econometric parameters to test its robustness. This may account for its limited use. However, it is used to compare with the robustness of autoregressive threshold analysis.

III.4.2 Autoregressive Threshold Models

Threshold in time series modelling is designed to capture asymmetric effects of shocks over shifts in economic relationships. This nonlinear model is used to determine a threshold value, or set of threshold values, used to predict the behaviour of variables in some important way. In this study, the threshold of MII is intended to serve as a warning signal that the level of macroeconomic instability is trending beyond the tolerance level. A central hypothesis is that there is some unobservable threshold, such that when exceeded, brings about a change in the behaviour of the MII.

Threshold regression model categorises the sample consistent with the realised value of some observed threshold variable (Yu and Phillips, 2014). The model employs Hansen (1996, 2000) methods for sample splitting and threshold estimation. The dependent variable, MII, with its lags, is regressed against its explanatory variables, using the Bai-Perron tests of sequentially determined threshold (Bai and Perron, 2003). Where this observed data lies in relation to some unobserved threshold, which is presumed to trigger regime changes in the MII, the model is called a threshold autoregressive (TAR) model.

III.4.2.1 TAR Model

In a threshold autoregressive (TAR) model for univariate time series, AR models are estimated separately in two or more intervals of values as defined by the dependent variable. These AR models may, or may not, be of the same order. Formal threshold models include the two-step TAR model of Tong & Lim (1980) as illustrated in (6).

$$y_t = \begin{cases} \chi_1 + \beta_1 y_{t-1} + \varepsilon_{1t} \; if \; q_{t-k} < \gamma \\ \chi_2 + \beta_2 y_{t-1} + \varepsilon_{2t} \; if \; q_{t-k} \geq \gamma \end{cases} \quad (6)$$

In the TAR model, γ ands for a threshold estimated jointly with all the parameters in the model. The variable qt-k is the state determining variable. The integer k determines the number of lags that the state-determining variable influences the regime in time t. The basic assumption in the TAR model is that the regime is determined by a variable qt-k, relative to a threshold value. In estimating the TAR model, when qt-k = yt-k, the result is a self-exciting TAR (SETAR) model.

III.4.2.2 SETAR Model

The SETAR model is a subset of autoregressive models, which provides for higher degree of flexibility in the model parameters through a regime switching behaviour in a time series data. The model is a tool for predicting future values of data series, which respond to different regime changes of its past values. In a SETAR(k, p) model, k is the number of regimes and p is the order of the autoregressive part. The SETAR(k, p) model allows for changes, triggered by delay in past values of the data series, in the model parameters in response to the value of weakly-exogenous threshold variable. A two-step Self-Exciting TAR (SETAR) model is given (7).

$$y_t = \begin{cases} \chi_1 + \beta_1 y_{t-1} + \varepsilon_{1t} \; if \; y_{t-k} < \gamma \\ \chi_2 + \beta_2 y_{t-1} + \varepsilon_{2t} \; if \; y_{t-k} \geq \gamma \end{cases} \quad (7)$$

This study explores the TAR and SETAR alternative models with a view of selecting the optimum.

IV. Empirical Findings

IV.1 MII Results and Diagnostics

Employing the data described in III.2.1 to III.2.4 on model 4 in III.3, the quarterly MII spanning for the Nigerian economy spanning from 2010q1 to 2017q2 was computed. Figure 1 depicted a graph of the computed MII values, compared with the corresponding GDP growth rates for the economy from 2010q1 to 2017q2. The result showed that calculated values for the index of macroeconomic instability over the study period fluctuated between 0.3155 and 0.6088, with a mean of 0.4095. The lowest MII value of 0.3155 (Point A) was attained in 2011q2, while the highest value of MII of 0.6088 (Point B) was recorded in 2016q1, when negative real GDP growth was first recorded.

Figure 1: Macroeconomic Instability Index and Economic Growth in Nigeria

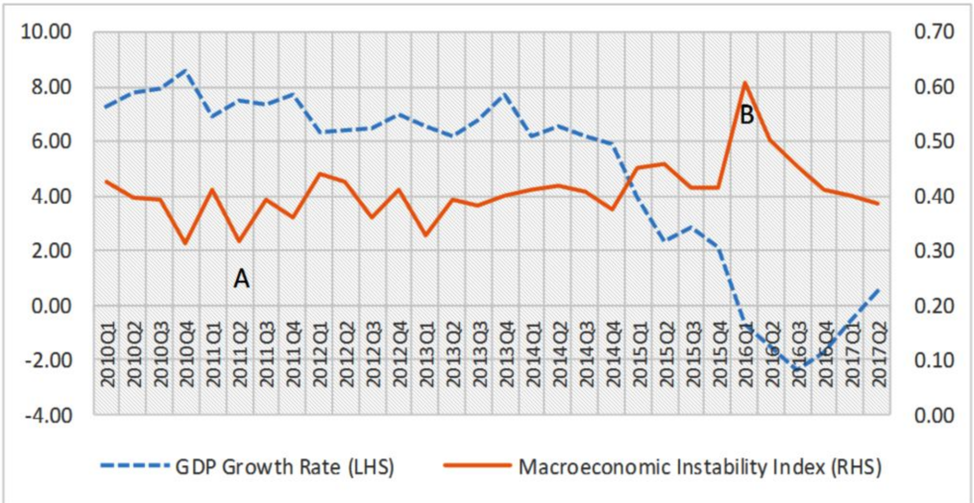

Table 1 indicated a significant negative correlation (-0.58) of MII and GDP growth rate in Nigeria. This confirmed the general findings that macroeconomic instability has an inverse relationship with economic growth. This compared favourably with the negative correlation (-0.6) reported by Haghighi et al., (2012) in a study of the Iranian economy from 1974 to 2008.

Table 1: Correlation Analysis

Variables	MII	FBG	FBM	INF	NPL	GRT
MII	1.0000§					
FBG	0.4122§	1.0000§				
	[2.3937]	-----				
	0.0236*	-----				
FBM	-0.3773§	-0.4813§	1.0000§			
	[-2.1560]	[-2.9056]	-----			
	0.0398*	0.0071*	-----			
INF	0.9137§	0.2504§	-0.2736§	1.0000§		
	[11.8936]	[1.3688]	[-1.5052]	-----		
	0.0000*	0.1820*	0.1435*	-----		
NPL	0.8170§	0.5157§	-0.4092§	0.5121§	1.0000§	
	[7.4984]	[3.1846]	[-2.3730]	[3.1550]	-----	
	0.0000*	0.0035*	0.0247*	0.0038*	-----	
GRT	-0.5849§	-0.2968§	0.7072§	-0.4515§	-0.5954§	1.0000§
	[-3.8154]	[-1.6447]	[5.2923]	[-2.6776]	[-3.9210]	-----
	0.0007*	0.1112*	0.0000*	0.0123*	0.0005*	- ----

(§) is the correlation; t-statistics are in parenthesis []; and (*) is probability, indicating the level of significance.

IV.2 The MII Thresholds Diagnostic Tests and Results

Threshold autoregressive models hypothesise that there are some unobservable thresholds, such that when crossed, brings about a change in the behaviour of the target variable, in this case, the macroeconomic instability index. The aim is to determine when the transition between regimes is made, and which transition variable (or threshold value) is more significant in explaining the regime change between the TAR and SETAR models.

Using the quarterly MII for the Nigerian economy spanning from 2010q1 to 2017q2 as displayed in Figure 1 (section IV.1), (section IV.1), an autoregressive conditional heteroskedasticity (ARCH) test was carried out to ensure that the presence of heteroskedasticity was not likely to have a significant influence on the results of the models. However, the Breusch-Godfrey test for serial correlation was first performed, to ensure the validity of the ARCH test. The null hypothesis was that there was no serial correlation. The null hypothesis was accepted, as shown in Table 2a.

Table 2a: Breusch-Godfrey Serial Correlation

F-statistic	0.617767	Prob. F(2,19)	0.5496
Obs*R-squared	1.526440	Prob. Chi-Square(2)	0.4662

Table 2b: Ljung-Box Q-statistic

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
. |* . |	. |* . |	1	0.192	0.192	1.0345	0.309
. |* . |	. |* . |	2	0.135	0.102	1.5667	0.457
. *| . |	. *| . |	3	-0.103	-0.153	1.8929	0.595
. | . |	. | . |	4	-0.040	-0.010	1.9452	0.746
. |**. |	. |*** |	5	0.306	0.375	5.1106	0.403
. | . |	.**| . |	6	-0.038	-0.213	5.1620	0.523
. |* . |	. |* . |	7	0.161	0.118	6.1313	0.525
. *| . |	. | . |	8	-0.081	-0.001	6.3918	0.603
. | . |	. | . |	9	-0.001	-0.036	6.3918	0.700
. | . |	. *| . |	10	-0.052	-0.154	6.5150	0.770
. *| . |	. | . |	11	-0.159	-0.037	7.7321	0.737
. | . |	. *| . |	12	-0.023	-0.071	7.7590	0.804

**Probabilities may not be valid for this equation specification*

Table 2c: Ramsey RESET Test

	Value	Df	Probability
t-statistic	0.182858	20	0.8568
F-statistic	0.033437	(1, 20)	0.8568
Likelihood ratio	0.041762	1	0.8381

The three statistics of the Breusch-Godfrey serial correlation (Table 2a); the Ljung-Box Q-statistic test for autocorrelation and partial autocorrelation (Table 2b); and the Ramsey RESET test (Table 2c), all rejected the presence of serial correlation, indicating that there was no serial correlation in the model. The tests for heteroskedasticity in Table 3 rejected the null hypothesis of the presence of heteroskedasticity. These tests justified the robustness of the SETAR models.

Table 3: Heteroskedasticity Test (ARCH)

F-statistic	0.260345	Prob. F(1,22)	0.6150
Obs*R-squared	0.280691	Prob. Chi-Square(1)	0.5962

In the SETAR model, the threshold variable was the endogenous lagged dependent variable. The best fitting delay parameter for lagged values of MII was found by minimising the sum of square residual (SSR) of the SETAR model. The delay parameter was allowed to vary from 1 to 5, while specifying the model and choosing the delay parameter that minimised the SSR. The maximum number of regimes was set to five and the models were estimated iteratively, capturing the SSR for each specification through the Bai-Perron method of L+1 vs L sequentially determined thresholds (Bai & Perron, 1998).

Table 4: SETAR Model Selection Criteria

Threshold Variable	SSR	Regimes
MII(-3)	0.039491	2
MII(-4)	0.046771	2
MII(-1)	0.079538	1
MII(-2)	0.079538	1
MII(-5)	0.079538	1

Table 4 showed that the best fitting threshold variable for the SETAR model was found to be MII(-3) with SSR of 0.0395. This corresponded with the value of the best fitting threshold variable for the TAR model which was found to be MII(-5) as shown in Appendix V. The congruence of results of the two models eliminated the problem of selection between TAR and SETAR through further tests to determine the one with the minimum SSR, since the derived threshold would remain same for the two models.

Table 5: Summary of SETAR Specifications and Threshold Values

Dependent Variable: MII
Method: Threshold Regression
Threshold type: Bai-Perron tests of L+1 vs. L sequentially determined thresholds
Threshold variables considered: MII(-1) MII(-2) MII(-3) MII(-4) MII(-5)
Threshold variable chosen: MII(-3)
Threshold selection: Trimming 0.15, , Sig. level 0.05
Threshold value used: 0.4606442

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MII(-3) < 0.4606442 -- 22 obs				
MII(-5)	0.084273	0.157153	0.536251	0.5974
C	0.371303	0.064384	5.766969	0.0000
0.4606442 <= MII(-3) -- 3 obs				
MII(-5)	-5.082672	1.336222	-3.803764	0.0010
C	2.514060	0.536982	4.681833	0.0001

R-squared	0.503509	Mean dependent var	0.413662
Adjusted R-squared	0.432582	S.D. dependent var	0.057569
S.E. of regression	0.043365	Akaike info criterion	-3.292687
Sum squared resid	0.039491	Schwarz criterion	-3.097667
Log likelihood	45.15859	Hannan-Quinn criter.	-3.238597
F-statistic	7.098953	Durbin-Watson stat	1.374286
Prob(F-statistic)	0.001794		

Figure 2 indicated that at 0.9180, the probability of Jarque-Bera was well above the 5 per cent model acceptance level of goodness of fit. Thus, the SETAR model was normally distributed and, hence, a reliable MII threshold prediction framework.

Figure 2: SETAR Model Normality Test

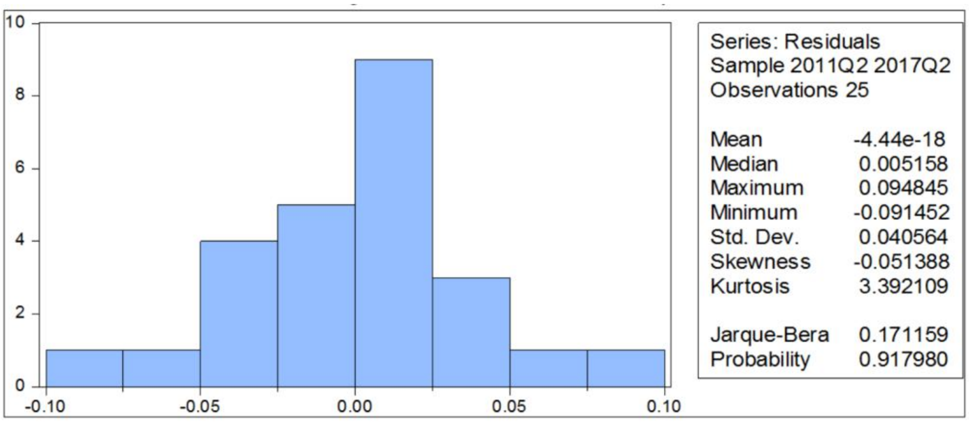

Table 5 summarised the threshold specification and the associated threshold values for the TAR model. The MII threshold was 0.461 at 5 per cent significant level. This compared well with the Sameti's (2012) crisis threshold model given as follows:

Given that mean (MII) = 0.4095; and stdev(MII) = 0.0574,

$$MII_t > 0.4957, t \in (2010_{q1}: 2017_{q2})$$

This value exceeded the 0.461 from the SETAR model. It should be noted, however, that the Sameti threshold was designed to identify crisis periods, which is usually a point when the economy is already plunged into economic predicament. This is different from the autoregressive thresholds, which were intended to be early warning signals as the economy moves gradually away from a tranquil period. Thus, this study adopts the SETAR value.

IV.3 Results and Discussion

The result of the threshold diagnostic studies indicated that the autoregressive threshold value was 0.461. This threshold parameter has significant macroeconomic implications for the economy. It implies that any value of MII above 0.461 flags off a warning signal that the economic condition is heading towards instability, with the attendant adverse effect of economic crisis. Beyond this threshold value, the economy is most likely to slide into a recession.

In-sample result of this study attested to this prediction. It revealed that the 2016-2017 economic recession was preceded with a warning signal in 2015q2, when the MII rose to 0.461. The threshold value is essential in determining when and how to switch over from traditional to unconventional economic policy stance. It is also important in designing an appropriate unconventional policy, when necessary, to avoid unintended consequences on the economy.

Perhaps, had this warning been noted and heeded with appropriate policy actions, the 2016-2017 economic recession might have been averted, or at least mitigated. The major implication of a prolong instability condition, beyond the threshold is that the efficacies of most of the conventional economic policies become weak. Consequently, normal economic policies may no longer produce the desired macroeconomic outcomes. To forestall the continuous worsening of existing economic conditions, monitoring the MII and the EWS is imperative in ensuring a stable macroeconomic condition.

V. Conclusion

From empirical results, it has been established that macroeconomic instability is inimical to growth and that the strength of empirical relationship has remained uncertain in Nigeria. This makes it difficult to have reliable planning, monitoring, and predicting macroeconomic instability. The distinctive implications include the inability to detect and diagnose symptoms of macroeconomic instability as early as possible; as well as determine the appropriate policy options, to address it. The use of multiplicity of proxies for this latent variable suffers the usual limitations of measurement error, associated with disaggregated variables across a range of indicators. This problem broadly underlines the significance of this paper.

Statistical algorithms and econometric techniques, including factor analysis and threshold autoregressive models, were employed. The results identified a mix of monetary and fiscal factors, as key drivers of macroeconomic instability in Nigeria. These were fluctuations in price level changes, volatility in the ratio of non-performing loans to total loans of deposit money banks (DMBs), variability of fiscal balance to GDP, and swings in foreign reserves to base money. In relative terms, inflation and the ratio of non-performing loans to total DMBs loans ranked very high in influencing macroeconomic instability in Nigeria. The calculated values for the index of macroeconomic instability ranged between 0.316 and 0.859, with a mean value of 0.609. The instability threshold for Nigeria was 0.461. This should serve as a EWS beyond which unconventional policy options to mitigate and reverse the MII trend becomes eminent. The result also confirmed that GDP growth rate was adversely correlated (-0.58) with macroeconomic instability, confirming that macroeconomic instability has generally been associated with poor economic growth performance.

The policy implication is that there is need to monitor carefully the MII, as an early warning signal, to ensure that macroeconomic conditions remain stable, over time.

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Appendices

Appendix I: Exploratory Factor Analysis

	Loadings F1	Communality	Uniqueness
FBG	0.635884	0.404348	0.595652
FBM	-0.550885	0.303474	0.696526
INF	0.556954	0.310197	0.689803
NPL	0.823160	0.677593	0.322407

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	1.695612	1.695612	---	1.000000	1.000000
Total	1.695612	1.695612		1.000000	

	Model	Independen ce	Saturated

Appendix II: EFA Goodness-of-fit Summary

	Model	Independence	Saturated
Parameters	8	4	10
Degrees-of-freedom	2	6	---
Parsimony ratio	0.333333	1.000000	---

Absolute Fit Indices

	Model	Independence	Saturated
Discrepancy	0.090303	0.933063	0.000000
Chi-square statistic	2.618792	27.05884	---
Chi-square probability	0.2700	0.0001	---
Bartlett chi-square statistic	2.362933	25.03720	---
Bartlett probability	0.3068	0.0003	---
Root mean sq. resid. (RMSR)	0.075199	0.421276	0.000000
Akaike criterion	-0.046040	0.501961	0.000000
Schwarz criterion	-0.139453	0.221722	0.000000
Hannan-Quinn criterion	-0.075924	0.412310	0.000000
Expected cross-validation (ECVI)	0.642027	1.208926	0.689655
Generalised fit index (GFI)	0.956092	0.652563	1.000000
Adjusted GFI	0.780459	-0.737185	---
Non-centrality parameter	0.618792	21.05884	---
Gamma Hat	0.959071	0.407775	---
McDonald Noncentralilty	0.989388	0.695528	---
Root MSE approximation	0.103290	0.347891	---

Incremental Fit Indices

	Model
Bollen Relative (RFI)	0.709656
Bentler-Bonnet Normed (NFI)	0.903219
Tucker-Lewis Non-Normed (NNFI)	0.911848
Bollen Incremental (IFI)	0.975306
Bentler Comparative (CFI)	0.970616

Appendix III: CFA Robustness Thresholds

Measure	Threshold
Chi-square/df (cmin/df)	< 3 good; < 5 sometimes permissible
p-value for the model	> .05
CFI	> .95 great; > .90 traditional; > .80 sometimes permissible
GFI	> .95
AGFI	> .80
SRMR	< .09
RMSEA	< .05 good; .05 - .10 moderate; > .10 bad
PCLOSE	> .05

Appendix IV: Principal Components Analysis

Eigenvalues: (Sum = 4, Average = 1)

Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	2.233376	1.403589	0.5583	2.233376	0.5583
2	0.829786	0.276712	0.2074	3.063162	0.7658
3	0.553074	0.169310	0.1383	3.616236	0.9041
4	0.383764	---	0.0959	4.000000	1.0000

Eigenvectors (loadings):

Variable	PC 1	PC 2	PC 3	PC 4
FBG	0.511041	-0.441163	0.523388	0.519883
FBM	-0.482412	0.459788	0.735138	0.124281
INF	0.442182	0.739976	-0.247431	0.442368
NPL	0.557307	0.215421	0.352726	-0.720130

Ordinary correlations:

	FBG	FBM	INF	NPL
FBG	1.000000			
FBM	-0.481316	1.000000		
INF	0.250432	-0.273594	1.000000	
NPL	0.515650	-0.409191	0.512124	1.000000

Appendix V: Summary of TAR Specifications and Threshold Values

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MII(-3) < 0.4606442 -- 22 obs				
MII(-5)	-6.93E-16	4.33E-15	-0.160249	0.8746
C	-8.57E-15	3.98E-15	-2.151999	0.0461
0.4606442 <= MII(-3) -- 3 obs				
MII(-5)	2.34E-13	5.92E-14	3.952247	0.0010
C	-1.04E-13	2.70E-14	-3.850860	0.0013