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On Application of Cointegration and Vector Error Correction Model to Macroeconomic Time Series Data

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Abstract
Investment in the stock market is long term in nature. Any development that could affect the stability of the economy usually has serious impact on the stock market performance. This research work examines the impact of some macroeconomic variables (Inflation, Interest and Exchange rates as well as Real Gross Domestic Product) on Nigerian stock market index. The methodologies used are cointegration and vector error correction model using annually data collected from Nigeria stock exchange fact book and Central Bank of Nigeria statistical bulletin (2013). From the results obtained the Augmented Dickey-Fuller (ADF) test reveals that all other macroeconomic indicators were stationary at the first order of difference except for SMI and RGDP that were stationary at the second order of difference, I(2). The Johansen co-integration test shows there are at least three co-integrated variables out of the five economic series considered in this study at 5% level of significance. The vector error correction models obtained generalised that there exists dynamic relationship between all the macro economic variables, but the four macroeconomic indicators jointly affect and influence the stock market index.The portmanteau test for residual autocorrelation in the *VEC* show no autocorrelation is left at lag(1) and VEC(1) is the better specification for analysing the interaction between stock market index and macroeconomic variables. In conclusion, government should implement policies that will reduce inflation rate and poverty level through infrastructural development and improved standard of living. Also, interest rates should be made moderate in order to encourage investment and transactions in stocks in the Nigerian Capital Market. The negative exchange rate shows that the Nigeria economy is readily open for international trade. And finally, the RGDP indicates positive impact with the stock market index.
Keywords: Market Interaction, VEC, Cointegration and Macroeconomic variables.

1. Introduction

The Nigerian economy has been experiencing series of social, political and economic policies and reforms over the years. Before 1970, the economy was basically agrarian. The need to encourage private capital for development was realised early enough with the establishment of the Nigerian Stock Exchange (NSE) formally called the Lagos Stock Exchange in 1961 to develop the capital market.

Investment for promotion of economic growth and development requires long term funding, far longer than the duration for which most savers are willing to commit their funds (Alile, 1992). The capital market is the heart beat of the economy given it ability to respond almost instantaneously to fundamental changes in the economy. It encourages savings and real investment in any healthy economic environment. Aggregate savings are channelled into real investment that increases the capital stock and therefore economic growth of the country.

The Nigerian Stock Exchange is influenced by macroeconomic variables, which are outside the realm of capital market. The macroeconomic variables or indicators are external factors that cause variation in the stock prices movement. The changes are reflected by the magnitude and direct movement in stock prices, market index and liquidity of the market. Over the past few decades, the interaction of the capital market and the macroeconomics variables has been a subject of interest among financial economists, econometrician and statistician.

Nwokoma, (2002) argued that stock prices are determined by some fundamental macroeconomic variables such as the interest rate, Gross Domestic Product (GDP), exchange rate, inflation and money supply. Investors generally believe that monetary policy and macroeconomic events have large influence on the volatility of the stock price (Business Day, 2009). This implies that macroeconomic variables could cause variation on share returns and influence investors' investment decision. This motivates many researchers to investigate the

dynamic relationships between share returns and macroeconomic variables (Christopher, *et al*; 2006).

Macroeconomic variables that influence stock market have been documented in recent literature without a consensus on their appropriateness as regressors. This is confirmed by Lanne (2002), Campbell and Yogo (2003), Jansen and Moreira (2004), Donaldson and Maddaloni (2002) and Goyal (2004). Macroeconomic variables that are frequently cited are GDP, price level, industrial production rate, interest rate, exchange rate, current account balance, unemployment rate and fiscal balance.

To date, only a very few studies have been conducted examining the direct impact of interest rate, Real

Gross Domestic Product (RGDP), inflation rate, and exchange rate on Nigerian stock market index. It is in line with this, that the research work seeks to examine how these macroeconomic variables impact on the Nigerian stock market index. Nigeria stock exchange all share index is used to represent the Nigerian stock market index, because it provides an easy way to gauge the performance of the capital market as well by proxy the economy as a whole. On the other hand, macroeconomic indicators are treated as statistical indicators which are used for assessment of general state of the country's economy during a certain period of time (Rogers, 1998). They are also regularly published governmental statistics which reflect the economic situation in the specified country. Therefore, the macroeconomics variables to be used are the interest rate, inflation rate, exchange rate and real gross domestic product. In order to achieve our set objective stated above, we first attain stationarity for all the indicators using augmented dickey fuller test since the nature of macroeconomic indicators are non-stationary. A cointegration test will be carried out to determine the long run relationship between the indicators and the level of cointegrated variables will be determined and discussed using a vector error correction (VEC) model which is a restricted *VAR*. The *VEC* model will be used to build cointegration relations into our specification in order to restrict the long-run behaviour of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The cointegration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

2. Literature Review

Studies like Mukherjee and Naka (1995) and Nasseh and Strauss (2000) examine the impact of several macroeconomic variables on stock markets in both developed and emerging economies. Most studies find that these macroeconomic variables have significant influence on the stock market and the existence of a long-run relationship between these macroeconomic variables and stock prices.

The gap that exist between this study and the empirical studies review can be seen in the area of the countries in which the study was conducted, choice of combining the variables, the choice of year of study, methodology used and sector of the market under study.

However, Maysami *et al* (2005) examine the existence of long-run cointegrating relationship among stocks listed dually in the US and Singapore stock markets. In addition, Ibrahim (1999) investigates the dynamic interactions between the KLSE Composite Index, and seven macroeconomic variables (industrial production index, money supply M1 and M2, consumer price index, foreign reserves, credit aggregates and exchange rate) in Malaysian stock market. Observing that macroeconomic variables led the Malaysian stock indices, he concludes that Malaysian stock market was informationally inefficient. Chong and Koh's (2003) results were similar, they showed that stock prices, economic activities, real interest rates and real money balances in Malaysia was linked in the long run both in the pre and post capital control sub periods.

Mukherjee and Naka (1995) used the VECM to analyze the relationship between the Japanese Stock Market and exchange rate, inflation, money supply, real economic activity, long-term government bond rate, and call money rate. They conclude that a cointegrating relation indeed existed and that stock prices contributed to this relation. However, upon applying this method they failed to find the strong evidence on the impact of these variables on the stock market index. Wong *et al* (2005) examine the long- run equilibrium relationships between the major stock indices of Singapore and the United States using selected macroeconomic variables with time series data from January 1982 through December 2002. The results of co integration test suggest that Singapore's stock prices generally display a long- run equilibrium relationship with interest rate and money supply (M1) but similar relationship does not exist in the United States. However, the study is not country specific.

Elumilade and Asaolu (2006), examine the relationships between stock market capitalization rate and interest rate. They find that prevailing interest rate exerts positive influence on stock market capitalization rate. They also found that government development stock rate exerts negative influence on stock market capitalization rate and prevailing interest rate exerts negative influence on government development stock rate.

3. Theory and Methods

3.1. Data Exploration

The macroeconomic data and share market index used in this research work was obtained from the Central Bank of Nigeria statistical bulletin (2013) and the Nigerian stock exchange fact book. The pattern and general behaviour of inflation rate, interest rate, exchange rate, real gross domestic product and Nigerian Stock Market Index will be examined from the time plot to reveal the important information regarding the structure of the economic series. The series will be examined for stationarity using the augmented Dickey –Fuller methods.

3.2. Time Plot

This is the first and most important diagnostic tool of time series data. It is a graphical representation of a time series data. It is constructed by plotting the observation $\{y_t\}$ on the vertical axis against time 't' on the horizontal axis. When properly drawn, it shows the important features of the series such as trend, seasonality, discontinuities and outliers.

The time plot of the data gives an idea of the type of model that is suitable for the data in order to indicate whether it is necessary to transform the observed data to achieve certain stable conditions suitable for meaningful analysis and inference. The time plot may exhibits a structure that can show trend or secular movement, seasonal variation, cyclical variation and irregular variation.

3.3. Augmented Dickey Fuller Test

The present of trends and unit roots can be detected from the slowly decaying autocorrelation function (ACF) in a univariate process, thus indicating non-stationary, but this has very little power to detect the process of trend or unit root.

Consider the AR (1) series

$$y_t = \phi y_{t-1} + U_t \quad (1)$$

Since we know that if $-1 < \phi < 1$ then y_t is stationary

If $\phi = 1, y_t$ is not stationary

Hence the unit root hypothesis is

$$H_0: \phi = 1 \;\; vs$$

$$H_1: \phi < 1$$

Subtract y_{t-1} from (1) we have

$$y_t - y_{t-1} = y_{t-1} - \phi y_{t-1} + U_t$$

$$\Delta y_t = (\phi - 1) y_{t-1} + U_t$$

Let $\delta = \phi - 1, hence$

$$\Delta y_t = \delta y_{t-1} + U_t$$

Thus, testing for $\phi = 1$ is tantamount to testing for $\delta = 0$.

The Augmented Dickey Fuller (ADF) test involves checking through and testing the three sets of models:

$$\Delta y_t = (\lambda - 1) y_{t-1} + \sum_{j=1}^{j} \beta_j \, \Delta y_{t-j} + U_t \quad (2)$$

$$\Delta y_t = \alpha + (\lambda - 1) y_{t-1} + \sum_{j=1}^{j} \beta_j \, \Delta y_{t-j} + U_t \quad (3)$$

$$\Delta y_t = \alpha + \delta_t + (\lambda - 1) y_{t-1} + \sum_{j=1}^{j} \beta_j \, \Delta y_{t-j} + U_t \quad (4)$$

Where equation(2)is a pure random walk model (A time series that has a unit root is known as random walk and a random walk is an example of a non-stationary time series). Equation (3)contains an intercept or drift term and equation(4)contains both the drift and linear time trend.

Unit root test involves one of more of the above equations and the associated standard errors and comparing the test statistic with the appropriate values in the Dickey Fuller table.

3.4 Co-integration

This will be used to analyze the joint movement of economic variables and their departure from equilibrium overtime. It will as well express the relationship that exists between two non-stationary series for which the stochastic relationships are bounded. It establishes a link between two non-stationary series by obtaining a linear combination which gives integration of order zero $I(0)$ stationary and cointegration helps specifies the Error Correction Mechanism (ECM).

Considering two economic series, revenue (EXG) and inflation rate (INF)

$$EXG_{it} = U_{it} + \Sigma_{it} \quad (5)$$

$$INF_{it} = U_{zti} + \Sigma_{it} \quad (6)$$

Where EXG and INF are both non-stationary, since they both have stochastic trends U_{it} and U_{zti}

U_{it} represents trend in variables, period t.

Σ_{it} represents stationary components in variables, period t

EXG and INF are co-integrated of order (1,1) if there are non-zero values of β_1, β_2 in the linear combination.

$$\beta_1 EXG_{it} + \beta_2 INF_{it}$$

$$= \beta_1(U_{it} + \Sigma_{it}) + \beta_2(U_{zti} + \Sigma_{it})$$

$$= \beta_1 U_{it} + \beta_1 \Sigma_{it} + \beta_2 U_{zti} + \beta_2 \Sigma_{it}$$

The necessary and sufficient condition for EXG and INF to be $CI(1,1)$ is that $\beta_1 U_{it} + \beta_2 U_{zti} = 0$ (vanishes)

Where $CI(1,1)$ is co-integrated vector

Suppose we have the series

$$Y_t = N_{yt} + E_{yt} \quad (7)$$

$$Z_t = N_{zt} + E_{zt} \quad (8)$$

Where Y_t and Z_t are both non-stationary since the two have stochastic trends N_t and N_{2t}, E_{yt} and E_{zt} are the disturbance terms. A linear combination of Y_t and Z_t is stationary if there are non zero values of β_1 *and* β_2 in $\beta_1 Y_t + \beta_2 Z_t = \beta_1(N_{yt} + E_{yt}) + \beta_2(N_{zt} + E_{zt}) = \beta_1 N_{yt} + \beta_1 E_{yt} + \beta_2 N_{zt} + \beta_2 E_{zt}$

For the LHS to be stationary, the term $\beta_1 N_{yt} + \beta_2 N_{zt}$ must vanish. Therefore the necessary and sufficient condition for $\{Y_t\}$ and $\{Z_t\}$ to be co-integrated of order(1), $CI(1,1)$ is that, $\beta_1 N_{yt} + \beta_2 N_{zt} = 0$.

Then, $CI(1,1)$ co-integrating vector and Y_t and Z_t must have the same stochastic trend since we preclude β_1 *and* β_2 from being equal to zero.

that is, if $Y_t = N_{yt} + E_{yt}$ and

$Z_t = N_{zt} + E_{zt}$ then

the difference, $Y_t - Z_t = E_{yt} - E_{zt}$

Summarily, co-integration of two or more macro-economic indicators suggests that there is a long run or equilibrium relationship between them.

3.5 Vector Autoregressive (VAR)

A vector autoregressive **(VAR)**is a multivariate simultaneous equation system in which each variable under study is regressed on a finite number of lags of all variables jointly considered. The method focus on deriving a good statistical representation of the interactions between variables and the data determine the model. The main uses of **(VAR)**are for structural analysis and forecasting.

The vector autoregressive (VAR) model was developed in the econometric modeling of time series. Sims (1980) has forcefully argued against the standard approach to modeling economic relationship, particularly in a dynamic context. Using the vector autoregressive methodology reveal interesting hidden association of variables considered for investigation.

3.5.1 Vector Autoregressive (VAR) Processes of Order (*P*)

A process y_t is said to be a vector autoregressive process of order P denoted by VAR (P) if it satisfies the equation

$$y_t = v + A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t, \qquad t = 0, \pm 1, \pm 2 \ldots, \quad u_t \sim N(0, \sigma^2) \qquad (9)$$

Where $y_t = (y_{1t}, \ldots, y_{kt})'$ is a $(k \times 1)$ random vector, the A_i are fixed $(k \times k)$ coefficient matrices, $V = (V_1, \ldots V_k)'$ is a fixed $(k \times 1)$ vector of intercept terms allowing for the possibility of a non-zero mean, $E(y_t)$.

Finally $u_t = (u_1, \ldots u_t)'$ is a k-dimensional white noise or innovation process, that is,

$$E(u_t) = 0$$

$$E(u_t u_t') = \Sigma_u$$

$$E(u_t u_s') = 0 \quad for\ t \neq s$$

The covariance matrix Σ_u is assumed to be non-singular, if not otherwise stated.

For $P = 1$, $VAR(1)$ model:

$$y_t = v + A_1 y_{t-1} + u_t \qquad (10)$$

3.6 Vector Error Correction Model

A vector error correction *(VEC)* model is a restricted *VAR* designed for use with non stationary series that are known to be cointegrated. The *VEC* has cointegration relations built into the specification so that it restricts the long-run behaviour of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The cointegration term is known as the *error correction* term since the deviation
from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.
To take the simplest possible example, consider a two variable system with one cointegrating
equation and no lagged difference terms. The cointegrating equation is:

$$y_{2,t} = \beta y_{1,t} \qquad (11)$$

The corresponding *VEC* model is:

$$\Delta y_{1,t} = \alpha_1 (y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{1,t} \qquad (12)$$

$$\Delta y_{2,t} = \alpha_2 (y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{2,t} \qquad (13)$$

In this simple model, the only right-hand side variable is the error correction term. In long run equilibrium, this term is zero. However, if y_1 and y_2 deviate from the long run equilibrium, the error correction term will be nonzero and each variable adjusts to partially restore the equilibrium relation. The coefficient measures the speed of adjustment of the *i*-th endogenous variable towards the equilibrium.

4. Result and Discussion

The descriptive analysis was used to summarize the characteristic of the macroeconomic indicators considered in this research work with a view of showing the important features of each economic series through the use of time plot.

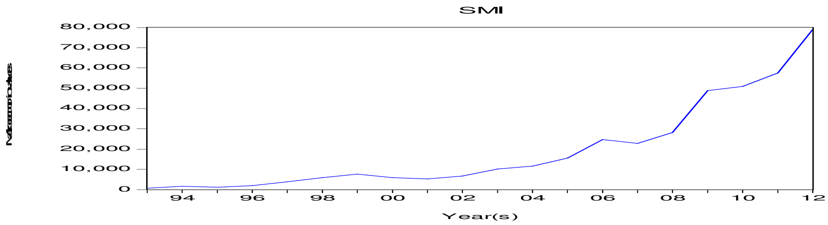

Figure 1.Time Plot of Share Market Index

The time plot for SMI shows a long-term movement of the value of the series in the same direction over the period considered and this indicates a secular movement.

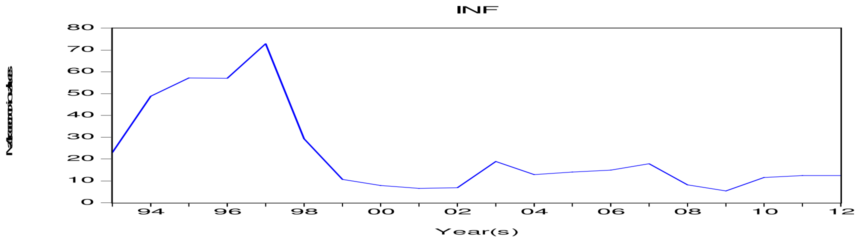

Figure 2.Time Plot of Inflation Rate

The time plot for inflation rates shows a long-term oscillation about the trend every three years, that is, a cycle is completed every three years. The movement in the time plot above does not follow exactly similar pattern after every three years. The movement describe above is cyclical in nature and is referred to as cyclical variation or cyclical movement.

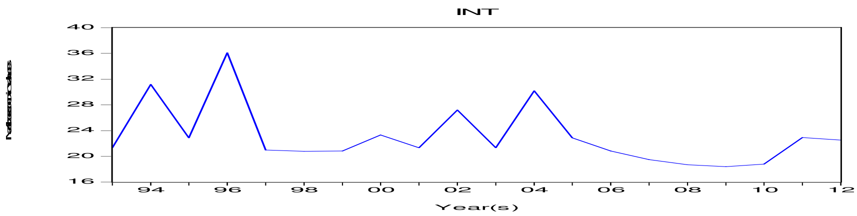

Figure 3.Time Plot for Interest Rate

The time plot for interest rates shows a long-term oscillation about the trend every three years, that is, a cycle is completed every three years. The movement in the time plot above does not follow exactly similar pattern after every three years. The movement describe above is cyclical in nature and is referred to as cyclical variation or cyclical movement.

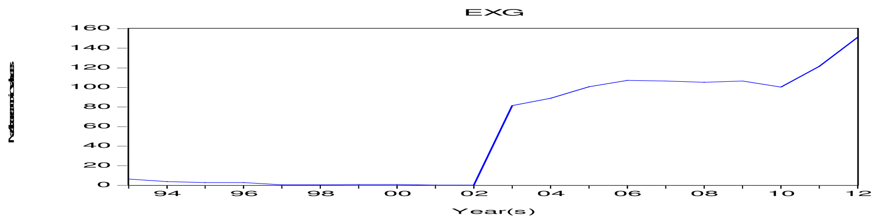

Figure 4.Time Plot for Exchange Rate

The time plot for exchange rates shows long term movement in the same direction over the period considered. This movement is characterized by a continuous increase in the values of investment over the period of time and this shows a general increase in the value of exchange rates every year in Nigeria. It can be seen that there was a sharp shift upward in 2003 which could be due to uncontrolled inflation rate and lack of exportation.

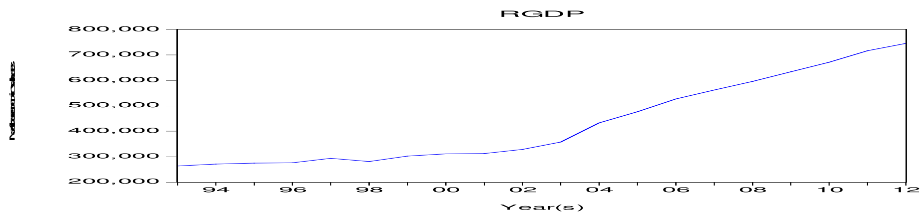

Figure 5 Time Plot for Real Gross Domestic Product

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The time plot for RGDP shows a long-term movement of the value of the series in the same direction over the period considered. This movement is characterized by a continuous increase in the values of RGDP over the period of time and this shows a general increase in the value of RGDP every year in Nigeria.

Unit Root Test and Results

All the macro economic variables tested for stationarity using the Augmented Dickey-Fuller (ADF) test reveals that all other macroeconomic indicators were stationary at the first order of difference except for SMI and RGDP that were stationary at the second order of difference, I(2).

Table 1. Unit Root Test Using Augmented Dickey-Fuller (ADF)

Economic Series	ADF Test Statistic	At 95% Critical Level	Order of Integration
SMI	-10.4062	-1.9644	I(2)
INF	-4.1968	-1.9614	I(1)
INT	-10.4527	-1.9614	I(1)
EXG	-3.2653	-1.9614	I(1)
RGDP	-6.67035	-1.9628	I(2)

Hypothesis:

$H_0: There\ exist\ unit\ root$

$H_1: There\ is\ no\ unit\ root$

Significant level: 5%

Johansen Co-integration Tests and Results

The test statistic strongly rejects the null hypothesis of no co-integration in favour of three cointegration relationship. Likelihood ratio (Trace test) indicates three cointegrating equations at 5% significant level.

Table 2. Johansen Co-integration Test

Hypothesized		Trace	0.05	
No. of CE(s)	Eigen value	Statistic	Critical Value	Prob.**
None *	0.875632	93.73031	69.81889	0.0002
At most 1 *	0.768449	56.20917	47.85613	0.0068
At most 2 *	0.668301	29.87601	29.79707	0.0490
At most 3	0.422708	10.01252	15.49471	0.2798
At most 4	0.006821	0.123206	3.841466	0.7256

* Denotes rejection of the hypothesis at 5% significant level.

Vector Error Correction Estimation

Vector Error Correction Model for SMI

$$D(SMI)_t = (143190.2 - 1.071560SMI_{t-1} - 1571.887EXG_{t-1} - 0.186752RGDP_{t-1}) + (321.8 + 40.99584INF_{t-1} - 10.976979EXG_{t-1} + 0.000526RGDP_{t-1}) + (29.9 + 1100.537115INT_{t-1} - 1.457216EXG_{t-1} + 5.255150e^{-05}RGDP_{t-1}) + (2737.8 + 0.080266D(SMI)_{t-1} - 192.187101D(INF)_{t-1} - 467.641795D(INT)_{t-1} + 293.920204D(EXG)_{t-1} - 0.025653D(RGDP)_{t-1}$$

Interpretation of Vector Error Correction Model for SMI

The equation above is the vector error correction model for SMI, where the differenced current SMI is explained and determined by SMI, exchange rate, inflation rate and interest rate in its first lag, while the differenced SMI is as well explained and determined by the differenced inflation rate, interest rate and exchange rate in their first lags. The value of $R^2 = 0.8982$ and this implies that 90% of variation in the dependent variable is explained and the model is a good fit.

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Vector Error Correction Model for Inflation Rate

$$D(INF)_t = (143190.2 + 2.165499\mathrm{SMI}_{t-1} - 1571.887359EXG_{t-1} - 0.186752RGDP_{t-1}) - (321.8 - 0.268269\mathrm{INF}_{t-1} - 10.976979\mathrm{EXG}_{t-1} + 0.000526\mathrm{RGDP}_{t-1}) + (29.8 + 1.805389\mathrm{INT}_{t-1} - 1.4572161\mathrm{EXG}_{t-1} + 5.255150\mathrm{e}^{-05}\mathrm{RGDP}_{t-1}) + (6.19 + 0.000634\mathrm{D(SMI)}_{t-1} + 0.177235\mathrm{D(INF)}_{t-1} + 0.431009\mathrm{D(INT)}_{t-1} - 0.167015\mathrm{D(EXG)}_{t-1} - 0.000360\mathrm{D(RGDP)}_{t-1}$$

Interpretation of Vector Error Correction Model for Inflation Rate

The equation above is the vector error correction model for Inflation rate, where the differenced current inflation rate is explained and determined by SMI, exchange rate and interest rate in its first lag, while the differenced current inflation rate is not explained and determined by the differenced macroeconomic indicators in the model. The value of R^2=0.8482 and this implies that 85% of variation in the dependent variable is explained and the model is a good fit.

Vector Error Correction Model for Interest Rate

$$D(INT)_t = (143190.2 + 0.000265\mathrm{SMI}_{t-1} - 1571.887359EXG_{t-1} - 0.186752RGDP_{t-1}) + (321.8 + 0.103898\mathrm{INF}_{t-1} - 10.976979\mathrm{EXG}_{t-1} + 0.000526\mathrm{RGDP}_{t-1}) + (29.9 - 1.115845\mathrm{INT}_{t-1} - 1.457216\mathrm{EXG}_{t-1} + 5.255150\mathrm{e}^{-05}\mathrm{RGDP}_{t-1}) + (-0.09 - 0.000271\mathrm{D(SMI)}_{t-1} + 0.007172\mathrm{D(INF)}_{t-1} - 0.029645\mathrm{D(INT)}_{t-1} + 0.051526\mathrm{D(EXG)}_{t-1} + 5.53372\mathrm{e}^{-06}\mathrm{D(RGDP)}_{t-1}$$

Interpretation of Vector Error Correction Model for Interest Rate

The equation above is the vector error correction model for Interest rate, where the differenced current interest rate is explained and determined by exchange rate and interest rate in its first lag. The differenced current Interest rate is not explained and determined by the differenced macroeconomic indicators in the first previous lags. The value of $R^2 = 0.67049$ and this implies that 67% of variation in the dependent variable is explained and the model is a good fit.

Vector Error Correction Model for Exchange Rate

$$D(EXG_t) = (143190.2 - 0.002930\mathrm{SMI}_{t-1} - 1571.887359EXG_{t-1} - 0.186752RGDP_{t-1}) + (321.8 + 0.092844\mathrm{INF}_{t-1} - 10.976979\mathrm{EXG}_{t-1} + 0.000526\mathrm{RGDP}_{t-1}) + (29.9 + 3.495336\mathrm{INT}_{t-1} - 1.457216\mathrm{EXG}_{t-1} + 5.255150\mathrm{e}^{-05}\mathrm{RGDP}_{t-1}) + (-14.5 + 0.000759\mathrm{D(SMI)}_{t-1} - 0.440834\mathrm{D(INF)}_{t-1} - 1.023848\mathrm{D(INT)}_{t-1} + 1.045713\mathrm{D(EXG)}_{t-1} + 0.000532\mathrm{D(RGDP)}_{t-1}$$

Interpretation of Vector Error Correction Model for Exchange Rate

The equation above is the vector error correction model for exchange rate, where exchange rate and interest rate in their first lag has an impact on the differenced current exchange rate and the current differenced interest rate is explained and determined by the differenced interest rate and exchange rate in their first previous lags. The value of R^2=0.78672 and this implies that 79% of variation in the dependent variable is explained and the model is a good fit.

Vector Error Correction Model for RGDP

$$D(RGDP_t) = (143190.2 + 0.108445\mathrm{SMI}_{t-1} - 1571.887359EXG_{t-1} - 0.186752RGDP_{t-1}) + (321.8 - 264.930334\mathrm{INF}_{t-1} - 10.976979\mathrm{EXG}_{t-1} + 0.000526\mathrm{RGDP}_{t-1}) + (29.9 + 1500.283505\mathrm{INT}_{t-1} - 1.457216\mathrm{EXG}_{t-1} + 5.255150\mathrm{e}^{-05}\mathrm{RGDP}_{t-1}) + (30867.09 - 0.071294\mathrm{D(SMI)}_{t-1} - 224.482244\mathrm{D(INF)}_{t-1} - 352.335469\mathrm{D(INT)}_{t-1} + 347.836358\mathrm{D(EXG)}_{t-1} - 0.261847\mathrm{D(RGDP)}_{t-1}$$

Interpretation of Vector Error Correction Model for RGDP Rate

The equation above is the vector error correction model for RGDP, where SMI, exchange rate, inflation rate, interest rate and RGDP in their first lag has an impact on the differenced current RGDP, while the current differenced RGDP is explained and determined by the differenced inflation rate, interest rate and exchange rate in their first previous lags. The value of R^2=0.840622 and this implies that 84% of variation in the dependent variable is explained and the model is a good fit.

Table 2. *VEC* Residual Portmanteau Tests for Autocorrelations

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	27.01557	NA*	28.60472	NA*	NA*
2	49.84868	0.0022	54.29197	0.0006	25
3	74.03788	0.0152	83.31901	0.0022	50
4	96.27695	0.0496	111.9121	0.0037	75
5	117.4341	0.1123	141.2066	0.0042	100
6	138.1660	0.1985	172.3044	0.0032	125

H_0: No residual autocorrelations up to lag h

*The test is valid only for lags larger than the VAR lag order.

df is degrees of freedom for (approximate) chi-square distribution

The residual passes the white noise test since no autocorrelation is left in $lag(1)$ and on the basis of this, we can select $VEC(1)$ as the specification for analysis.

Table 3. Vector Error Correction Residual Normality Test

Component	Skewness	Chi-sq	Df	Prob.
1	0.100206	0.030124	1	0.8622
2	-0.047578	0.006791	1	0.9343
3	0.155846	0.072864	1	0.7872
4	0.266676	0.213349	1	0.6442
5	-0.077385	0.017965	1	0.8934
Joint		0.341093	5	0.9968
Component	Kurtosis	Chi-sq	Df	Prob.
1	0.574962	4.410608	1	0.0357
2	0.788904	3.666710	1	0.0555
3	0.772512	3.721278	1	0.0537
4	1.065011	2.808136	1	0.0938
5	0.693756	3.989070	1	0.0458
Joint		18.59580	5	0.0023
Component	Jarque-Bera	df	Prob.	
1	4.440732	2	0.1086	
2	3.673501	2	0.1593	
3	3.794142	2	0.1500	
4	3.021485	2	0.2207	
5	4.007035	2	0.1349	
Joint	18.93690	10	0.0411	

Interpretation of Vector Error Correction Residual Normality Test

H_0: Residuals are multivariate normal

The residual normality test shows that the residual are jointly normal since the joint Skewness, Kurtosis and Jarque-Bera are significant.

5. Conclusion

From the results obtained the time plots showed that each year there is a simultaneously increase in the values of share market index, real gross domestic product and exchange rate, except a sharp upward shift in exchange rate in 2002. While inflation and interest rates fluctuate from year to year, cyclical in movement and a cycle is completed every three years.

The Augmented Dickey Fuller tests shows that inflation, interest rate and exchange rate are stationary at the first differencing, I(1), while share market index and real gross domestic product are stationary at the second differencing level, I(2).

The Johansen co-integration test shows that there is at least three co-integrated series out of the five economic series considered in this study at 5% level of significance.

The vector error correction models obtained generalised that there exists dynamic relationship between all the macro economic variables considered in this study and the four macroeconomic indicators considered has significant impact on share market index in Nigeria. The portmanteau test for residual autocorrelation in the *VEC* model shows that no autocorrelation is left at *lag(1)* and *VEC(1)* is the better specification for the analysis. The residual normality test show that the residual are jointly normal since joint skewness, kurtosis and jarque-bera are significant.

Our results show investment perception of Nigeria is a mixture of other mature stock markets, as was found in New-Zealand, Korea, the US and Japan. Considering the gradual recovery of economies from the global financial meltdown, prospective or existing investors either Nigeria or foreigners should pay more attention to the significant above mentioned macroeconomic variables in their investment decision. This result signals the importance of these variables as government targets to emphasize policy effects on stock market. Conclusively, government should implement policies that will reduce inflation rate and poverty level through infrastructural development and improved standard of living. Also, interest rates should be made moderate in order to encourage investment and transactions in stocks in the Nigerian Capital Market. The negative exchange rate shows that the Nigeria economy is readily open for international trade. And finally, the RGDP indicates positive impact with the stock market index.

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