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Time series analysis of structural breaks in Nigeria's macroeconomic data

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Abstract
This research paper investigates empirically the analyses of structural breaks in Nigeria's macroeconomic time series data using annual data spanning from 1970 to 2015. Among other objectives is to examine whether there is stability or breaks in the mean level of interest rates, exchange rates and inflation rates over the periods under review. The research paper adopts a Lee and Strazicich (2003) unit root tests with multiple break test using LM approach to examine the stability of data employed and structural changes in linear regression model, using Chow test to identify the break dates. The paper further assumes three different dates – 1970 to 2015, where there was no break, 1970 to 1986 before break and 1986 to 2015 after break, at which there was a statistically significant breaks. The F-statistic test from the Chow test results indicates 28.98, which is greater than the 95 percent critical value of 2.62 This suggests that endogenously determined breaks for the macroeconomic variables (interest rates, exchange rates and inflation rates) of the Nigerian economy was found to exhibit structural breaks within the periods under review. This implies that the null hypothesis of no significant relationship between structural breaks and macroeconomic variables in Nigeria was rejected. Based on the above evidence, the paper submits that there should be an adoption of regime switching models that will minimize the potentiality of breaks in time series data in Nigeria.

Keywords: structural breaks, macroeconomic variables, chow test, Nigeria

1. Introduction
Time series data have structural changes occur for a number of reasons, among which are economic crises, changes in institutional arrangements, policy changes, civil war and regime shifts among others. Most importantly, if the structural changes are present in the data generating process but not incorporated in the unit root test specification, the results may be biased towards flawed non-rejection of the non-stationarity hypothesis (Perron, 1989; Perron, 1997; Leybourne and Newbold, 2003) [38, 39, 31]. The consequence of such a result in turn implies that any shock whether demand, supply or policy induced to the variable will have effects on the variable into the very long run, which invariably may affect accuracy in prediction and forecasting (Chukwu,, Agu & Onah, 2010) [9].

The launch of Structural Adjustment Programme (SAP) in 1986 in Nigeria marks a structural break in the
Nigerian economy. This resulted in a large shift to export promotion strategy and attempts to provide the enabling environment to attract foreign investment. In the manufacturing sector, the basic objectives of SAP were to restructure and diversify the production base of the economy, increasing capacity utilization to about 50 percent, streamlining the administration of import licensing by involving the manufacturers themselves, realignment of the tariff structure to favour local sourcing of raw materials, and provision of adequate infrastructure. The fixed exchange rate regime adopted since independence was replaced by floating exchange rate after the devaluation of the Nigerian Naira in 1986 (Strazicich, Lee & Day, 2004) [43]. In 1987, government amended the 1984 tariff policy in response to complaints by manufacturers. Also, government deregulated the interest rate so that it was now market determined. The 1987 revised tariff policy was replaced by 1988-1994 tariff policy to bring a measure of stability, consistency, and predictability (Hailegiorgis, Belayand Bekele, 2011) [20].

Indeed, in between 2002 to 2013, Nigeria witnessed a series of policy changes both structurally and institutionally. For instance, the structure of the Nigerian financial sector changed within these periods in terms of the number of institutions, capital requirements and licensing of new institutions. Most especially, in the banking sub-sector, the number of commercial banks declined to twenty (20) from twenty-four (24), following the mergers/acquisitions of four (4) of the intervened banks by four (4) healthy banks (CBN, 2010). The number of commercial bank branches, however, increased to 5,810, from 5,799 in 2012 indicating an increase of 0.2 per cent (CBN Annual Abstract, 2013) [8]. In structural term, changes account for approximately one-fifth of the total change in labour productivity in Nigeria between 2001 and 2013. With changes in these policy shifts, macroeconomic variables such as interest rates, exchange rates and inflation rates were adversely affected.

2. Literature Review
2.1 Theoretical Consideration
The theory of balanced growth in its analysis, as was first proposed by John Von Neumann in 1945 and was popularized by Hoffmaister, Roldos & Wieckham (1997) [23], is adopted in this research paper. According to the theory's proponent, the theory stipulates that goods are produced not only from "natural factors of production", but in the first place from each other. This implies that the processes of production may be circular, that is good G1 is produced with the aid of good G2 and good G2 with the aid of G1. This theory was read for the first time in the winter of 1932 at the mathematical seminar of Princeton University. It was first published in German. After which, it was translated into English by G. Morgenstern. The model is also known as Von Neumann's "Expanding Economic Model". It represented a controversial source of many strands of research in economic theory, from general equilibrium models, to linear models of

production based on input-output analysis, to structural models of reproduction.

The model presented by von Neumann is, therefore, the first complete and mathematically rigorous formulation of a fully circular view of the economic system, in which neither original resources nor final consumption play a crucial role. The model reflects an economic system, within a given period of time, which allows the transformation of certain goods into others. The model works with *n* goods and *m* production processes and it represents a closed economy in which the production requirements of certain goods in any given period, cannot come from outside the economy, but must proceed from the production of the previous period of the same economy.

The theory assumes the following; that there are constant returns to scale. This assumption means that any economic process can be carried out at *x* times its given scale, without any increase in costs per unit output; that the natural factors of production, including labour, can be expanded in unlimited quantities. This assumption implies that there are no limits on natural resources needed for expansion. Moreover, conditions of perfect competition in the long run are assumed; and finally that consumption of goods takes place only through the processes of production which include necessities of life consumed by workers and employees. This assumption implies that all income from property in excess of necessities of life is saved and reinvested. The theory is therefore, relevant to the present study because it represents the structural changes of economic phenomenon through a natural state and fluctuations of economic variables.

2.2 Empirical Literature

A number of research studies have identified various macroeconomic fluctuations, in particular, sudden and often negative variations in output and economic fundamentals in the design of sound economic and stabilization policies (Koze and Riezman, 1998; Collier and Gunning, 1999; Sachs and Warner, 1996 and Rodrick, 1998) [25, 11, 42]. Indeed, most recent literatures do confirm that a highly unstable domestic macroeconomic environment is one of the primary reasons for the poor growth performance of African countries in the past three decades (Emmanuel and Cletus, 2011; Nyong and Udah, 2012, and Lydia, Conrado and Ciliaka, 2014) [14, 35, 33]. Also, changes in phases, may affect economic relationship between variables and hence, stability of parameters over a period of analysis. These can lead to misspecification and misleading inferences due to inefficiency and lack of consistency of parameters (Yang, 2002). For instance, Altinay (2005) [3] investigated structural breaks in Turkish macroeconomic data using the sequential Dickey-Fuller type test and the minimum Lagrange Multiplier (LM) test for endogenous breaks within the periods 1960 to 2002. Zivot and Andrews (1992) [45] and Lumsdaine and Papell (1997) [32] tests indicates the shocks are permanent contrary to Lee and Strazicich (2003 and 2004) [27, 30] minimum LM unit root tests.

Waheed, Mohammed, Tasneem Alam, and Saghir (2007) [44] using Pakistan data adopted the approach developed by Zivot and Andrews (1992) [45], which identified endogenously the point of the single most significant structural break for a set of time series, between the periods 1972 to 2004. Their study found that there is a presence of a structural break during the period under investigation.

Alaro, Kassa and Hundie (2011) [2] using 1974 to 2009 annual data from Ethiopia, applied the Chow test to determine the break dates and found that the break date occurred in 2003, eleven years after the regime shift through a policy change. Their results showed that some break points could occur with a lag for different variables.

Ghatak (1997) [19] tests the unit root hypothesis under structural breaks for twelve macroeconomic time series data for India for the period 1960-1988. The results show that conventional ADF test allowing for no structural breaks cannot reject the unit root hypothesis for any of the series thereby supporting Nelson and Plosser's (1982) [34] findings.

Arize, Malindretos and Nam (2005) [4] in a study of inflation and structural shift in fifty developing countries (including five African countries, namely Gabon, Ghana, Kenya, Mauritius and Morocco) used the fractional integration test of Geweke and Porter-Hudak (1983, GPH hereafter) within the periods 1970 to 2000, the authors found that inflation can be modeled as a non-stationary variable. Kumar, Webber and Scott (2011) [33] in a study to evaluate the stability of the money demand function in Nigeria applied the ADF and Elliot-Rothenberg-Stock (ERS) tests on real money, real income, nominal rate of interest, real exchange rate and inflation rate over the period 1960-2008. The study found for the ADF test that the unit root test under the null of no unit root in these variables cannot be rejected at the five per cent level (except for the inflation rate).However, the ERS test suggests that all the levels of the variables are non-stationary. Unlike the ADF test, the ERS test finds that the inflation rate is a non-stationary series.

In a related study, Chukwu, Agu and Onah (2010) [9] investigated the presence of co-integration and structural breaks in the Nigerian long-run money demand function using co-integration approach within the periods 1970 to 2007. Their study founds that the Ng – Perron test for unit root suggests that the null hypothesis of a unit root in real money demand, real income, inflation and the spread between the lending and deposit rates in their levels cannot be rejected. However, the Ng – Perron test rejects the null that their first differences have unit roots. Godwin (2011) [16] in his study on macroeconomic fluctuations, regime switching (structural breaks) and impulse response in Nigeria using annual time series spanning 1960 to 2008. Applying ADF and co-integration approach to determine the break periods, the study found that there was a structural breaks in the variables under investigation and concludes that there should be stability in policy design within the period under review.

Also, Emmanuel and Cletus (2011) [14] investigated on structural breaks in some selected West African Monetary Zone (WAMZ) using the method of Lee and Strazicich (2003) [27] to identify the point of structural breaks in all the variables under study within 1970 to 2008. Their study found that there were spurious rejections in the ADF tests of the selected WAMZ countries. They concluded that breaks in these fundamentals are important source of persistence and hysteresis in the price level.

Olanrewaju, OlaOluwa and Raphael (2012) [14] investigated on the structural breaks and non stationary fractional integration on times series in Nigeria within 1960 to 2006 using Autoregressive Fractional Integrated Moving Average (ARFIMA) and Autoregressive Integrated Moving Average (ARIMA) models as a tool. The authors found that Nigeria under investigation experience one or more breaks over the years and concluded that this is due to instability in government and economic policies.

Following, Nyong and Udah (2012) [35] studied on Structural breaks and industrial time series of Nigeria within 1970 to 2009. The aim was to test the unit roots in the presence of multiple endogenous structural breaks. Adopting the Lee and Strazicich (2003) minimum Lagrange Multiplier (LM) approach to test the null hypothesis of unit roots against the break stationary alternative, the authors found that the fall in the price of oil in 1981, introduction of SAP in 1986, tariff policy reform as well as policy shift towards measures to promote capacity utilization and grant tax concession were the major causes of structural breaks in the variables under review. They therefore concluded that there should be a policy shift towards measures to promote capacity utilization, increase manufacturing output and grant tax concessions to exporters.

Douglason and Patience (2012) [13] worked on structural breaks, demand for money and monetary policy in Nigeria between the periods 1960 to 2008, using the Gregory and Hansen procedure or technique and co-integration approach to establish the break points. They discovered that there is a stable money demand function for Nigeria and concluded that CBN has effectively used money supply as a monetary policy instruments. Lydia, Conrado and Ciliaka (2014) [33] studied on the evidence of structural breaks in Kenya macroeconomic variables within 1973 to 2011. By using ADF unit root tests and co-integration approach, the study identified structural breaks which coincide with identifiable climatic, economic and political shocks within the period under study. They concluded that care must be taken to tackle these macroeconomic fluctuations in Kenya so that it may not lead to model misspecification and spurious results of model parameters. In conclusion from the empirical studies, as reviewed above, findings on the structural breaks in the macroeconomic time series data in both developed and developing economies have been divergent and inconclusive. This variation could be traced to choice of variables, methodologies and (or) sample periods, hence; the need for this study to fill the gap.

3. Methodological Issues

3.1 Model Specification

The method of Lee and Strazicich (2003a & b) as modified by Emmanuel and Cletus (2011) [14] was adopted in this paper to test for unit root hysteresis and persistence in the Nigeria's macroeconomic variables. The single and two-break LM unit root tests are vigorous as it is placidly affected by breaks under the null hypothesis. The choice of Lee and Strazicich (2003a & b) [27, 28] was informed by the fact that it allows for structural changes under the unit roots null hypothesis as stochastic non-stationarity may lead to size distortions. Another merit of adopting this method lies on its flexibility of identifying the number of breaks given the information asymmetry about specific break points. All data were largely sourced from Central Bank of Nigeria (CBN) Statistical Bulletin Volume 24, December 2013, the CD - ROM of 2014 and International Financial Statistics (IFS), various years.

However, the Lagrange Multiplier (LM) unit root test is employed and it takes the following form;

$$y_t = \alpha^I M_t + e_t \quad (1)$$

Where

$$e_t = pe_{t-1} + \varepsilon_t \quad (2)$$

M_t denotes the exogenous variables (interest rates, exchange rates and inflation rates) and ε_t is an error term that follows the classical properties. As pointed out by Perron (1989), the use of Lagrange Multiplier (LM) unit root test allows for structural breaks. By bringing the model into a more explicit form gives credit to equation (3) as specified thus:

$$y_t = \alpha^I + Intr_{t-1} + Exr_{t-1} + Infr_{t-1} + pe_{t-1} + \varepsilon_t \quad (3)$$

where, y_t denotes the growth rate of GDP per capita lagged in a period of time t; $Intr$ represents interest rates of a single lag of time t; Exr signifies the exchange rate of a single lag of time t while $Infr$ stands for the inflation rate of a single lag of time t.

3.2 Estimation Procedure

As earlier stated, this research paper adopts a Lagrange Multiplier (LM) unit root test to determine the stationarity status of all the macroeconomic time series data engaged in this study within the specified periods (1970 - 2013). However, the F test (Chow test) was also applied to test the existence of endogenously determine structural break time in these dates. Thus, the paper signifies structural break with adopted Chow test of Perron (1989) [38] structural break analysis model. In this case, in order to apply the Chow test, equation (4) specifies a single regression line to fit the data points or scatter plot, which can be expressed as;

$$\log s_t = \alpha_0 + \alpha_1 \log x_1 + \alpha_2 \log m_1 + \alpha_3 \log n_t + u_t \quad (4)$$

where; s refers to structural breaks, x denotes interest rate, m represents exchange rate, n is the inflation rate, α are the parameters to be estimated, t is time in years while u_t is the random term that is independently and identically distributed with mean zero and variance. The model in effect determines whether a single regression is more efficient than three separate regressions involving splitting the data into three subsamples as given below:

$$\log s_t = \beta_1 + \beta_2 \log x_t + ut_1 \quad (5)$$

$$\log s_t = \delta_1 + \delta_2 \log m_t + ut_2 \quad (6)$$

$$\log s_t = \theta_1 + \theta_2 \log n_t + ut_3 \quad (7)$$

Where, all variables are as previously defined, β's, δ's, and θ's are unknown parameters to be estimated and ut is the random disturbances.

The above analysis follows that model (5) applies before the break at time t, while model (6) applies after the structural breaks. If the above three models (that are; models 5, 6 and 7) are the same, then the three models can be expressed as a single model as in the case of model (4), where there is a single regression line. The Chow test (the F-test) basically tests whether the single regression line or the three separate regression lines fit the data best. For this research work, regressions were run for each of the assumed policy events date (1970 – 2013; 1970 – 1986; and 1987 - 2013). Then, test for structural break involves testing whether the coefficients on $\beta_2 \log x_t$, $\delta_2 \log m_t$ and $\theta_2 \log n_t$, are significantly different from zero. The empirical results were obtained to test the Hypothesis H0: α = structural stability versus H1: α = structural breaks, regression of RSS (regression using all the data, before and after the structural break), RSS_1

(regression on the data before the structural break) and RSS_2 (regression on the data after the structural break) is done (Hailegiorgis, Belay and Bekele, 2011) [20].

4. Results and Discussion

4.1 Unit Root Test

In analyzing the unit root test, this research paper noted that given several economic crises such as changes in institutional arrangement, policy changes and regime shift in Nigeria, time series macroeconomic variables such interest rates, exchange rates and inflation rates were subjected to structural breaks and the LM unit root test is considered biased towards not rejecting the unit root at the first difference. Thus, the time series properties of the selected macroeconomic data for Nigeria were first examined by using the LM unit root test during the periods under study. As odserved, the null hypothesis of a unit root in all the variables under investigation was not rejected at the five percent significant level.

However, the LM unit root test results without break are as reported in Table 1, while those with structural breaks are as shown in Table 2 below:

Table 1: Summary of Results of Unit Root Tests without Structural Break in Nigeria

Variables	ADF [k]
Real GDP	-3.67042 (0)*
Interest Rate	-6.96609 (1)**
Exchange Rate	-4.01044 (1)*
Inflation Rate	-3.82556 (1)*

Note: Linear trend included. For LM test, critical values at 1%, 5% and 10% significant level are: -3.5930, -2.9320 and -2.6039 respectively. * denotes statistical significance at 1% and ** denotes statistical significance at 5% level.

Table 2: Summary of Result of Lee and Strazicich with Multiple Break Test using LM approach

Variables	a (t-statistics)	[k]	TB 1/TB 2	t- statistics
Real GDP	-0.3674	[1]	1970	-3.5474
	(-5.6278) ***		1982	-4.2166
Interest Rate	-0.5278	[1]	1986	-2.5647
	(-7.4398) **		1993	-3.6714
Exchange Rate	-0.3672	[1]	2001	-2.6883
	(-5.4637) **		2006	-3.6847
Inflation Rate	-0.4725	[1]	2007	-2.4636
	(-6.4636) *		2015	-3.3259

The critical values for Lee-Strazicich two break test are -6.15, -5.87 and -4.73 at 1%, 5% and 10% levels of significance, respectively. (*), (**) and (***) denote statistical significance at 10%, 5% and 1% levels, respectively.

Table 2 above reports the empirical evidence of Lee-Strazicich with multiple break tests of the time series macroeconomic variables selected in Nigeria. The table shows that breaks in Nigeria's time series data were attributed to economic adjustments in the mid 1980s, specifically the Structural Adjustment Programme (SAP) launched in Nigeria in 1986. Other reasons adduced to the break included regime shift from control to indirect monetary policy implementation technique witnessed between 1991 and 1993, and thereafter. Also, interest rate was deregulated by government such that the rates charged by financial institutions were solely determined by the forces of demand and supply.

However, the exchange rate, which was hitherto fixed by current policy then, was allowed to be devalued. This was done to boast the value of domestic currency in terms of foreign currency. Again, the banking crisis which Nigerian financial institutions witnessed in the late 80s, between 1994 and 1998, and also between 2005 and 2010, caused a serious break in the money supply and consequently a rise in interest rates. In the area of inflation rates, the results show that breaks in the consumer price level were associated with breakpoints in output, exchange rates, interest rates and money supply. This could be attributed to a break in institutional arrangement in the late 2000s. Specifically, breaks in these fundamentals are important sources of persistence and hysteresis in the price level.

4.2 Chow Test

From the foregoing, it has been established that time series of data can often contain a structural break, due mainly to a change in policy, which invariably could lead to a sudden shock to the economy. However, in order to test for a structural break, we often use the Chow's test. This paper therefore, adopts the Chow's first test since the second test relates to prediction, which is not within the scope of this paper. Thus, the model uses an F-test to determine whether a single regression is more efficient than two separate regressions which splits the data into two sub-samples. From our sample data, the study noted that three periods were significant in the application of Chow test, that is; the periods 1970 to 2013, 1970 to 1986 and the periods 1987 to 2015.

In each of the time series, two cases exist. In the first case, the paper adopts a single regression line to fit all the data points, which can be expressed as in equation (5). In the second case, where there is a structural break and two separate models, as can be seen in equations (6) and (7) above. Thus, the classical test for structural change is attributed to Chow (1960). It is a famous econometric test which splits the sample into sub-periods, estimates the parameters for each of the sub-periods and then tests if the two sub periods are equal with the help of F-statistics (Hanson, 2001). The Chow test basically shows whether the single regression line or the two separate regression lines fit the data best (Morley, 2006). Thus, Table 4 reports the result of the Chow test using the data set.

Table 3: RSS (Residual sum of squares) for all data (1970 - 2015)

Model	Source of Variation	Sum of Squares	Degree of Freedom	Mean Squares	F (statistics)	Sig.
1	Regression	4313.232	4	1078.308	92.5283	0.000 (a)
	Residual	512.768	44	11.65382		
	Total	4826.000	48			

RSS = 512.768

Table 4: RSS (Residual sum of squares) before structural break time (1970 - 1986)

Model	Source of Variation	Sum of Squares	Degree of Freedom	Mean Squares	F (statistics)	Sig.
2	Regression	164.162	4	41.0405	832.5638	0.000(a)
	Residual	0.838	17	0.049294		
	Total	165.000	21			

RSS_1 = 0.838

Table 5: RSS (Residual sum of squares) after structural break time (1987 - 2015)

Model	Source of Variation	Sum of Squares	Degree of Freedom	Mean Squares	F (statistics)	Sig.
3	Regression	1764.125	4	441.0313	112.4708	0.000(a)
	Residual	105.875	27	3.921296		
	Total	1870.000	31			

RSS_1 = 105.875

Analysis of Chow Test Results

From the empirical results obtained and presented in tables 4, 5 and 6, it can be stated that a single regression line in not a good fit of the data due to the obvious structural break witnessed in Nigeria in 1986 as a result of Structural Adjustment Programme (SAP). Therefore, it becomes necessary to analyze three separate regression equations which is more efficient compared to a single regression line. Thus, the analysis requires a Chow test, which is a variation of the F-test for a restriction. This can be stated as:

$$F = \frac{RSSR - (RSS_1 + RSS_2)k}{RSS_1 + RSS_2/(N_1 + N_2 - 2k)} \quad (8)$$

where; $RSSR$ is the residual sum of squares of the model on all data; RSS_1 and RSS_2 are the sum of residual squares of the models on the two subset of data (before and after structural break time) respectively; and k is the number of restrictions (parameters to be estimated). Based on the regression results as seen in the above tables, the F-statistics can be computed and obtained as follows:

F = 28.98

From the computation above, it can be noted that the F-statistics is given as 28.98. The critical value for F (4, 44) is 2.62 at 5 percent level of significance. This implies that the test statistic of 28.98 is greater than the 95 percent critical value of 2.62. Based on the above evidence, the paper therefore, rejects the null hypotheses as postulated in chapter one which states that there is no significant relationship between interest rates, exchange rates, inflation rates and structural breaks in Nigeria. The implication of the above findings suggests that there is a structural break time in the macroeconomic variables under investigation. This empirical evidence, however, coincides with the recent study of those of Lydia, Conrado and Ciliaka (2014) [33] who studied on the evidence of structural breaks in Kenya's macroeconomic variables within 1973 to 2011 and identified structural breaks with identifiable climatic, economic and political shocks among the variables under study. Conclusively, from the empirical evidence as shown above, the paper decides that structural breaks occur in the variables under study within the periods under review.

5. Conclusion

So far, the research paper has established that structural breaks exist in all the variables employed in this study. However, structural change is pervasive in macroeconomic time series relationships, and it can be quite perilous to ignore. Inferences about economic relationships can go astray, forecasts can be inaccurate, and policy recommendations can be misleading or worse. The new tools developed in the past few years are useful aids in econometric model specification, analysis and evaluation. Ideally, a more realistic model is one with time varying parameters. A genuine structural break can still be accommodated by allowing the parameters to change rapidly at the time of the event. Such models also provide much better forecasts, because they better approximate the underlying data generating mechanism.

Finally, though a simple testing procedure has been identified in this paper, the study however, may not conclude completely whether breaks stem from loadings or from the volatility of the factors, rather the paper plan to derive other alternative tests based on the rank of the covariance matrix of the estimated factors in different subsamples which can also be extended to test for other sources of parameter instability.

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